SANDEE

Working Paper No. 97–15

Demand for Piped Drinking Water and a formal Sewer System in Bhutan

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ECONOMICS & THE ENVIRONMENT

Published by the South Asian Network for Development and Environmental Economics (SANDEE)
PO Box 8975, EPC 1056, Kathmandu, Nepal.
Tel: 977-1-5003222 Fax: 977-1-5003299

SANDEE research reports are the output of research projects supported by the South Asian Network for Development and Environmental Economics. The reports have been peer reviewed and edited. A summary of the findings of SANDEE reports are also available as SANDEE Policy Briefs.

National Library of Nepal Catalogue Service:

Ngawang Dendup and Kuenzang Tshering
Demand for Piped Drinking Water and a formal Sewer System in Bhutan

(SANDEE Working Papers, ISSN 1893-1891; WP 97–15)

ISBN: 978-9937-596-27-5

Key words:
Hedonic pricing method
Sanitation
Sewage
Drinking water
Valuation
Willingness to pay
Bhutan

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July 2015

South Asian Network for Development and Environmental Economics (SANDEE)
PO Box 8975, EPC 1056, Kathmandu, Nepal

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The South Asian Network for Development and Environmental Economics

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SANDEE is financially supported by the International Development Research Center (IDRC), The Swedish International Development Cooperation Agency (SIDA), the World Bank and the Norwegian Agency for Development Cooperation (NORAD). The opinions expressed in this paper are the author's and do not necessarily represent those of SANDEE's donors.

The Working Paper series is based on research funded by SANDEE and supported with technical assistance from network members, SANDEE staff and advisors.

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Contents

Abstract

In this study, we estimate demand for sewage connections and piped drinking water in Bhutan. To estimate household willingness to pay for these services, we use data from a sample of 18,766 households surveyed through the Bhutan Living Standard Survey of 2007 and 2012. A Hedonic model is estimated using pooled data with sub-district level fixed effects to control for heterogeneity and unobserved effects across sub-districts. The findings from our study indicate that there is significant demand for sewage and piped water connections inside dwellings. On average, unconnected urban households are willing to pay Nu 348 and Nu 362 (USD 5 to 6) per month for sewage and piped drinking water connections or 6 percent of their monthly household expenditures for each service. Un-connected urban households are willing to pay significantly more than the current joint charge of Nu 78 per month for water and sanitation. Similarly, rural households are willing to pay some 2 percent of monthly household expenditures for piped water. There is scope for municipalities in Bhutan to increase their revenues from public services and to cover potential investment costs associated with expanding services. This study also provides a baseline for designing contracts should Bhutan choose to privatize water and sanitation services.

Key words

Hedonic pricing method, Sanitation, Sewage, Drinking water, Valuation, Willingness to pay, Bhutan

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1. Introduction

In 2012, some 2.5 billion people in the world did not have access to improved sanitation facilities, of which 40 percent lived in Southern Asia (WHO and UNICEF, 2014). Further, 748 million people – mostly the poor – lacked access to improved drinking water source. Some 20 percent of people without access to clean water live in Southern Asia (WHO and UNICEF, 2014). The situation in Bhutan is better than this global scenario. Yet, there is still much to be done to improve water and sanitation access in order to ensure basic public health and livelihood benefits.

According to the Bhutan Living Standard Survey 2012, about 78 percent of Bhutanese households have access to piped water inside their dwelling (NSB and ADB, 2012). Similarly, some 81 percent of households have access to improved sanitation facilities and 63 percent have a flush toilet. However, only 20 percent of households have flush toilets connected to a piped sewer system (NSB and ADB, 2012). Soak pits and septic tanks are used when there is no sewage system and the municipal office provides septic-pumping services. Most residents directly release domestic waste water from the kitchen and washrooms to nearby streams (NSB, 2006; RAA, 2008; WHO, 2006).

Waterborne diseases, such as diarrhea and dysentery, are among the top five diseases in Bhutan (RGOB, 2012). Some 2,368 children per 10,000 population below the age of 5 were infected by diarrhea in 2011(RGOB, 2012). These water borne diseases are generally associated with a lack of sufficient access to clean water and sanitation services (Kolahi et al. 2009; WHO and UNICEF 2014). Clearly, Bhutan has not fully reaped the public health dividends associated with access to improved water and sanitation

In Bhutan, the office of the mayor, which manages utility services in urban centers, is often criticized for lack of adequate service supply and there are calls for privatizing service delivery. As Van den Berg and Nauges (2012) argue in the case of Sri Lanka, organizational reform in the management of the utility may be required in order to satisfy health and sanitation demands. One option that Bhutan could explore is privatizing public water and sanitation services to deliver better health outcomes. Municipal offices are legally allowed to enter into contracts with private investors. However, for such contracts to be meaningful, it is important to correctly value the costs and benefits of piped sewage and drinking water connections.

A good understanding of what households are willing to pay for public services would allow policy makers to make informed investment decisions related to water and sanitation infrastructure. It would also allow for accurate determination of tariffs for piped connections and clarify payment parameters in any contractual agreements with private entrepreneurs (Pattanayak, 2006). With these considerations, this study seeks to estimate household willingness to pay for a piped sewage connections and piped drinking water inside dwellings in Bhutan.

We use the Hedonic pricing method to estimate willingness to pay. This approach estimates the value of a connection to piped network by comparing the property values or rents between connected and unconnected houses after controlling for other factors. While many studies have estimated willingness to pay for drinking water in other South Asian countries (see Van den Berg and Nauges (2012) for Sri Lanka; Anselin, Lozano-Gracia, Deichmann, & Lall (2008) for India; and, Whittington, Pattanayak, Yang & Bal Kumar (2002) for Nepal), there are no such estimates available for Bhutan. Our study attempts to fill this gap in the literature and offer some robust economic information to the water and sanitation decision-makers in Bhutan.

2. Study Area

Bhutan is a small country, sandwiched between India and China. A predominantly agricultural economy, the majority of Bhutan's 7.5 million people still depends on subsistence farming (NSB, 2014). Bhutan's landscape is dominated by rugged mountain terrain with altitudes ranging from 300 meters above sea level in the south to 7,300 meters in the north. Beyond agriculture, this majestic landscape offers a market for regulated tourism and for trade in hydro-electricity with its larger neighbors.

Politically, Bhutan is administered through 20 districts and 272 sub-districts, which are divided into 205 *gewogs* (rural sub-districts) and 67 towns (urban sub-districts). Four towns are categorized as A towns and 63 towns fall into category B. Category A towns include Thimphu, Phuntsholing, Gelephu, and Samdrup Jongkhar. An elected city mayor administers these towns, with the mayor's office functioning as an autonomous organization. According to the Population and Housing Census 2005 (RGOB, 2005), the only census to date conducted in Bhutan, approximately 17 percent of the total population lives in these four towns.

Wastewater treatment plants are available only in Thimphu, Phuntsholing and Gelephu. Within these towns, some 52 percent, 30 percent and 37 percent of households are connected to the existing sewage system (NSB and ADB 2012).[1] Other households and towns resort to septic tanks and soak pits, while some households still use pit latrines.[2] Existing Water and Sanitation Rules allow a house to get connected to the sewage system if the house is within the distance of 70 meters from main sewage line and if it is technically feasible to do so. Municipal offices generally offer septic pumping services to un-connected homes for a modest fee.

Thimpu is Bhutan's capital city. Only about 40 percent of Thimphu's sewage is currently being treated and its stabilization pond is at maximum capacity (Sabapathy and Rajarathnam 2008). Thus, the Thimphu Corporation is developing a sequential batch reactor to replace the technology currently being used to treat waste water. Similarly, Phuntsholing Corporation is conducting a feasibility study for relocating the existing stabilization pond since it cannot cope with demand. The existing sewerage system in Gelephu was built in 2008 and meets current needs, but may not be adequate if demand increases.

The overall context in Bhutan is of a growing country that is inadequately served by available water and sanitation infrastructure. As towns grow, the demand for water and sanitation services will only increase. Given this situation, our study seeks to estimate the price households are willing to pay for improved access to these services, with the intention of clarifying for policy makers the kinds of contracts and investments that may be feasible.

3. Data

We use data from the Bhutan Living Standard Survey (BLSS) conducted in 2007 and 2012. The BLSS 2007 and 2012 report data on demographic and socio-economic characteristics. These surveys were designed to develop indicators at the district level, and data were collected from households across the country. Information was collected at both household and individual levels.

In the BLSS, household stratification is at the district and at the urban/rural level. Blocks serve as primary sampling units (PSU) for urban areas, while *chiwogs* (the lowest rural administrative unit of the district) do so for rural areas. Thus, using the probability proportional to size of rural and urban populations in each block or *chiwog*, 2,942 urban households and 6,859 rural households were surveyed in BLSS 2007 (NSB, 2007). In BLSS 2012, 4,619 urban households and 4349 households from rural areas were selected as the sample in order to capture detailed socio-economic variability in urban areas (NSB, 2007; NSB and ADB, 2012).

The unit of analysis of our study is at the household. Thus, our study sample size is18,766 households, which includes 9798 and 8968 households from BLSS 2007 and BLSS 2012, respectively. This translates to about 60 percent of the urban and 40 percent of the rural sample.

[1] In 1996, Thimphu and Phuntsholing's waste stabilization ponds and central sewage system were connected to 60 percent and 80 percent of the houses in each town (WHO, 2006). However, with housing growth, by 2012, piped sewage connections have significantly decreased (NSB and ADB, 2012).

[2] Personal communication with Mr. Sangay Chedar, Senior Planning Officer under Gross National Happiness Commission (Planning Commission), Royal Government of Bhutan.

A main variable of interest to us is housing prices and rental. In this dataset, house rent refers to the monthly rent paid by the tenants. If a household owns a house, households were asked how much they would spend to rent a similar house. The monthly rent from 2007 to be compared with 2012 needs to be adjusted for inflation. Instead, we use the nominal rent for our analysis but add a year dummy variable in our model to control for such differences.

Several housing attributes are included in our analyses to control for differences in houses that may influence rent. These include the number of rooms, materials used for the floor, roof and external wall, and types of toilet facilities. In addition, we also include neighborhood attributes such as distance to the nearest market, bus-station, tarred road, district headquarters and agriculture extension office. We measure distance in terms of the number of hours it takes to reach the nearest amenities. Table1 shows the details of variable definitions as well as their summary statistics, which we discuss in section 5.

4. Model and Estimation Methods

4.1 The Hedonic Pricing Model

To estimate the value of connection to main sewage line and piped water inside the dwelling of a house, we use the Hedonic pricing method developed by Lancaster (1966) and Rosen (1973). The hedonic pricing method is frequently used to measure the value of environmental quality associated with a private good, including an amenity or disamenity (Freeman, 2003). In our case, we are interested in examining the value households place on access to a piped sewer system and piped drinking water. The basic idea is to estimate the value of an environmental amenity by examining the difference between the property value of houses with and without the amenity, after controlling for other factors influencing housing values.

In the hedonic model the utility function of a household is defined as:

$$U = U(C, S, N, Q) \tag{1}$$

where C is a composite goods; S denotes attributes of a house such as structural characteristics; N denotes neighborhood characteristics; and Q denotes environmental quality. A household chooses to maximize utility in Equation (1), subject to the following budget constraint:

$$M - C - R = 0 \tag{2}$$

where M is the income and R is the monthly rental price of house. We assume that the housing market is in equilibrium, that is, each household makes a utility-maximizing residential choice given the rental prices and characteristics of alternative housing options, and that these rental prices clear the market given the stock of housing and its characteristics. Under these assumptions, the rental price of a house would be a function of the structural, neighborhood, and environmental characteristics of that location (Freeman 2003):

$$R = R(S, N, Q) \tag{3}$$

Equation (3) is referred to as hedonic price function. In our study, Q represents environmental characteristics including connection to piped sewer system and piped drinking water inside the house. The value of any particular characteristic can be measured by computing its marginal effect on the rental price using this equation.

Economic theory, generally, suggests that the sales value of a house is a function of its attributes. However, such data are not available in the case of Bhutan. We, therefore, use monthly house rent instead of sales value. Studies by Morais and Cruz (2003), Yusuf and Koundouri (2005) and Van den Berg and Nauges (2012) have also used rent as a function of other housing attributes to estimate willingness to pay for different amenities. Morais and Cruz (2003) show that rent can be used as a function of other housing attributes, as rent is directly linked with the market value of a house.

4.2 Econometric Model and Estimation Methods

An important consideration in estimating the hedonic price function in Equation 3, is the specification of its functional form. Rosen (1974) argues that the function can only be linear when the attributes of a house can be unbundled. Freeman (1979) too agrees that the function can be linear only if the attributes of the product can be repackaged. However, the repackaging of housing attributes is almost impossible, thus, the hedonic price function may need to be specified as a nonlinear function (Freeman, 2003; Rosen, 1974).

Figure 1 presents histograms of rent and the natural log of rent from the pooled dataset, which indicate that the natural log of rent approximates to a normal distribution. We, therefore, specify the model with the natural log of rent as a dependent variable. This also ensures positive predicted values for rent. For explanatory variables, we select the transformation based on the nature of variable and model selection criteria, explained in Section 4.3 below. The econometric model for the Hedonic price function can be written as:

$$Y_{it} = X_{it}\beta + u_{it} \quad (4)$$

where subscripts *i* and *t* denote household *i* in year *t*; Y_{it} is the natural log of monthly rent; X_{it} is a vector of explanatory variables (in level or natural log) for structural, neighborhood and environmental attributes of a house; β is a vector of coefficients to be estimated; and u_{it} is the error term.

In the explanatory variables, structural attributes include number of rooms, presence of flush toilet and materials used for wall, roof and floor. Neighbourhood characteristics include distance from market, tarred road, bus station, district head quarter and agriculture extension office. Environmental attributes include access to central sewage system and piped water inside the dwelling.

In the econometric model in Equation (4), we expect that the rent will increase with the increase in the number of rooms, presence of flush toilets and with the use of improved construction materials for wall, floor and roof. Therefore, we expect a positive sign of coefficients on these variables. For neighborhood attributes like distance from market, tarred road, bus station, district head quarter and agriculture extension office, we expect negative coefficient indicating that farther the house is located from these facilities, the value of house will decrease. We also expect that value of house would increase if a house is connected to sewage system and have piped water inside dwelling. Therefore, we expect positive coefficients from our environmental variables for sewage and water amenities.

For estimating Equation (4), we use pooled cross-section data for two time periods. Hedonic pricing estimation requires addressing empirical issue such of omitted variable bias due to heterogeneity of attributes across time and locations. To address this issue, we use fixed effects for two time periods and for 272 sub-districts (*gewogs* in rural areas and towns in urban areas). Recent studies have used spatial fixed effect in hedonic models to hedge against the problem of omitted variable bias (Kuminoff et al., 2010, Anselin et al., 2008; Anselin, 2001), allowing for estimation of spatial lag and spatial error models. However, in our case, we do not have geo-referenced data and we are restricted to using fixed effects for time periods and sub-districts.

One of the concerns related to model estimation using more than one time-period data is the problem of serial correlation. The explanatory variables may be correlated with error terms so that they are no longer adequate for the purpose of drawing inferences. We, therefore, allowed the standard error for the intra-*gewog* and intra-town (group) to be correlated and relaxed the model mandate that observations are independent. We now assume that observations are independent across *gewogs* and towns. To allow this, we estimate robust clustered standard errors (clustered by *gewog* and town), which also relaxes the requirement of independence of observations.

4.3 Model Selection

The choice of a functional form is one of the challenges with the Hedonic pricing model. According to Van den Berg and Nauges (2012), not much has been written on the choice of the functional form while the most commonly used method for estimating the Hedonic model is the ordinary least squares (OLS) method (Poudyal et al., 2009). Several scholars express concern over incorrect functional forms, which can result in inconsistent estimates (Anselin et al,. 2008; Kuminoff et al., 2010; Leong, 2002). A key finding by Cropper, Deck and McConnel (1988) suggests that a flexible model specification for equilibrium prices generates the most reliable marginal values, only when all variables are included in the model. However, in the presence of omitted variables, simpler functional forms, including log-level and log-log model, tends to perform better. We follow their findings in developing our model specification.

We use the natural log of rent as the dependent variable. As most explanatory variables have a monotonic ˆ (positive or negative) relationship with rent, we consider level and natural log transformations. We consider no transformation for dummy variables as they are indicator variables with the values of 0 or 1. Furthermore, we do not make any transformation for the variable 'number of rooms' which takes only discrete values. We compare two functional forms: with and without log transformation of the remaining explanatory variables, which we refer to as log-log and log-level, respectively. To select the final model, we use the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC), which are measured as:

$$\text{AIC} = -2 * ln(likelihood) + * K \quad (5)$$

$$\text{BIC} = -2 * ln(likelihood) + ln(N) * K \quad (6)$$

where *likelihood* is the maximized value of likelihood function, K is the number of parameters estimated, and N is the number of observations or independent term. Both AIC and BIC are a measure of the fit and complexity of the regression model. Complexity is measured as 2 * K in the case of AIC and $ln(N)$ * K in the case of BIC. According to Akaike (1974) and Hoeting et al. (1999), the smaller the value of the information criterion, the better it is for the model. The dependent variable is the natural log of rent in both functional forms (log-log and log-level), thus we can use AIC and BIC for selecting the model.

While using BIC to determine the best model, the determination of N is a concern as N differs with the estimation technique and is very subjective. We therefore adopt the more conservative approach of allowing N to be equivalent to the number of observations. However, in our model estimation, we have relaxed the assumption of independence across observations and we only assume independence across *gewogs* and towns (clusters). We therefore use a number of groups as N (N = 272) to allow the model assumption to estimate BIC. Note that AIC does not use N to determine complexity.

4.4 Estimating WTP

Our econometric model (equation 4) includes two dummy explanatory variables of interest: connection to sewer system and connection to piped drinking water inside the dwelling. Denote X_j as one of these variables, say connection to sewer system. The willingness to pay (WTP) or the value of connecting to the sewer system can be measured by computing its marginal effect on the house rent. As the explanatory variable is a dummy variable and the dependent variable is the natural log, WTP is measured as follows (Van den Berg and Nauges (2012) and Yusuf and Koundouri (2005)):

$$WTP_j = \bar{R}^{NC} (e^{\hat{\beta}_j} - 1) \quad (7)$$

where $\bar{R}^{NC}$ is the mean value of monthly rent of a house with no connection, and $\hat{\beta}_j$ and is an estimated coefficient on the dummy variable for the connection. Since $\hat{\beta}_j$ and $\bar{R}^{NC}$ are estimates and have standard errors, we accounted for this in constructing the 95 percent confidence interval for WTP. This allows us to estimate upper and lower bounds of WTP using the standard error of estimates. From Equation (7), WTP as a proportion of house rent is measured as $(e^{\hat{\beta}_j} - 1)$.

5. Results and Discussion

5.1 Descriptive Statistics

Table 1 presents the definition of the variables and summary statistics of the variables used in the study. It shows that mean monthly rent increased from 1,309 Bhutanese Ngultrum (Nu) in 2007 to Nu 2,556 in 2012. The percentage of houses connected to main sewage system decreased by from 14 to 13 percent during this period. In terms of piped water inside dwellings, 56 percent of households were connected in 2007, while 83 percent were connected by the year 2012.

Now we compare changes between urban and rural areas and examine changes over time. Mean urban and rural rents in 2007 was Nu 2351 and Nu 863 per month, respectively, which increased to Nu 3,677 and 1,365 per month in 2012. In 2007, 41 percent of urban households were connected to the main sewage system. This decreased to 26 percent in 2012 (see Figure 2). The decrease in the percentage of households connected to sewage may be attributed to the boom in housing construction, particularly in Thimphu and Phuntsholing between these two time periods. In terms of piped water inside the dwelling, 83 percent of urban households had piped drinking water in 2007 and 87 percent had access in 2012 (Figure 3). In case of rural households, as Figure 3 shows, while 45 percent were connected in 2007, 73 percent were connected in 2012.

Table 2 presents descriptive statistics of all households by connected and unconnected status, and reports the results of t-test to test whether the mean value of each variable is statistically different between houses with connections and without connections (to sewage system and piped drinking water). The average monthly rent with and without sewage connection is Nu 4137 and Nu 1553, respectively, and the average difference is statistically significant at 1 percent level. Similarly, the mean monthly rent of a house with and without piped drinking water is Nu 2369 and Nu 932, respectively, and the average difference is statistically significant at 1 percent level.

Figure 4 presents a box plot of rent by sewage connection. It is important to note that the median rent for houses with a sewage connection is higher than those not connected. Similarly, Figure 5 also shows that the median rent of a house connected to piped drinking water inside dwelling is higher than those not connected.

5.2 Fixed Effect Regression Results

This study estimates the effects of sewage connection and piped drinking water inside dwelling on the house rent after controlling for other variables. Table 3 shows the regression results with two functional forms with sub-district fixed effects. Table 3 makes it clear that the coefficients of sewage connection and piped drinking water are consistently significant and that the results are comparable between two different functional forms.

Based on AIC and BIC results, we select the log-log model and we estimate fixed effect results of rural and urban samples separately. The coefficients of most of the variables are significant and are consistent with the existing literature. The fixed effect regression results suggest that, for urban dwellers monthly house rent increases by 12 percent if the house is connected to central sewage system and it increases by about 20 percent if there is piped water inside dwelling, other things remaining constant. Similarly for the rural dwellers, the rent of a house increases by about 12 percent if the house is connected to piped water inside dwelling, other things remaining constant. This result shows that there is significant demand for sewage and water infrastructure in Bhutan.

Structural variables like room, types of toilet, materials used for floor, roof and walls are significant and consistent with conventional Hedonic results. We expected the coefficient signs of all these structural variables to be positive and their signs are positive as expected. Results show that the presence of flush toilet, more rooms, concrete external walls, modern roof and floor increases the value of a house.

The signs of coefficients of neighborhood attributes including distance from market, road, bus-station and agriculture extension office are negative as expected, however only distance from market and tarred road turns out be significant at the conventional level. This indicates that the value of a house decreases when it is located farther away from these amenities. This result is consistent with the results of studies by Baranzini and Schaerer (2011) and Jim and Chen (2009) who show that households have a stronger preference for a natural rather than a man-made environments.

We also estimate the log-log model for renter subsamples (those who pay rent) households in Table 4. As mentioned in section 3, rent is the actual value of rent for renter households only, whereas homeowners were asked how much they would spend to rent a similar house. Therefore, it is important to check the sensitivity of results using the Renter household sub-sample. This performs the robustness check of the result and our results are still comparable and significant at conventional level.

From a policy stand point, it is also important to compare results between urban and rural areas, which we do in Table 4. However, in the rural sub-sample model, we had to drop the sewage connection variable since there are no sewage facilities in rural areas. Thus, we are unable to estimate WTP for sanitation connections in rural areas. We also dropped the variable 'Wall' since a majority of rural households reported using mud as wall construction material. Similarly, we replaced Flush Toilet with Separate Toilet as rural households use only pit toilets and we included Separate Toilet to indicate those households that owned their own toilet. Since there is no bus-station in rural Bhutan, we replaced the variable Bus Station with distance from the nearest temple. We assume that as the distance from the temple increases, the value of the house will decrease in the rural sub-sample, thus yielding a negative coefficient.

5.3 WTP for Sewage Connection and Piped Drinking Water

We now estimate the willingness to pay for a sewage connection and piped drinking water based on the log-log model presented in Table 4. The log-log model was selected based on AIC and BIC, as mentioned in the above section. We estimate WTP with for urban and rural samples separately. Table 5 shows the mean WTP for sewage connection and piped water inside dwellings.

Our results in Table 5 show that households' mean WTP for piped water inside dwelling and sewage connection is roughly Nu 362 (USD 5.7) and Nu 348 (USD 5.5)[3] per month for urban dwellers, respectively.[4] The WTP for piped water inside dwelling for rural dwellers is Nu 66 per month with a 95 percent confidence interval of Nu 24 to109.

The WTP for a sewage connection and piped drinking water for urban dwellers translates to 13 percent and 22 percent of household mean monthly rent. This result suggests that urban households are WTP approximately 6 percent of their monthly household income (expenditures) for a sewage connection and the same for piped water (see Table 5). The WTP for piped drinking water inside a dwelling for rural dwellers translates to 9 percent of monthly house rent and 2 percent of monthly household expenditures. These results suggest that the urban household has a higher demand for piped water connections relative rural dwellers.

Other studies have found that the WTP for piped water is 3.6 percent of household monthly expenditures in the case of Indonesia (Yusuf and Koundouri, 2005), 5-7 percent of household monthly expenditures in the case of Sri Lanka (Van den Berg and Nauges, 2012) and 2.4 percent of household monthly income in the case of the Philippines (North and Griffin, 1993). Thus, our WTP estimates of 6 percent and 2 percent of expenditures of urban and rural dwellers for piped water are comparable with the WTP estimates from similar studies.

5.4 Financing Urban Sewage and Water Infrastructure

We now estimate the potential revenue that can be generated for the towns of Thimphu, Phuntsholing and Gelephu if sewage and piped water tariff is charged based on the estimates of WTP. We focus on these three towns because they are the only ones with sewage connections. We calculate revenues based on the urban and rural sample mean WTP.

Currently households pay Nu 2.45 per month for consuming less than 20 cubic meter of water, Nu 2.95 per month for consuming between 21 to 40 cubic meters, and Nu 3.70 per month for consuming more than 40 cubic meters, including a 50% surcharge for sewerage. However, the BLSS (2012) reports that households' pay an average of Nu 78 per month in water charges and 50 percent of this charge is considered as sewerage charges.[5] We calculate the current revenue generated by the three towns based on this charge (Nu 78) and compare this with potential revenue if charges were based on our study (see Table 6). To compare current and potential revenues we multiply the two different charges by the total number of households connected to sewage and piped in respective towns. According to BLSS (2012), in Thimphu, Phuntsholing and Gelephu towns, 52 percent, 30 percent and 37 percent of households were connected to sewage and 89 percent, 94 percent and 97 percent of households were connected to piped water inside a dwelling.

The results in Table 6 indicate that Thimphu has the highest potential to increase its revenue (by almost nine fold) by charging the estimate WTP, relative to what is currently earned. Gelephu and Phunthsoling municipals can increase

[3] 1 USD = 63.8 Nu as of June 2015.
[4] The 95 percent confidence interval of WTP for piped water connection is from Nu 134 to Nu 579 per month. Similarly, the 95 percent confidence interval of WTP for sewage connection is from Nu 246 to 485.
[5] The Ministry of Works and Human Settlement also reports revenues from water and sanitation charges but we cannot these numbers for comparison because they report the total revenue generated as the sum of revenue generated from industries, other institutions and residential houses.

their revenue per month revenue by roughly more than 5 folds by charging the fees identified in this study.

We also estimated the revenue that municipal offices would be able to earn from additional connections to currently unconnected households, based on both the current surcharge and the estimated WTP surcharge (see Table 7). As the Table shows, if un-connected households are brought into the system and current services are offered to them, all three municipalities could make significantly more revenues by charging at the rate estimated in our study.

The estimated WTP for water and sewerage can be used to make investment decisions for providing services to currently unconnected households. It is worth investing in additional connections if the revenue is more than the cost of building the required infrastructure and providing the services. To assess the viability of such investments, we calculated net present value for one additional household connection. For this, we calculated the WTP for both water and sanitation by adding the water and sewage surcharges to obtain a joint rate of Nu 710 per month or Nu 8520 per year. Discounting this at a rate of 10% (since housing loans are provided at 10 percent by commercial banks), this translates to a NPV of benefits of Nu 85,200 from one additional household connection to water and sewage. Thus, if the per household cost of investments is less than the benefits of Nu 85,200, then additional water and sewage connections are economically viable.

6. Conclusions and Recommendations

In Bhutan, some 73 percent of rural households and 87 percent of urban households currently have access piped water in their homes. Some 26 percent of urban homes are connected to a formal sewage system, while none of the rural households are.

By examining differences in the value of rent paid for homes, we are able to establish that there is significant demand for sewage connections and piped drinking water in Bhutan. Households with a connection to the existing sewage system and access to piped drinking water inside dwellings pay a higher monthly rent for these amenities. We exploit this information to estimate household willingness to pay for a formal sewage and piped water connection.

Our results show that urban households are, on average, willing to pay Nu 348 (USD 5.5) per month for access to a sewage connection and Nu 362 (USD 5.7) per month for access to piped water, while they currently pay a combined charge of Nu 78 per month. The WTP of rural dwellers is Nu 66 per month for the piped water connection inside the dwelling. Our findings suggest un-connected urban households are willing to pay significantly more than what is currently paid for water and sanitation services. Urban households are also willing to pay a lot more than rural households for piped water.

Our study suggests that municipalities in Bhutan can increase their current revenues from water and sanitation charges. Thimphu municipality can potentially see a nine-fold increase in its gross revenues from municipal charges if it charges the higher rate estimated in our study. Phuntsholing and Gelephu towns can potentially generate more than five times what they are currently generating by raising rates to the WTP estimates from our study.

The estimates from this research can be used to justify investments in public infrastructure. If the costs of investments to expand connections are lower than what household benefits from access to water and sanitation, such investments should be considered. Our study suggests that the investments are economically viable if the additional costs per household are less than Nu 85,200. Currently, at least two townships in the country are considering or in the process of making additional technological and infrastructure investments. This study offers some benefit estimates that can be compared with these costs.

Our study provides estimates of demand that can help revise existing tariff for sewage and water infrastructure and services in Bhutan. There is a legal provision for privatizing such services in Bhutan and this study may be useful to policy makers to develop contracts with private investors and organizations, if Bhutan decides to privatize these public services.

Acknowledgements

My special thanks go to my advisor Subhrendu Pattanayak and all other SANDEE advisors for their guidance and valuable suggestions. I would like to thank Mani Nepal, Heman Lohano and Priya Shyamsundar for their valuable suggestions and critical readings of the paper. I would also like to thank SANDEE for supporting this research and providing me with training on environmental and resource economics. I am also grateful to Anuradha, Neesha, Bhawana and Malvika for their administrative help. Finally, I would like to thank the National Statistical Bureau of Bhutan, city corporations and municipal offices of Bhutan for providing me with data and information.

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Tables

Table 1: Definition of Variables and Summary Statistics by Year

Variables	Definition	Mean in 2007	Mean in 2012
Rent	Monthly house rent in Nu	1309.7 (1685.33)	2556.03 (3203.01)
Sewage	1 if a house is connected to sewage system	0.14 (0.35)	0.13 (0.34)
Water	1 if piped drinking water is inside dwelling	0.56 (0.50)	0.83 (0.40)
Flush Toilet	1 if toilet type is flush toilet	0.29 (0.45)	0.71 (0.45)
Separate Toilet	1 if households owns separate toilet	0.8 (0.40)	0.86 (0.35)
Room	Number of rooms excluding balconies and toilet	2.89 (1.78)	2.99 (1.61)
Wall	1 if external wall is concrete	0.22 (0.41)	0.33 (0.47)
Roof	1 if roof material is modern	0.75 (0.43)	0.94 (0.24)
Floor	1 if floor material is wood	0.52 (0.50)	0.53 (0.50)
Temple	Distance from nearest temple in hours	0.85 (1.83)	0.69 (2.35)
Market	Distance from the nearest food market in hours	2.07 (5.98)	1.00 (4.21)
Road	Distance from tarred road in hours	2.67 (7.32)	1.12 (4.42)
Bus Station	Distance from bus-station in hours	4.66 (2.47)	1.60 (4.79)
District	Distance from district headquarters in hours	4.18 (7.88)	2.28 (5.04)
Agriculture	Distance from agriculture extension office in hours	1.34 (2.38)	1.02 (3.83)
Observations	Number of observations in sample	9,798	8,968

Standard deviation in parentheses

Table 2: Mean Comparison Test of Connected and Unconnected Households

Variables	Sewage			Piped Drinking Water		
	Connected (Mean)	Not Connected (Mean)	p-value	Connected (Mean)	Not Connected (Mean)	p-value
Rent	4,136.88	1,552.79	0.000	2,369.38	932.52	0.000
Sewage				0.20	0.01	0.000
Water	0.97	0.63	0.000	–	–	–
Flush Toilet	1.00	0.41	0.000	0.63	0.20	0.000
Separate Toilet	0.87	0.82	0.000	0.85	0.78	0.000
Room	3.07	2.92	0.000	3.15	2.50	0.000
Wall	0.65	0.21	0.000	0.36	0.09	0.000
Roof	0.98	0.82	0.000	0.91	0.71	0.000
Floor	0.72	0.49	0.000	0.56	0.45	0.000
Temple	0.39	0.84	0.000	0.69	0.97	0.000
Market	0.22	1.77	0.000	0.95	2.82	0.000
Road	0.09	2.22	0.000	1.04	3.79	0.000
Bus Station	2.56	3.30	0.000	2.71	4.23	0.000
District	0.83	3.66	0.000	2.18	5.55	0.000
Agriculture	0.41	1.31	0.000	0.90	1.78	0.000
Year 2012	0.46	0.48	0.059	0.57	0.29	0.000
Observations	2,560	16,206		12,705	6,061	–

Table 3: Fixed Effect Regression Results [Dependent Variable: In(Rent)]

Variables	Log-Log Model	Log-Level Model
Sewage	0.150***	0.153***
	(3.916)	(4.106)
Water	0.076***	0.081***
	(3.524)	(3.795)
Flush Toilet	0.235***	0.247***
	(10.146)	(10.509)
Room	0.234***	0.235***
	(22.982)	(22.866)
Wall	0.235***	0.241***
	(10.705)	(11.147)
Roof	0.257***	0.269***
	(12.060)	(12.991)
Floor	0.012	0.016
	(0.639)	(0.895)
Market (*ln*)	-0.025**	
	(-2.571)	
Road (*ln*)	-0.024***	
	(-2.868)	
Bus Station (*ln*)	0.002	
	(0.693)	
District (*ln*)	-0.008	
	(-0.563)	
Agriculture (*ln*)	-0.013	
	(-1.626)	
Market		-0.000
		(-0.117)
Road		-0.004
		(-1.230)
Bus Station		0.002
		(0.586)
District		-0.001
		(-0.496)
Agriculture		0.000
		(0.080)
Year 2012	0.311***	0.315***
	(8.678)	(8.862)
Constant	5.537***	5.583***
	(112.599)	(117.185)
Observations	18,766	18,766
R-squared	0.337	0.334
AIC BIC	40,363 40,465	40,441 40,543

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Fixed Effect Log-Log Model of Urban and Rural [Dependent Variable: ln(Rent)]

Variables	Urban	Rural	Renter
Sewage	0.124***		0.118***
	(3.236)		(3.071)
Water	0.196***	0.082***	0.210***
	(6.539)	(3.140)	(5.108)
Toilet	0.259***		0.189***
	(6.687)		(4.860)
Room	0.280***	0.216***	0.286***
	(28.752)	(29.080)	(23.666)
Wall	0.191***		0.119***
	(5.096)		(3.781)
Roof	0.419***	0.302***	0.369***
	(7.612)	(15.018)	(7.051)
Floor	0.047**	0.015	-0.004
	(2.262)	(0.536)	(-0.067)
Market (*ln*)	-0.044**	-0.025**	-0.041**
	(-2.055)	(-2.246)	(-2.344)
Road (*ln*)	-0.031**	-0.030***	-0.038***
	(-2.459)	(-3.035)	(-3.509)
Bus Station (*ln*)	-0.007		-0.007
	(-1.006)		(-0.889)
District (*ln*)	0.009	-0.023	0.012
	(0.379)	(-1.452)	(0.366)
Agriculture (*ln*)	-0.015	-0.021**	-0.013
	(-0.680)	(-2.117)	(-0.690)
Temple (*ln*)		-0.022**	
		(-2.483)	
Separate Toilet		0.084***	
		(2.874)	
Year 2012	0.354***	0.321***	0.301***
	(9.743)	(9.581)	(8.558)
Constant	5.518***	5.274***	5.681***
	(62.695)	(145.717)	(56.563)
Observations	7,561	11,205	5,552
R-squared	0.397	0.294	0.324

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Household Willingness to Pay for Sewage Connection and Piped Water inside the Dwelling (per month)

	Mean WTP for Piped Water			Mean WTP for Sewage		
	WTP (Nu)	WTP as % of monthly rent	WTP as % of monthly expenditures	WTP (Nu)	WTP as % of monthly rent	WTP as % of monthly expenditures
Urban	362 (246-485)	22%	6%	348 (134-579)	13%	6%
Rural	66 (24-109)	9%	2%	-	-	-

Note: (95% Confidence Intervals in parenthesis)

Table 6: Current and Potential Revenue from Water and Sewage per Month

	Number of Households Connected to Sewage	Number of Households Connected to Piped Water	Current Revenue (Nu Million) with current charges for Sewage: Nu 39 and Water: Nu 39			Potential Revenue (Nu Million) with WTP for Sewage: Nu 348 and Water: Nu 362		
			Sewage	Water	Total	Sewage	Water	Total
Thimphu	8,179	13,998	0.32	0.55	0.86	2.85	5.07	7.91
Phuntsholing	1,248	3,911	0.05	0.15	0.20	0.43	1.42	1.85
Gelephu	685	1,795	0.03	0.07	0.10	0.24	0.65	0.89

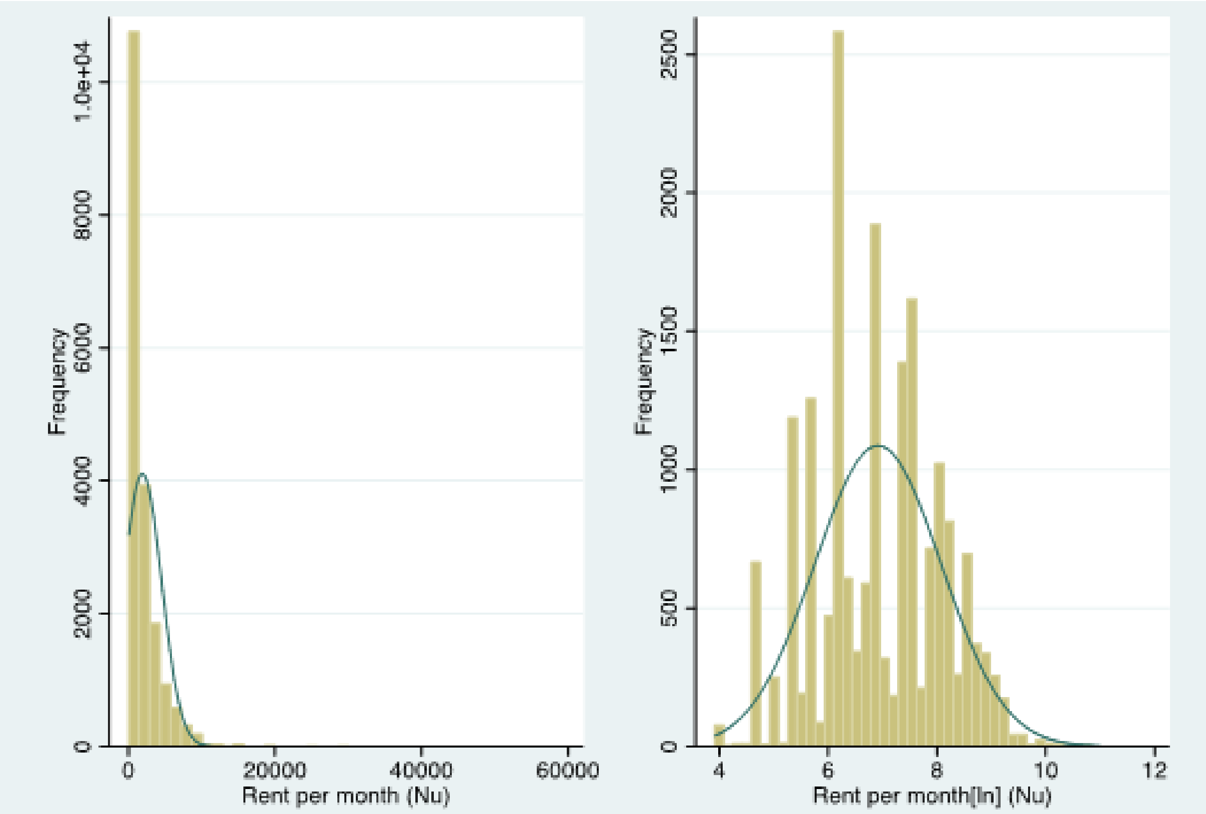
Table 7: Revenue from Additional Connection at the estimated WTP Surcharge

Towns	Number of Household Not Connected to Sewage[1]	Number of Households Not Connected to Piped Water[1]	Additional Revenue (Nu Millions) with Current Sewage charge: Nu 39 and Water charge: Nu 39			Additional Revenue (Nu Millions) with New Sewage charge: Nu 348 and Water charge: Nu 362		
			Sewage	Water	Total	Sewage	Water	Total
Thimphu	7,549	1,730	0.29	0.07	0.36	2.63	0.63	3.25
Phuntsholing	2,913	250	0.11	0.01	0.12	1.01	0.09	1.10
Gelephu	1,166	56	0.05	0.00	0.05	0.41	0.02	0.43

[1] Unmber of unconnected households are estimated based on BLSS 2012

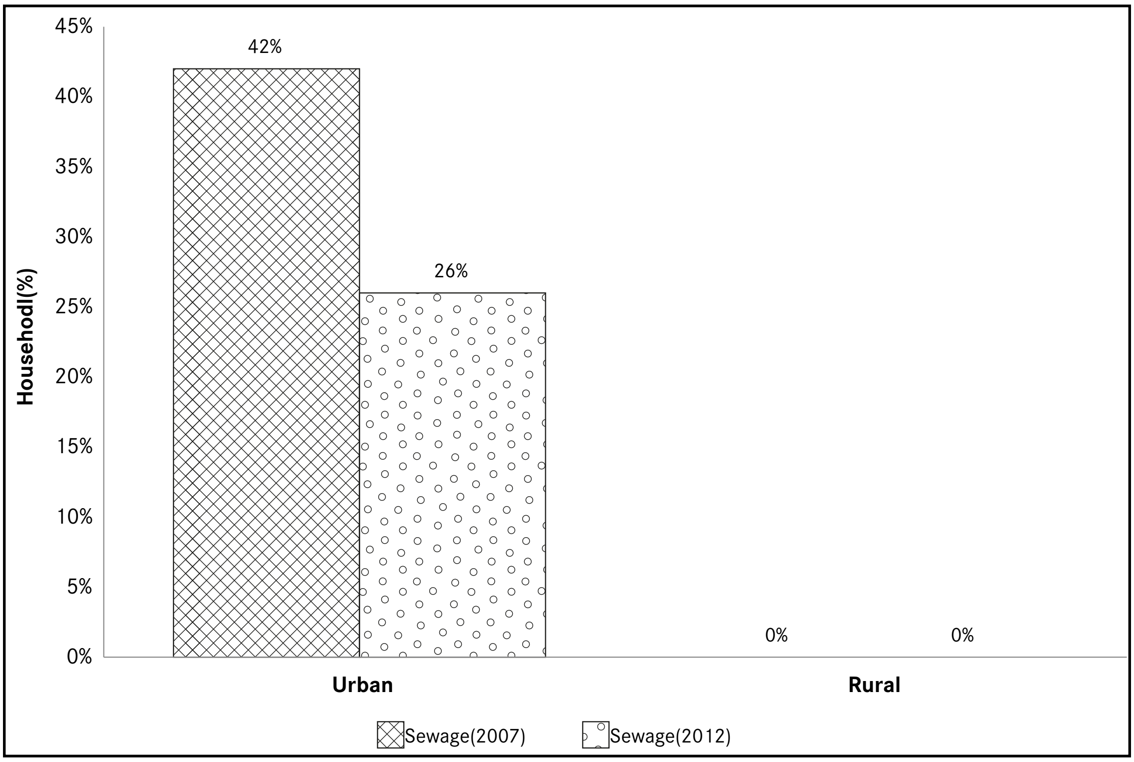
Figures

Figure 1: Histograms of Rent and ln (Rent) (2007 and 2012 pooled data)



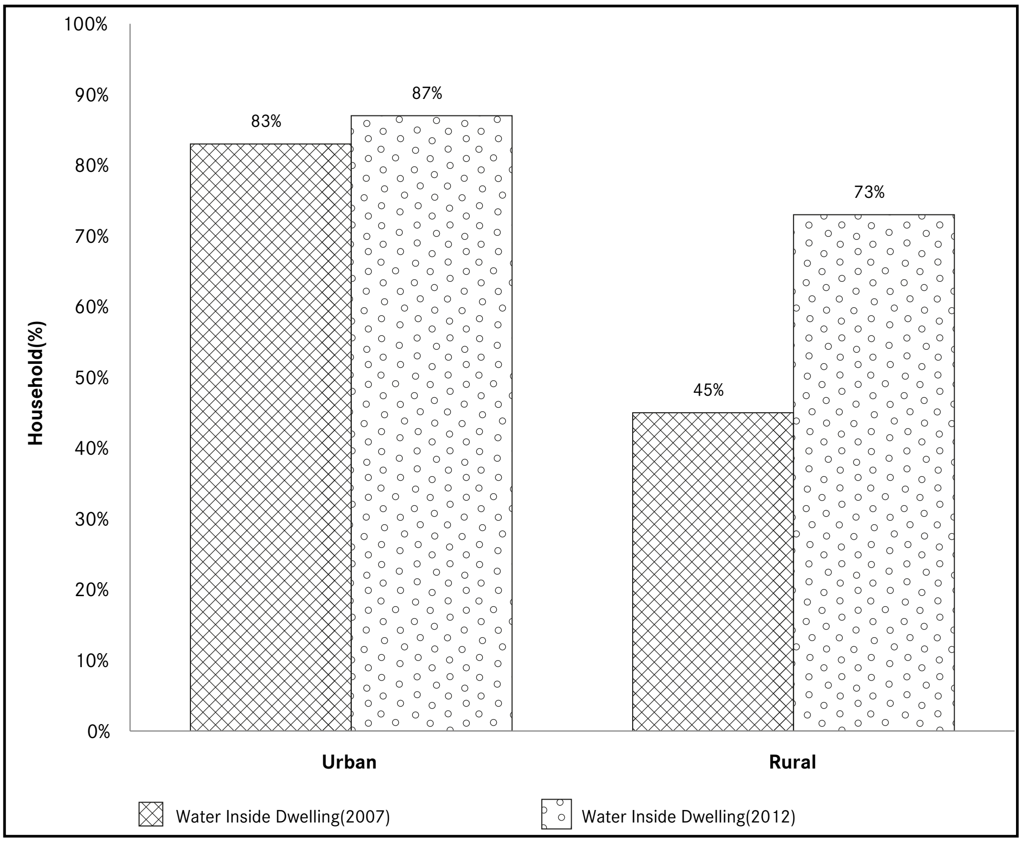
Source: BLSS 2007 and BLSS 2012

Figure 2: Household Access to Sewage by Urban and Rural (2007 and 2012)



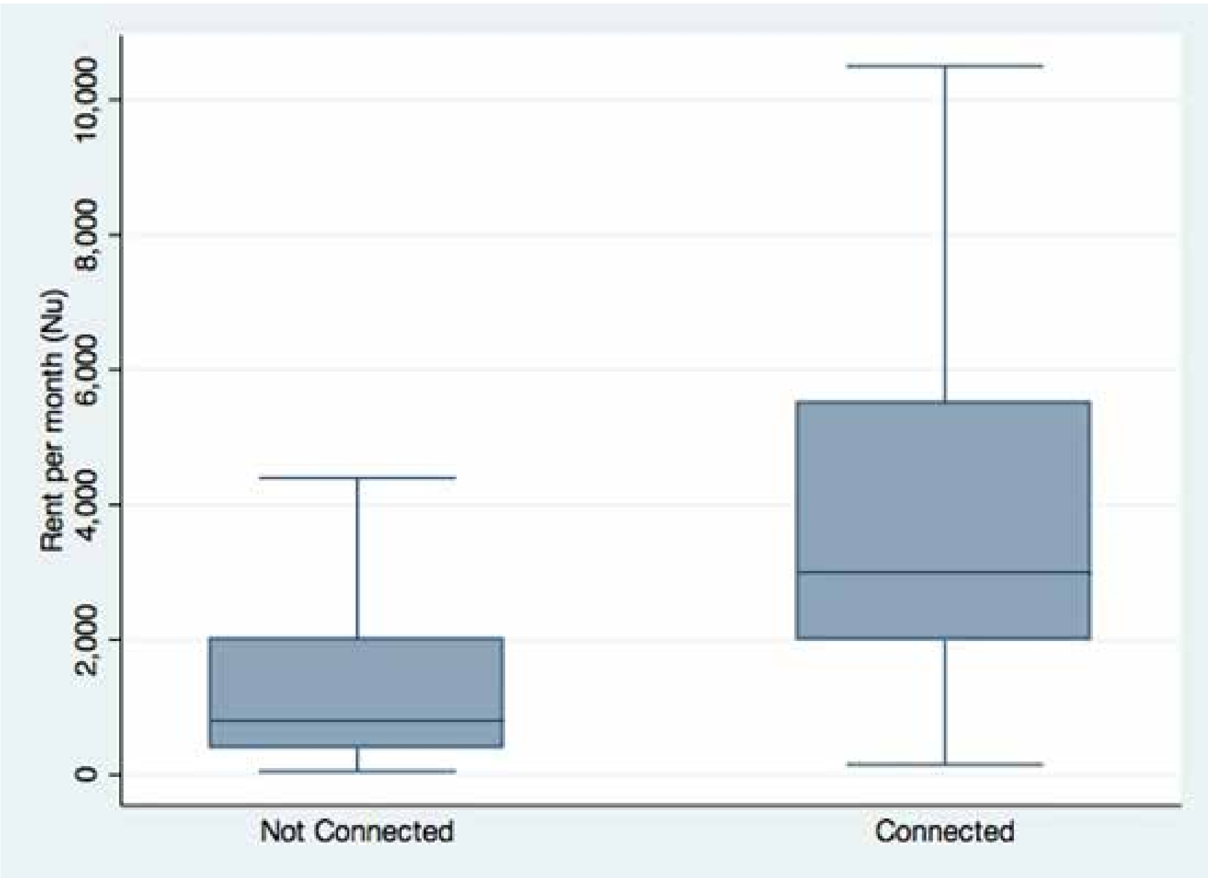
Source: BLSS 2007 and BLSS 2012

Figure 3: Household Access to Piped Water inside Dwelling by Urban and Rural (2007 and 2012)



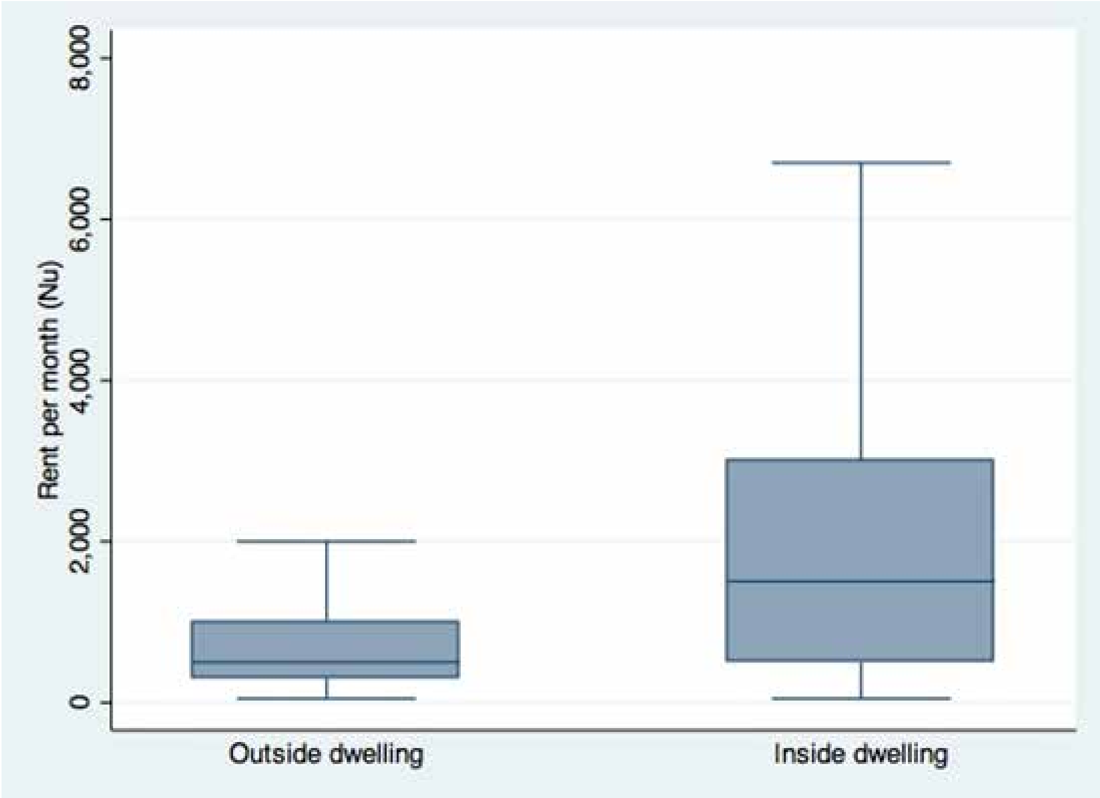
Source: BLSS 2007 and BLSS 2012

Figure 4: Median Rent with and without Sewage



Note: This graph shows that those connected to sewage are paying higher median rent than those not connected. Min and max lines presents first and fifth quartile rent. Source: BLSS 2007 and BLSS 2012

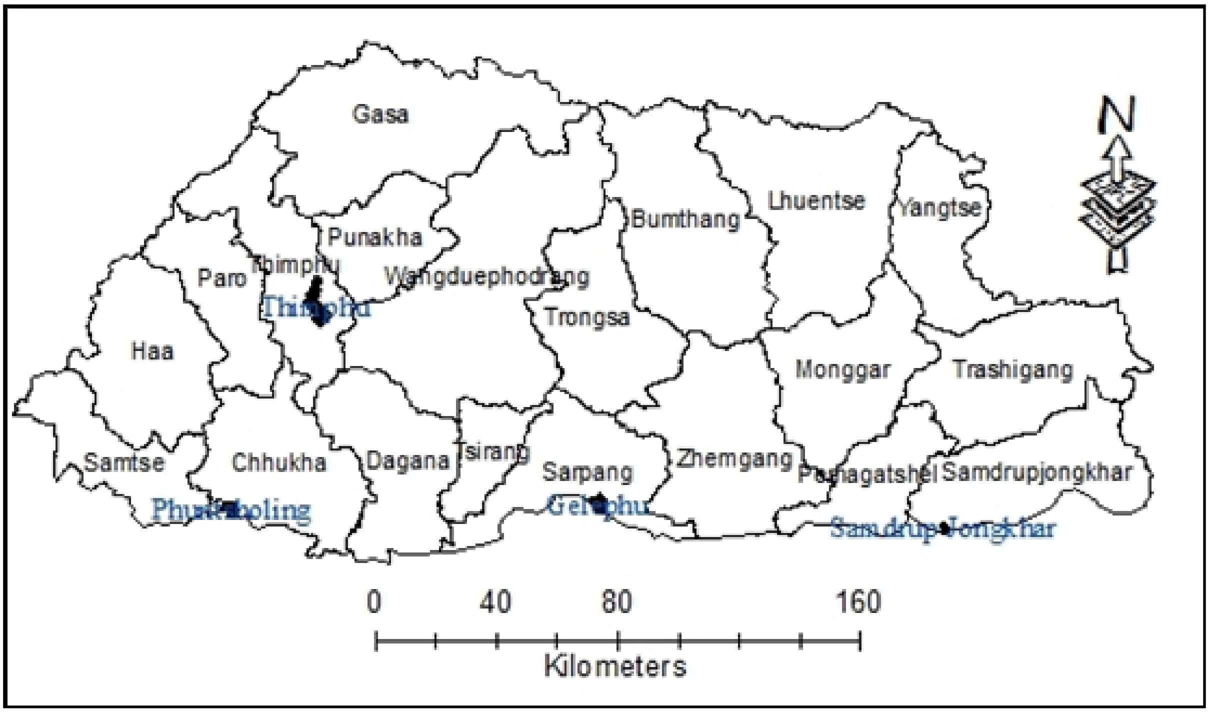
Figure 5: Median Rent with and without Piped Water



Note: This graph shows that households with piped drinking within dwelling are paying higher median rent than those outside dwelling. Min and max lines presents first and fifth quartiles rent.

Source: BLSS 2007 and BLSS 2012

Figure 6: Map of Bhutan with District Boundaries and Four Major Towns



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