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#2016-046

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UNU-MERIT Working Papers
ISSN 1871-9872

Maastricht Economic and social Research Institute on Innovation and Technology
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The Impact of Piped Water Supply on Household Welfare*

Raquel Tsukada[†] Degol Hailu[‡]

August 29, 2016

Abstract

In the absence of piped water from a utility company, households rely on alternative supply from small-scale private providers. We quantify losses of wellbeing associated with using small-scale private providers instead of piped water from the utility company. We measure welfare in three dimensions: health, wealth (income), and time available for education, work, or leisure. An empirical application to Burkina Faso reveals that households' greatest welfare losses are in terms of time availability. The opportunity cost of collecting water is estimated to be 23 hours per week, which is comparable to half of a full weekly working period of an employed person. This loss is often borne by women. In terms of health and affordability of water, paradoxically, households using alternative sources of water are slightly better off.

JEL classification: L95, L33, I18
Keywords: piped water, small-scale private provision, welfare loss, synthetic index

1 Introduction

The Millennium Development Goals (MDG) classify access to water based on both supply technology and water source in the following way: (i) *improved access* – piped water delivered inside the dwelling, plot, or yard; (ii) *other improved* sources – public taps and standpipes, tube wells and boreholes, protected dug wells, protected springs and rainwater; and (iii) *unimproved access* – unprotected dug well, unprotected spring, cart with

*We thank Arnaud Dupuy, M. Christian Lehmann, Wim Naudé and the participants at the UNU-Merit Health Workshop for helpful comments on this paper. We also thank Ida S. Nabolle and the CREPA team for successful data collection.

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small tank or drum, and surface water collected from rivers, dam, lakes or ponds (JMP, 2010). The MDGs also incorporate a distance criterion of a maximum of one kilometer from the homestead in order to consider a source as improved access.[1]

Since 1990, an estimated 2.3 billion people gained access to improved water sources. The MDGs target for clean water has been globally achieved (JMP, 2014). Nevertheless, about 768 million people still lack access to improved water sources.[2] In the absence of clean and treated piped water, households use water supplied by small-scale providers (Collignon, 1999; Kariuki and Schwarz, 2005; Hailu et al., 2011). This paper proposes a methodology to assess the extent to which household welfare is affected by not using a piped water supply. We propose a synthetic index that captures the effect of water supply on three welfare dimensions: health, wealth, and time availability for learning, work, and leisure. Our study covers urban households in Burkina Faso and the data was collected through a survey administered in 2012.

The results show that the welfare dimension most importantly affected when households have no access to piped water is time availability. The opportunity cost of collecting water is estimated to be 23 hours per week for the average household. This can be quantified as a substantial income loss, as time could be invested in more productive activities: comparable to half of a full weekly working period of an employed person. Paradoxically, we find that households with access to piped water have slightly worse health outcomes. Similarly, households with alternative sources of water afford water more readily than households with piped water in their homes.

The paper is structured as follows: Section 2 sketches the household water provision modalities. Section 3 presents the conceptual framework that outlines the channels through which water supply affects household welfare. Section 4 describes the methodology and the data. Section 5 presents the results of the welfare loss analysis. Concluding remarks are provided in Section 6.

2 Problem Statement

It is widely recognized that piped water provided inside the dwelling, preferably from a utility company, is the best water supply technology (UNDP, 2006; JMP, 2010). Piped

[1] Other authors define water provision by means of the technology adopted: (i) grid or network distribution; (ii) point source (fixed location vendor); or (iii) mobile vending (Kariuki and Schwarz, 2005).

[2] The hard-to-reach urban population lives usually in informal settlements, where legal issues concerning land ownership deter dwellers from connecting to the utility provider. Underserviced rural households often live in sparsely populated areas where cost recovery is difficult to be achieved because of either low demand or high cost of grid expansion, thus hindering supply. Reaching populations is a challenge that becomes harder at each percentile increase in water coverage rate (Hailu and Tsukada, 2011).

water requires the lowest degree of water handling from source until the end use, therefore being more convenient and with lower contamination risk. Commuting distance to fetch water is also minimal (virtually zero) and, because of economies of scale in distribution, the unit price of piped water is usually lower than alternative commercial sources. In this sense, inferior technologies are those that require water handling, storage care and transportation. The least recommended water provision technology is fetching water at natural sources outside the dwelling, which includes unprotected wells and springs and surface water.

When piped water or home-based protected natural sources are not available, households rely on the secondary market for water: small-scale private providers. Collignon (1999) and Kariuki and Schwarz (2005) provide comprehensive descriptions of this large market in Sub-Saharan Africa. Water is either sold in a fixed-point location (standpipe or taps), requiring consumers to transport water from source to the homestead and store it. Water can also be sold in small containers (usually 20 liters) delivered to the homestead by mobile vendors (push carts, tankers). The origin of water sold by small-scale private providers may vary: it could be a private connection to the utility company or a private natural source. There might also be intermediaries, as in the case of tankers and pushcart vendors, who buy, store and resell water purchased from another private provider (e.g. the owner of a borehole).

Thus, small-scale water provision entails a sequence of water management and handling from source until the end use. The higher the number of intermediate steps between the water source and final consumption, the larger the probability of water contamination. Alternatively, individuals can commute up to the fixed sales point in order to fill in their own empty water containers. This may reduce the price of water; however, water contamination might still be an issue given storage conditions.

Other non-monetary costs involved in water provision from small-scale providers are the opportunity cost of time, health burden on carrying heavy loads, and safety of women and girls during trips to the water source (Blackden and Wodon, 2006; Malmberg-Calvo, 1994; Barwell, 1996). All these negative impacts derived from lack of access to piped water constitute welfare losses to households.

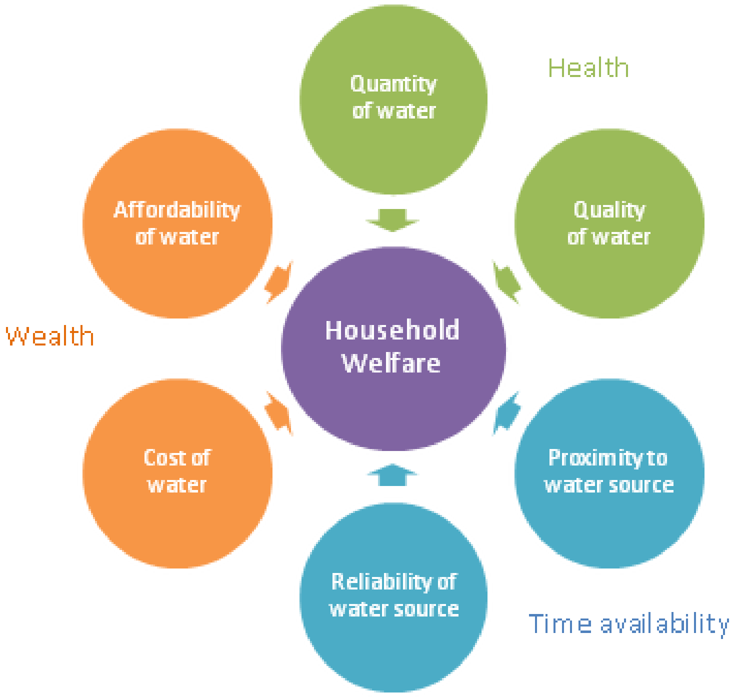
The impact evaluation literature in economics and epidemiology have so far mainly focused on health outcomes (Kremer et al., 2011; Fewtrell et al., 2005). Access to piped water reduces diarrhea incidence (Jalan and Ravallion, 2003) and decreases child mortality (Burström et al., 2005; Gamper-Rabindran et al., 2010). However, the decomposition of welfare gain and loss reveals that health might not be the only outcome affected. We suggest that more important dimensions such as time availability need to be considered as indicators of household wellbeing[3].

[3]Welfare and wellbeing are used interchangeably.

3 Conceptual Framework

Figure 1 depicts the conceptual framework used in this paper to demonstrate the three impact dimensions: health, wealth, and time.

Figure 1: Conceptual framework of the impact of access to water on household welfare



First, water provision affects household health depending on the quantity and quality of the water consumed. In terms of quantity, scarcity of water may lead to infectious diseases, caused by precarious hygiene standards. Quality of the water consumed at home is affected by two factors: quality at the source and management at the homestead. Microorganisms grow in standing water, and bad storage or exposure to the environment contaminates water. The consumption of contaminated water for drinking, cooking, bathing and washing food exposes people to water-borne diseases.[4] This is especially dangerous to individuals with a history of malnutrition and low immunity, common in low-income communities, and infants and children. UNICEF (2014) estimates more than 1,400 child deaths per day caused by diarrheal diseases, which are often caused by water contamination, lack of sanitation, and precarious hygiene. Water supply also directly affects human capital accumulation. Some evidence shows that lack of water and sanitation facilities in schools is a reason for school absenteeism, in extreme cases a reason for

[4] WHO (2008, p. 122) compiled a list of pathogens and their significance in the water supply.

teenage girls to drop out.[5]

Second, regarding impact on wealth, several studies have shown that non-piped water is expensive compared to piped water (Collignon, 1999; Hailu et al., 2011; Whittington et al., 1991). The commonly agreed affordability threshold determines that household water expenditure must not exceed three per cent of household income (UNDP, 2006). Therefore, a high rate of use from alternative small-scale non-piped water sources might reduce households' disposable income for consumption. In other words, a high unit price of water might trigger two effects: reduce the quantity of water consumed and/or reduce household consumption of other goods. Especially among the poor, the consumption trade-off between water and other goods is costly in terms of welfare, as most products consumed are essential goods.

Third, time availability of household members is affected by the distance to the water source. Time is also spent in queues at the water source to fill in the containers. Crowding at the source can be a substantial part of the total time spent on water collection, particularly in urban settlements. It depends on the size of population served by a water point, and by the water pressure at the tap. When households' time constraint is binding, they might switch time away from education, income-enhancing activities, or decrease leisure time. Hence, household income is also affected indirectly, as less time might be devoted to market work or human capital accumulation. A further issue that compromises time availability is the (non-) reliability of the service provision and frequent discontinuity of services.

4 Data and Empirical Strategy

4.1 Data

We apply the Welfare Loss Index to household survey data collected in Burkina Faso. The Water and Sanitation Household Survey in Burkina Faso was conducted in January 2012 by UNDP in collaboration with the Centre Régional pour l'Eau Potable et l'Assainissement (CREPA).[6] Data were collected on demographic profiles, access to water, access to sanitation, and household economic vulnerability in five poor communities in Ouagadougou. Interviews were conducted with the household heads or most informed adult household member present at the homestead at the time of the interview. Most questions were multiple-choice with opportunity for open answer if different from the

[5] http://www.unicef.org/wash/index_schools.html, http://www.wsp.org/Hygiene-Sanitation-Water-Toolkit/BasicPrinciples/GenderRoles.html and http://www.wateraid.org/$\sim $/media/Publications/school-wash.pdf, accessed on 14 May 2014.

[6] A more comprehensive description of the dataset can be found at the Data Appendix, section **??** in this thesis.

given options. Questions regarding water quantity, time use and consumption expenditure were open response. Interviews lasted on average 40 minutes per household.

The sampling method focused on the following: (i) identifying five communities on the outskirts of Ouagadougou (maximum 20 km from the center) with large concentration of low-income population and where drinking water facilities are precarious or not available; (ii) studying areas that include informal settlements and peri-urban areas; (iii) including communities that have benefited from an output based aid (OBA) project for improving piped water network distribution, having parts of the community not yet been benefited with the investment project; (iv) including communities that have not participated in output based aid projects.[7] We provide a description of these five communities in Appendix A.[8]

Households were randomly selected from two groups in each of the five communities: (i) households with piped water connection to the utility provider and water meter at the homestead; and (ii) households without piped connection, relying on alternative water sources. Based on an estimation of number of household in the communities, provided by the Atelier de Construction Metallique Génerale (partner of the water utility ONEA - Office National de l'Eau et de l'Assainissement), the sample size contained 12.5 percent of households in each community. In communities that participated in an OBA project, households were randomly selected from census lists of households that benefited from piped water and water meters. Each household with a water meter is identified by the meter's serial number, known by the water provider. For participation in the survey, serial numbers were selected randomly by lottery in each area where parts of the community have access to piped water.

The enumerators received a list of random numbers corresponding to the water meter or household to be interviewed. After the interview, the enumerator wrote the serial number of the water meter on the form and his enumerator code at the household's door. This would later allow verifying the visit of the enumerator agent at the correctly identified households. In the communities and parts of communities with no access to piped water, household randomization took place in the field, following a systematic counting or skip system[9] in order to select the households to be interviewed. Each enumerator

[7]The last two criteria fulfilled the interest in collecting data for a comparative study of infrastructure upgrading programs based on the financing OBA scheme.

[8]Since some communities were larger than our data collection capacity, we geographically partitioned two communities in half (Bissighin and Zongo) and one community in four parts (Toukin). We randomly selected only one part of each of these communities to be surveyed. The entire communities of Nioko II and Polsogo participated in the survey. The sampling frame is thus the total population in Nioko II and Polsogo, and the population living in the selected areas in the other communities.

[9]The survey began with a specific random number provided by the supervisor. The code, for example 2, was written on the door of a first random household interviewed, before leaving the family. The enumerator then adds a specific fixed value, given by the supervisor and generated according to the

received a well-defined limited area. The sample consists of 394 households living in the five communities (see Table 9 in Appendix A for details).[10]

Table 1 shows the demographic profile of households living in Bissighin, Nioko II, and Toukin, communities where piped water supply is available. Households using either piped water or alternative technology are on average similar in terms of household size: in 40 percent of households the head is a woman, the head is about 38 years old and has less than three years of education. Households differ in dwelling characteristics: those using alternative technology reside for a longer period in the community than those using piped water. A larger share of households using piped water, relative to those using an alternative water supply, owns the dwelling. But a lower share of these households live in improved, cemented-floor dwellings. Moreover, income levels of households using piped water are higher. Households with piped water live on average just above the poverty line, while those using alternative sources live a few dollars below it.

Table 1: Summary statistics of households' demographic profile, WSHS-Burkina Faso

	Piped water			**Alternative technology**		
Variable	**N**	**Mean**	**St.dev.**	**N**	**Mean**	**St.dev.**
years in the community*	124	5.6	4.323	123	8.2	5.423
household size	125	5.5	2.614	124	5.1	1.9
head is literate*	124	0.548	0.5	120	0.383	0.488
head's age	125	38.3	8.656	124	38.1	9.573
head education*	125	2.9	2.061	124	2.5	2.192
female head	125	0.04	0.197	124	0.04	.198
cemented floor*	125	0.584	0.495	124	0.863	0.345
own the dwelling*	125	0.912	0.284	124	0.839	0.369

Notes: Head education: years of education of the household head. (*) Between-group statistically significant difference. Source: UNDP Water and Sanitation Household Survey, 2012. Sample: OBA communities – Bissighin, Nioko II and Toukin. For detailed profile of the five communities, see Table 8 in the Appendix A.

Table 1 suggests that households in the two groups may not be identical. We observe statistically significant between-group differences in some demographic characteristics - years living in the community, literacy of the household head, head's education, cemented-floor dwelling and ownership of the dwelling. In order to isolate the causal effect of the water supply technology, making sure that differences in outcomes are not due to under-

household size and area under the enumerator's domain, for example 6, to the household code. That gives the next household code, in this case for example, 8. The next codes after household 8 would be: 14, 20, 26, and so on. The enumerator then walks throughout pre-determined paths according to a map counting and skipping households consecutively up to reaching the next selected household code. Following this, the supervisor knows exactly where each enumerator had held the interview.

[10]Note that some missing variables reduced the sample by a few households in the analysis.

lying differences in household characteristics, we must compare households that are in fact comparable. Hence, to infer the causal effect we use a matching estimator based on households' propensity score to use a given water supply technology. We match similar households in the two groups, resembling "twin" or "clone" households in terms of observables, i.e. households must have very similar demographic and socioeconomic profiles and differ only in the water supply technology.

Profile of water supply in Ouagadougou

The utility provider in Ouagadougou, L'ONEA, is a state company responsible for the collection, management, and distribution of drinking water for household and industrial consumption in urban and peri-urban areas.[11] The main water supply technology varies across communities. In the absence of piped water in the community, households in Polsogo rely exclusively on boreholes and wells. Zongo's dwellers rely on public taps and standpipes (85 percent) or wells and boreholes (15 percent). 81 percent of households in Nioko II rely on protected wells or boreholes.[12] Public taps or standpipes are seen as a better technology to wells and boreholes. Because the water from the utility provider is resold, the water is subject to a safer quality control. These can be privately owned or public (managed by the community), usually generating local employment. In Bissighin and Toukin communities, households without access to in-house piped water rely mostly on a public tap or standpipe: 69 percent and 87 percent of households, respectively. Only 6 percent of households in Bissighin declared using unimproved sources.

The main reason for not using piped water as the primary water supply technology is the deficient infrastructure network. Overall, among households not connected to the piped network, 57 percent declared not using piped water because of unavailability. The main reason varies also across communities (see Figure 2). Over 50 percent of households in Zongo and more than 70 percent of households in Nioko II and Polsogo complain about lack of availability of a piped system at the location of their houses. In Bissighin and Toukin, lack of access to piped water is related to the high connection fee. In three of the five communities, households chose a water supply based primarily on the shortest distance to the homestead.

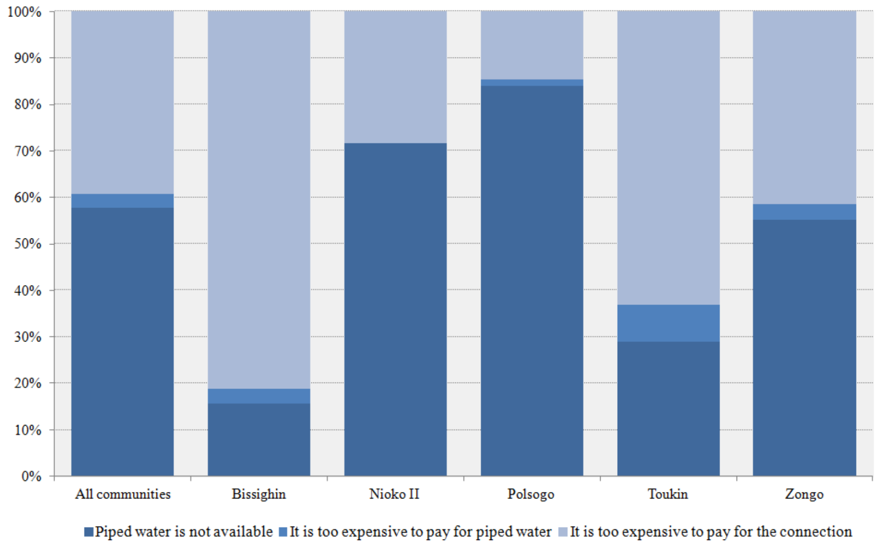
Over one-fifth (20.7 percent) of the surveyed households are water-poor (see Figure 3).[13] Water-poor households consume about half the amount of the average water con-

[11] The National Poverty Reduction Strategy Paper (2004) estimates that between 1998 and 2003 roughly 90 per cent of Burkinabe used dug wells, tube wells, and public taps. In-house piped water was available to just a minority of the population.

[12] Interestingly, about a decade ago, reselling water from private boreholes happened only on a seasonal basis in Ouagadougou (Collignon and Vézina, 2000).

[13] The WHO/UNICEF's Joint Monitoring Programme for Water and Sanitation recommends minimum 20 liters/day consumption for sustaining livelihood. Let us call water-poor a household with per capita

Figure 2: Main reason for households not being connected to a piped water network



Source: WSHS-Burkina Faso, 2012.

sumption per household as shown by the difference between the dashed and full lines in Figure 3. Households fall below the water poverty line by about 6 liters per capita per day, obtained by the difference between the poverty threshold (20 liters per capita per day) and the dashed line. Water deprivation happens both in households connected to piped water, as well as among those relying on alternative technologies. A desirable situation is a low share of water-deprived households (shorter bars in Figure 3), high water consumption level (high full line) and high water consumption among lower-consumption households (high dashed line), above the 20 liters per capita per day threshold. Polsogo is the community most similar to that, while Zongo is the most water-deprived.

Poverty measures such as the FGT index (Foster et al., 1984) can be useful for assessing the degree of household water deprivation.[14] When calculated for sub-groups, they uncover important differences in water consumption between households. Water poverty measures, P, can be obtained as:

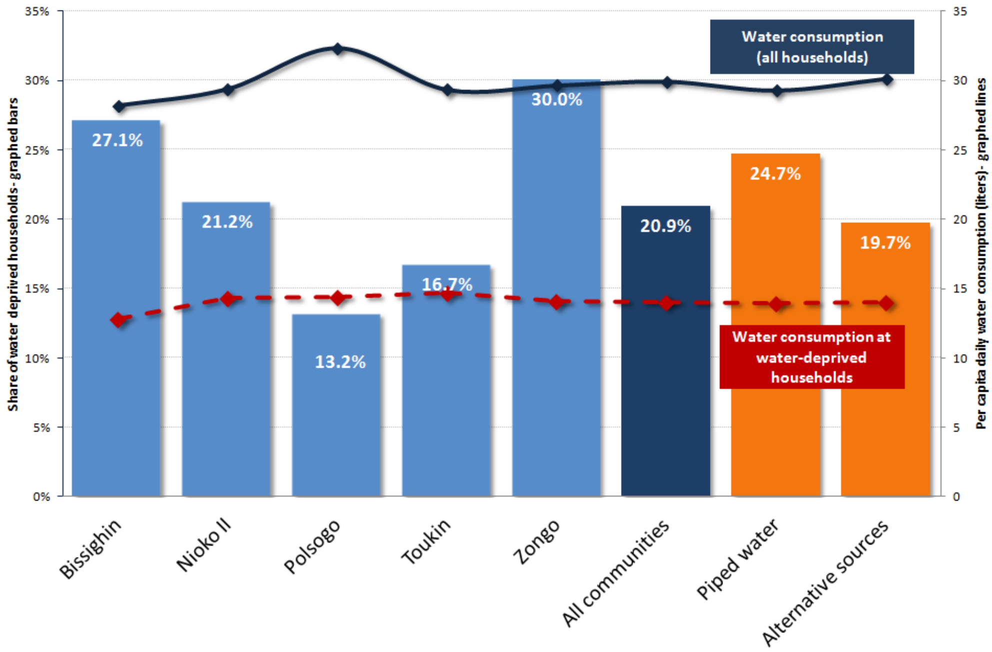
$$P_{\alpha}^{p,np} = \frac{1}{n}\sum_{i=1}^{q}(\frac{l - w_i}{l})^{\alpha} \tag{1}$$

where n is the population size, q is the number of water poor households, whose water consumption is no greater than the water poverty line, l, of 20 liters per capita/day.

consumption below this level.

[14] An assessment of poverty measures per community is not possible given the survey sample design. An exception is Polsogo and Zongo, for which estimates of poverty measures could be obtained for the community, but differentiating across groups is not possible since no households consuming piped water were found in those.

Figure 3: Average consumption and the incidence of water poverty in Ouagadougou



Source: WSHS-Burkina Faso, 2012.
Notes: Left-hand axis refers to the bars. Right-hand axis refers to the lines. (1) Unweighted to the population size in each community under piped water and alternative sources. Recall that the sample was built purposely consisting of 50 percent of households in each group (piped and not piped). The results for 'piped water' and 'alternative sources', however, need no weighting and can be interpreted as actual rates for those entire sub-populations; (2) Water poverty line: household per capita consumption of 20 liters of water per day.

w_i is the per capita water consumption of household i and α is the parameter of water poverty aversion. The superscripts p and np indexes the population groups according to the technology, piped and not piped respectively.

Given the sampling framework, we cannot assess water-poverty measures for each community or the entire population. Recall that our sample was constructed to have 50 percent of households connected to piped water and 50 percent relying on alternative technologies. These proportions do not necessarily reflect the actual proportions of households in each community. Therefore, we are limited to calculating poverty measures for each group within each community, and that is representative for the groups given the household randomization within groups.

Water poverty incidence, setting $\alpha = 0$ in Equation (1), shows that in the communities surveyed, 25 percent of households served with piped water consume below the water poverty line of 20 liters of water per capita per day, compared to 19 percent of households relying on alternative sources (see Table 2).

The water poverty gap (or severity), setting $\alpha = 1$, measures the average shortfall of water consumption among households consuming below the water poverty line. It assigns higher weight to those consuming further below the water poverty threshold. The poverty gap is interpreted in terms of the share of the water poverty line. Among households served by piped water, the water shortage falls on average 7.7 percent below the water poverty line. Among households relying on alternative technologies, the shortfall is on average 5.8 percent the poverty line.

Finally, water poverty depth or squared water poverty gap, analyzed by setting $\alpha = 2$, is a more sensitive measure of water deprivation. It complies with the transfer sensitivity axiom, which considers that transfers of a unit of water consumption from a water-poor household to a 'less' water-poor household (with slightly higher water consumption) would increase the poverty measure in smaller magnitudes.

Table 2: Water poverty incidence, poverty gap, and poverty depth in Ouagadougou

	Piped water (P_α^p)	**Alternative supply** (P_α^{np})
Water poverty incidence ($\alpha = 0$)	0.253	0.193
Water poverty gap ($\alpha = 1$)	0.077	0.058
Water poverty depth ($\alpha = 2$)	0.027	0.021

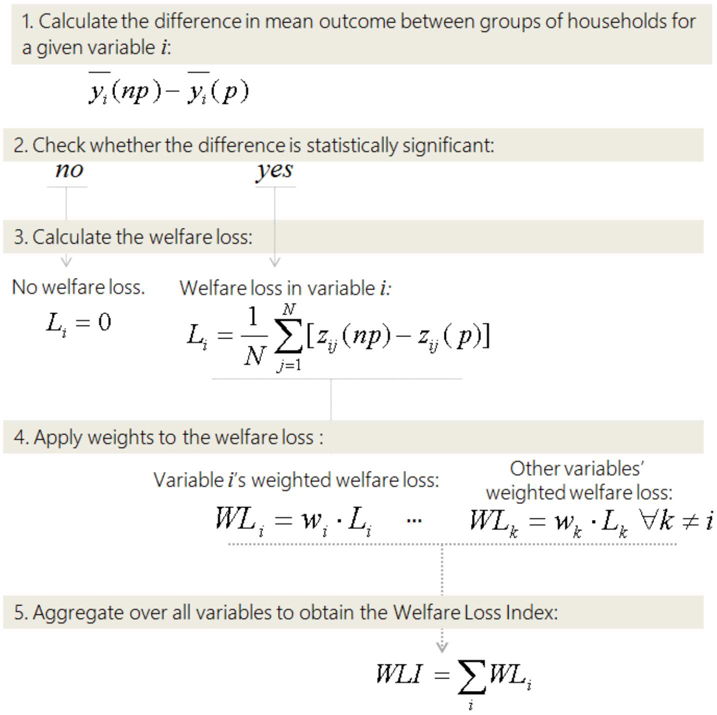
Source: Authors' calculations based on WHSH-Burkina Faso, 2012.

The water poverty analysis suggests that households relying on alternative water supply technologies other than a piped water supply are better off in these communities. This could be however misleading, as it ignores several other aspects of household welfare affected by water supply apart from quantity of consumption.

4.2 Welfare Loss Index

The welfare loss measure consists of a composite index that encompasses several dimensions and subdimensions of welfare. It is constituted in the following way (see Figure 4): (i) first, we analyze the difference in each outcome variable y_i across groups of households – with, p, and without, np, access to the piped water technology. We call this a loss, L_i in Figure 4. Note also that this could be a *gain*, depending on the sign of the difference. (ii) Then, we assign weights to the differences found in (i). If the difference is statistically significant, L_i is weighted according to that specific variable's weight, w_i, that is given in Table 3 and will be discussed below. We call this the weighted loss, WL_i in Figure 4. In case there is no significant difference, the welfare loss associated to that variable is null. (iii) Finally, we aggregate the weighted losses across dimensions (health, wealth and time) into a single index. The Welfare Loss Index – the overall household welfare loss associated with using the alternative water supply versus using piped water – is the sum of the variables' weighted losses (WL_i).

Figure 4: Five steps for the calculation of the Welfare Loss Index



Note: j indexes households, i indexes a variable, k indexes all other variables. L_j is the variable welfare loss, given by the difference between the normalized variables, z_i, of household with piped water, p, and no piped water, np. WL_i is the variable weighted loss, obtained using the variable weight w_i. Finally, the Welfare Loss Index, WLI, is the aggregated weighted losses across all variables.

We opted for weighting the dimensions of the composite index equally, i.e. assigning weights of 1/3 to health, wealth, and time availability, respectively. The literature, particularly on multidimensional poverty measurement, has discussed advantages and disadvantages of several alternative weighting schemes of composite indexes. Decancq and Lugo (2009) have identified eight approaches to set weights in such indexes, which follow from three classes: data-driven (frequency, statistical, most-favorable weighting schemes), normative (equal or arbitrary, expert opinion, price-based) and hybrid (self-stated, hedonic weights). All weighting schemes are, however, subject to some criticism. Data-driven approaches, from instance, draw weights from the distribution of achievements in a given population. The criticism is that this must not be confounded with the judgment or values of a "good-life", as it simply means what that population was able to achieve at a given moment in time, not necessarily the level that society considers as ideal. Normative approaches, on the other hand, are based on judgments of what the ideal should be. Their weakness is, however, on the definition of *whose* judgments and values should be taken into account to represent society. Finally, hybrid approaches, combining information on the actual distribution of achievements and individual valuations is another possibility for weighting. They are, however, subject to the same criticism of the former two approaches.

A way to overcome the above-mentioned criticisms is using a range of weights instead of a single-valued weight (Decancq and Lugo, 2009). This nevertheless implies having a composite index that takes a range of values, instead of a single number. In some cases, however, finding a single index is the objective – for instance, when the usefulness of the composite index lies in the ability to compare individuals or countries, as in the case of UNDP‘s Human Development Index, the Commitment to Development Index of the Center for Global Development, and the Index of Individual Living Conditions from the European System of Social Indicators, just to cite a few. Hence, some arbitrary decision on the weighting scheme must be made. Since the major goal of our empirical exercise is being able to compare different households with a single index, we use equal weights to each dimension of the index.

We acknowledge that setting weights uniformly as we do can be as arbitrary as defining some other ranking: it assumes perfect substitutability across the dimensions. And we also agree that there is no a priori reason to believe that substitutability is the same across the three dimensions of our index: health, wealth and time availability. We have, however, no indication that would support saying that health would be n-times more important than wealth or vice-versa, for instance, what could then justify a decision of setting different weights across dimensions in our index. We tried to be as parsimonious as possible.

Table 3 shows the dimensions and sub-dimensions of our welfare index, each consisting of different amounts of variables.[15] A variable's weight is defined so as to keep the dimensions at their original uniform distribution of weight: 1/3. In this sense, variable i's weight will depend on the amount of subdimensions in its dimension, and the number of variables in each subdimension. Hence, variable i's weight is obtained as:[16]

$$w_i = \frac{1}{d}\frac{1}{s_i}\frac{1}{n_i} \tag{2}$$

where d is the (fixed) number of dimensions (health, wealth and time), s is the number of sub-dimensions at a specific dimension and n_i stands for the number of variables in the subdimension to which variable i belongs. Hence, the sum of all weights across variables

[15] The welfare index can be generalized and adapted for the dataset in use. The weights for each variable must then be adjusted depending on the amount of information available for each dimension and subdimension.

[16] For example, the variable weight for "Average cost of 20 liters of water" is given by: $\frac{1}{d}\cdot\frac{1}{s_i}\cdot\frac{1}{n_i} = \frac{1}{3}\cdot\frac{1}{2}\cdot\frac{1}{1} = \frac{1}{6} = 0.16667$. This variable is a single variable in its sub-dimension, wealth-cost, $(n = 1)$, there are two sub-dimensions pertaining to the wealth dimension $(s = 2)$, and there are three dimensions in the index $(d = 3)$.

Table 3: The impact of water supply on household welfare: dimensions, variables, and weights

Dimension (d)	**Subdimension** (s)	**Variable** (n)	**Weight** (w)
Health	Quantity	Average per capita daily consumption of water (liters)	0.083
		Average shortfall in daily per capita water consumption among water deprived households (liters)	0.083
	Quality	Acceptability: perception of water quality regarding taste, cleanness, and safety as acceptable or excellent (dummy)	0.056
		Incidence of diarrhea to any household member in the previous month	0.056
		Age of the container used to store water at home (years)	0.056
Time availability	Proximity	Number of weekly round trips for water collection	0.083
		Hours per week spend on round trips for water collection	0.083
	Reliability	Share of households relying on two or more sources of drinking water	0.083
		Hours per day that water is available at the source	0.083
Wealth	Cost	Average cost of 20 liters of water	0.167
	Affordability	Household water expenditure is above 3 percent of income (dummy)	0.167
		Total	1.000

Source: Authors' elaboration.

is 1:

$$\sum_{i=1...n} w_i = 1 \tag{3}$$

The list of variables needs not to be fixed and it can be adjusted according to the dataset in hand. The only technical requirement is that weights are recalibrated accordingly. The dataset, however, must allow assessing each of the three dimensions, i.e. the dataset must contain at least one outcome variables covering each dimension: health, wealth, and time availability.

The first step is assessing the difference in outcomes across households in each group: piped water versus households relying on alternative supply. We normalize all variables in order to arrive at comparable units. It is essential that the units are comparable as the final index relies in the aggregation across variables, subdimensions and dimensions. Positive variables (when a higher level is desired) are normalized as below (see Table 8 in Appendix A for minimum and maximum values):

$$z_i^+ = \frac{x_i - x_{min}}{x_{max} - x_{min}}. \tag{4}$$

Negative variables (when reaching a lower level of the variable is desired, e.g. diarrhea incidence) are normalized as:

$$z_i^- = \frac{x_{max} - x_i}{x_{max} - x_{min}}. \quad (5)$$

The hypothesis is that piped water and alternative sources contribute equally to the welfare of households. That is, if two households are similar in terms of all characteristics and differ only in the type of water supply, households using either type of water supply should have similar mean values for any variables. A significant difference in water-related outcomes between these households can be attributed to a different contribution of the water provision to welfare. In other words, if we observe a difference in average outcome levels in households that are similar in observable characteristics apart from water supply, there is a welfare loss associated with using a particular water supply technology versus the other.

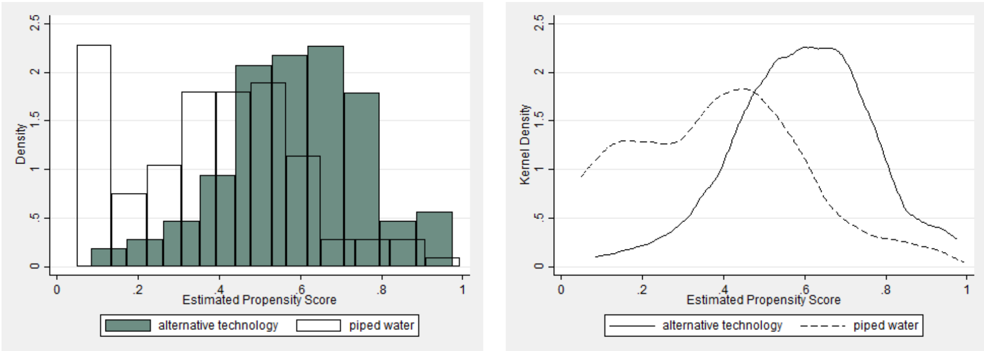
The water supply that provides the highest welfare level is identified as that which gives a better level for each variable. For instance, if diarrhea incidence is lower among households connected to piped water, for that specific variable we know that piped water technology is superior to alternative water sources. An empirical identification can capture the actual impact of a technology on peoples' wellbeing, avoiding preconceived judgments from an outsider.

4.3 Propensity score matching

One could argue that households living in the same community are more likely to be similar to each other (even though they might use different water supply sources) than households living in different communities. On the other hand, a large sample might increase the chance of finding a better match for any household. Hence, the analysis is done at different levels and all results are provided: (i) at the community level – households are matched with other households within the same community; (ii) OBA communities only, excluding the two communities where no household had access to piped water; and (iii) the full sample – households are matched to similar households using the entire sample.

Households are paired across groups based on their propensity to use piped and alternative water sources. The propensity score is estimated on the set of covariates in Table 1, using the standard algorithm of a probit regression model. The optimal number of blocks, as seen in Figure 5, left panel, is defined as the one to ensure that households have the same propensity score within the block and the distribution of observable variables is the same within each block (balancing property). The balancing property was satisfied for all optimal blocks designated by the algorithm. The common support region (for the sample of OBA communities) spans from 0.084 to 0.976, which means that for almost the entire distribution of propensity scores (with exception to the very lower tail) we do find observations in each group - treated and non-treated. The sample after matching is composed of 119 households in the treatment group (alternative technology) and 114 households in the control group (piped water), recalling that all these households live in the OBA communities Bissighin, Nioko II or Toukin, and thus some 10 observations were not matched, and excluded from the analysis.

Figure 5: Histogram and kernel densities of propensity scores for using alternative water supply



Source: WSHS-Burkina Faso, 2012. Sample: OBA communities – Bissighin, Nioko II and Toukin.
Note: Households in the treatment group use alternative technology, the control group uses piped water.

The welfare loss for variable i of using alternative versus piped water, L_i, is estimated using a nearest neighbor matching (Abadie et al., 2004; Imbens, 2004), implemented by the nnmatch routine in Stata. It proceeds as follows: the treatment variable is the alternative water supply technology.[17] For each household i in either outcome $z_{ij}(np)$ (normalized outcome of variable i when household j uses alternative water supply) or $z_{ij}(p)$ (normalized outcome of variable i when household j uses piped water) is observed, but not both. For each variable i and for each observation j, we would estimate the difference $z_{ij}(np) - z_{ij}(p)$. Since one of the two is not observed, the nearest neighbor matching technique finds in the opposite group a household very similar to i in terms of the propensity score and the outcomes of that matched household are used as the unobserved outcomes for individual j. In case there is more than one match for a given household, their average outcome is used as the unobserved outcome for j. Thus, the estimation of welfare loss of an individual variable i is given by:

$$L_i = \frac{1}{N}\sum_{j=1}^{N}[z_{ij}(np) - z_{ij}(p)] \;\; \forall i = 1, ..., n \; and \; \forall j = 1, ..., N \quad (6)$$

[17]Since we are interested in welfare loss, we consider alternative water supply as the treatment, thus households using piped water are the control group. Were the treatment assigned in the opposite direction, for instance if 'piped water' was our considered treatment, the sign of the coefficients would be inverted without changes in coefficient magnitude.

5 Results

Table 4 provides an overview of mean household outcomes across groups. There is already an indication of difference between households using piped water and alternative sources in terms of time availability and cost.

Table 4: Summary statistics of variables across treatment and control groups

	Alternative supply					Piped water				
Variable	N	Mean	St.dev.	Min	Max	N	Mean	St.dev.	Min	Max
Per capita water consumption	119	28.97	12.78	8	70	81	29.28	17.81	10	120
Water shortage	22	6.25	3.27	2.22	12	20	5.87	2.56	2.86	10
Acceptability rate[1]	119	0.89	0.31	0	1	123	0.99	0.09	0	1
Diarrhea incidence	119	0.19	0.40	0	1	123	0.24	0.43	0	1
Container age (years)	119	3.79	4.08	0.17	25	66	2.875	2.27	0.083	10
Frequency of water collection (trips/week)	114	8.56	7.50	1	60	59	0	0	0	0
Time collecting water (min/week)[3]	114	23.35	49.94	0.033	420	59	0	0	0	0
Rely on secondary source	119	0.40	0.49	0	1	123	0	0	0	0
Water availability at the source (hours/day)	118	11.48	2.87	2	24	123	23.28	3.78	0	24
Cost of 20 liters of water (USD)	118	0.021	0.008	0	0.049	123	0.007	0.001	0.007	0.017
Non affordability[2]	118	0.059	0.24	0	1	121	.099	.300	0	1

Note: (1) Self perception regarding water taste, cleanness and safety. (2) More than three percent of household income is spent on water. (3) In the regressions, we use the variable in hours/week. Source: WSHS-Burkina Faso, 2012. Sample: OBA communities – Bissighin, Nioko II and Toukin.

The welfare loss associated with relying on alternative sources of water supply is up to 12 percent in the surveyed communities. Table 5 reports the contribution of each variable to the household welfare loss. Household time availability is the most affected dimension, followed by wealth. Health is affected in terms of water quality only. While one would expect that access to piped water at the homestead would increase water consumption since the resource is readily available, no significant difference in quantity of consumption was found between households using piped or alternative water supplies. This suggests that water is indeed an essential commodity with quite inelastic demand. In the following we examine the impact of water supply on each dimension of welfare.

Table 6 provides robustness checks. The upper line is the reference, reproducing the average treatment effects, matching on the nearest neighbor, for the sample of OBA communities as in Table 5. We also estimated (i) ATE using a set of covariates instead of the propensity score (second line) and used (ii) five closest neighbors instead of only the nearest (third line). The results are robust. Finally, the two lines of results in the bottom show the average treatment effect on the treated (households using alternative source) and average treatment on the control group (households using piped water). These results are also robust, with different effects observed in acceptability rate across groups.

Table 5: Average treatment effects and welfare loss decomposition

	Health					Time availability				Wealth		
	Per capita water consumption	Water shortage	Acceptability rate	Diarrhea incidence	Container usage	Frequency of water collection	Time collecting water	Secondary source	Hours of supply	Water price	Affordability rate	WLI
Weights	0.083	0.083	0.056	0.056	0.056	0.083	0.083	0.083	0.083	0.167	0.167	
ATE												
OBA communities	0.003	0.019	-0.116**	-0.008	0.006	-0.141***	-0.052***	-0.483***	-0.496***	-0.102***	0.042	
Bissighin only	0.084	0.308	-0.045	-0.076	-0.107	-0.131*	-0.052	-0.318*	-0.473***	-0.066**	0.031	
Nioko II only	-0.020	0.001	-0.152**	0.043	0.004	-0.133***	-0.053***	-0.511***	-0.461***	-0.090***	0.1	
Toukin only	-0.023	-0.352	0.000	0.086	0.056	-0.135***	-0.030***	-0.519***	-0.550***	-0.141***	0.074	
All communities	-0.001	-0.048	-0.143***	-0.055	0.028	-0.138***	-0.053***	-0.296***	-0.527***	-0.091***	0.045	
Welfare Loss												
OBA communities	0	0	-0.006	0	0	-0.012	-0.004	-0.040	-0.041	-0.017	0	-0.121
Bissighin only	0	0	0	0	0	-0.011	0	-0.027	-0.039	-0.011	0	-0.088
Nioko II only	0	0	-0.008	0	0	-0.011	-0.004	-0.043	-0.038	-0.015	0	-0.120
Toukin only	0	0	0	0	0	-0.011	-0.003	-0.043	-0.046	-0.024	0	-0.126
All communities	0	0	-0.008	0	0	-0.012	-0.004	-0.025	-0.044	-0.015	0	-0.108

Note: ATE - average treatment effect. Nearest neighbor matching based on the propensity score of being treated. OBA (output based aid) communities include Bissighin, Nioko II and Toukin communities only. *All communities* includes also households in Polsogo and Zongo in the treatment group. Variable definitions: *per capita water consumption* is the average daily per capita consumption of water in liters. *Water shortage*: average shortfall in daily per capita water consumption among water deprived households (liters). *Acceptability rate* is a dummy of perception of water quality regarding taste, cleanness and safety as acceptable or excellent. *Diarrhea incidence* is the incidence of diarrhea to any household member in the previous month period. *Container usage* is the age (in years) of the water container used to store water at home. *Frequency of water collection* is the number of weekly round trips for water collection. *Time collecting water* is the hours per week spent on round trips for water collection. *Secondary sources* is the share of households that rely on two or more sources of drinking water. *Hours of supply* captures the hours per day that water is available at the source. *Water price* is the average cost of 20 liters of water. *Affordability rate* is a dummy whether the household spends more than 3 percent of income on water. * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Source: WSHS-Burkina Faso, 2012.

Table 6: Robustness checks of treatment effects

	Per capita water consumption	Water shortage	Acceptability rate	Diarrhea incidence	Container usage	Frequency of water collection	Time collecting water	Secondary source	Hours of supply	Water price	Affordability rate
ATE	0.003	0.019	-0.116**	-0.008	0.006	-0.141***	-0.052***	-0.483***	-0.496***	-0.102***	0.042
(nnmatch on pscore)	(0.03)	(0.14)	(0.05)	(0.08)	(0.03)	(0.02)	(0.02)	(0.07)	(0.03)	(0.01)	(0.05)
Robustness checks:											
ATE	-0.013	-0.053	-0.104**	0.060	-0.027	-0.124***	-0.049***	-0.340***	-0.481***	-0.117***	0.059
(nnmatch on covariates)	(0.02)	(0.12)	(0.04)	(0.07)	(0.03)	(0.02)	(0.02)	(0.06)	(0.02)	(0.01)	(0.05)
ATE	-0.011	-0.048	-0.130***	-0.005	-0.019	-0.138***	-0.053***	-0.447***	-0.481***	-0.103***	0.081*
(5 neighbors, match on pscore)	(0.02)	(0.10)	(0.04)	(0.06)	(0.03)	(0.02)	(0.02)	(0.06)	(0.02)	(0.01)	(0.05)
ATT	-0.015	-0.104	-0.076	-0.042	0.016	-0.143***	-0.056**	-0.403***	-0.494***	-0.112***	0.025
(nearest neighbor, match on pscore)	(0.03)	(0.13)	(0.06)	(0.09)	(0.04)	(0.02)	(0.02)	(0.08)	(0.03)	(0.01)	(0.06)
ATC	0.030	0.155	-0.154**	0.024	-0.013	-0.137***	-0.046***	-0.561***	-0.497***	-0.093***	0.058
(nearest neighbor, match on pscore)	(0.04)	(0.21)	(0.06)	(0.10)	(0.03)	(0.02)	(0.02)	(0.08)	(0.04)	(0.01)	(0.06)

Note: ATT - average treatment on the treated, ATC - average treatment on the control. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.
Source: WSHS-Burkina Faso, 2012. Sample: OBA communities – Bissighin, Nioko II and Toukin.

5.5.1 Impact on health

The two health sub-dimensions that could potentially be affected are the quantity and quality of water consumption. The results in Table 5 (left panel) show no significant difference in per capita water consumption and water shortage between households connected to piped water and those relying on alternative sources. Among households suffering water deprivation, shortage is on average 6 liters per capita per day in both groups of households (see Table 4).

On average, the use of alternative sources of water is associated with 11.6 percent lower chance of having access to good quality water. Overall, 99 percent of households using piped water classified their drinking water as either 'excellent' or 'acceptable', versus 85 percent of those relying on alternative supply (see Table 7). Households have rated quality based on perception and acceptability (taste, cleanness, and safety) using a scale from 1 ('very poor') to 4 ('excellent').[18] About 98 percent of consumers of public taps or standpipes considered the quality of water at least acceptable, compared to only 15 percent of consumers using protected boreholes and wells. Since water from public taps and standpipes would mostly come from the utility network, it is possible that water quality at these sales points could compare to the quality of piped water at the homestead. Water from boreholes and wells, on the other hand, may vary widely in quality.

Table 7: Household perception of water quality in Ouagadougou

		Alternative technology		
Water quality	**Piped water**	**Public tap or standpipe**	**Protected well or borehole**	**Average alternative**
very poor	0	0	0.7	0.4
poor	0.8	1.7	23.5	14.2
acceptable	78.0	79.3	74.3	76.0
excellent	21.1	19.0	1.5	9.4
n	123	116	136	254

Note: Water quality measured by the household perception of taste, cleanness and safety of water. Percent of households. Source: WSHS-Burkina Faso, 2012.

There seems to be no specific effect of the water supply technology on the incidence of water-related diseases in these communities. There is a high incidence of diarrhea among both households using piped water and households using alternative sources. Twenty-four percent of households using piped water and 19 percent of households relying on

[18] Most sophisticated methods to test quality of water use laboratory or testing kits for microbial, chemical, and organic concentration. Unfortunately the survey could not use these techniques. One implication is that households could possibly be misled towards accepting a clear-looking but contaminated water. For that reason we also assess diarrhea incidence among household members.

alternative sources reported that at least one member had diarrhea during the past 4 weeks. This is an indication of the low quality standard of water in these communities, in spite of the generally good perception of households.

Water handling and storage is probably the main source of water contamination. Eighty-eight percent of households in the sample use a container (jerry can type) to fetch or store water (all households not connected to piped water and about 65 percent of those served with piped water). Proper hygiene and container maintenance are fundamental for avoiding contamination. As containers get older, they may develop leakages, get grimy or lose the cover lid. In the communities surveyed, containers have been used for more than 2.5 years on average.

5.5.2 Impact on wealth

Piped water is the cheapest water source in Ouagadougou. The unit price of piped water is constant across communities: US$ 0.007 per 20 liters. It costs less than one cent per day to supply a person with the minimum water requirement, if piped water is available. Alternative technologies are two to three times more expensive: the average price per 20 liters of water for households relying on public tap or standpipe is USD 0.024, and USD 0.015 for those relying on protected well or boreholes.[19] Using alternative water supply sources is thus associated with lower welfare through higher water prices.

The standard affordability threshold determines that no household should spend above three percent of total household income on water (UNDP, 2006). About 9.9 percent of households using piped water spend more than the affordability threshold, compared to only 5.9 percent of households using alternative sources. While piped water is cheaper for piped water users, the affordability problem is more frequent among them. Possible explanations are that they consume slightly larger quantities, there are differences in income between the two groups, or billing is better enforced by the utility company. The overall effect of using one or another source, however, is not a determinant factor of affordability (see Table 5, right panel).

5.5.3 Impact on time availability

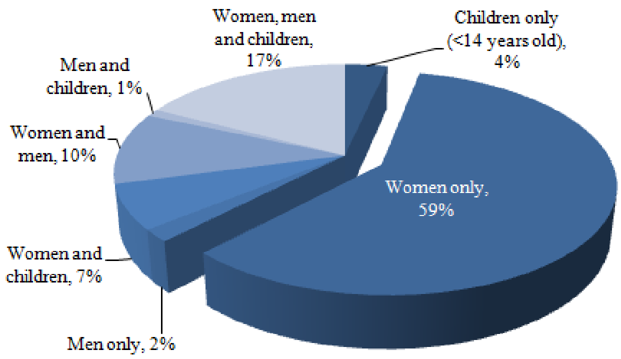
All households not connected to a piped network spend time collecting water. On average, households make eight round trips per week to the water source. This varies with household size, as larger families consume larger quantities. Table 5 (central panel) shows a significant effect of the water supply technology on the frequency of water collection,

[19] Average price declared by households at the WSHS - Burkina Faso 2012. Conversion rate at 20 January 2012: 1.00USD=506.88CFA.

time spent on the activity, and also the reliability on a secondary water source. Using piped water is associated with a 14.1 percent lower frequency, and about 5.2 percent less time spent on water collection. Table 4 estimates that the economic cost associated with not having piped water is equivalent to a ‘loss’ in productive hours of about 23 work hours per week per household. This is comparable to half of a monthly wage for an employed household member. Considering the income level and poverty status of households, this is a significant loss.

Preferred secondary sources in the communities surveyed are public taps or standpipes (50.7 percent) and protected tube wells or boreholes (43.5 percent). Both require time spent on collecting and storing water. Some 5.8 percent of households rely on unsafe water sources as a secondary source. Indeed it could be expected that access to piped water would confer higher reliability, in case the service continuity is assured. In fact, using an alternative water supply is associated with half the average hours of supply than piped service. Thus, there is a large welfare loss by using alternative water supply regarding time availability of households. We also find a noticeable disproportionate workload on women: water collection is exclusively a woman’s chore in 59 percent of households (see Figure 6).

Figure 6: Intrahousehold division of labor: share of household members by age and gender group responsible for water collection in the household



Source: WSHS-Burkina Faso, 2012.

6 Concluding Remarks

We find that water provision that accrues the highest contribution to household welfare is piped water at the homestead. The welfare loss associated with relying on an alternative water supply is about 12 percent in Burkina Faso's capital Ouagadougou and the areas we carried out the survey. Our analysis finds that the type of water supply sources does not significantly affect the quantity of water consumed. Regarding quality, the results are not conclusive: even though households using piped water perceive it to be safer, the incidence of diarrhea in these households is higher among them.

We analyzed how the unit price of water differs across sources of supply and how that impacts the affordability to households. The proportion of households with problems in affordability is high for both households with piped water and those relying on alternative sources. Interestingly, despite prices being much higher in the secondary market, affordability rates are a little better among those relying on alternative sources.

We find that the major gains accrued from access to piped water are related to time availability of household members and an income effect on wealth (disposable income for consumption). When households engage in fetching water outside the homestead, the time available for income-generating activities is significantly reduced. We estimate an income loss on average of 23 hours per week, in poor urban households in Ouagadougou.

There is a concern that utility companies would be less flexible than private providers in keeping constant supply when the household faces a temporary negative income shock (Hailu and Tsukada, 2011). This seems not the case in Burkina Faso. The most frequent coping strategy used by households when facing a water constraint situation is to ask for water from a neighbor. This highlights the importance of social networks in these communities; water lending is an important informal insurance mechanism (adopted 40 percent of time by households). The second most frequent coping strategy is to buy water of lower quality and to decrease the amount of water consumed. These call attention to a health threat caused by temporary water constraints. If water of lower quality is contaminated, the adverse effects on health (diseases) might last longer than the water constraint episode itself.

The results suggest that there is room for policy interventions in at least four areas in order to minimize the welfare loss of households that are not connected to a pipe water network: (i) improving proximity and regulating reliability (enforcing good water pressure in public standpipes and decreasing the ratio of water source to population in order to decrease waiting and collection time, guaranteeing continuity of services, and/or minimum hours of continuous service, for example regulating opening and closing hours of public standpipes); (ii) increasing awareness about water safety and hygiene practices among households using piped water; iii) regulating quality by setting up minimum quality standards and monitoring private providers; (iv) introducing water safety nets to protect vulnerable households during income declines and poverty spells; (v) improving the bargaining power of women through empowerment to improve sharing and time allocation of household members; and (vi) ensuring affordability especially for the poorest population, through for instance cross subsidies, social tariffs, or other transfer mechanisms.

There are several avenues for further research about the impact of water supply interventions on household welfare. The framework presented here treated households as unitary decision makers. However, water collection is a highly specialized activity in developing countries (mostly performed by women). There are reasons to believe that access to piped water technology would trigger intrahousehold resource allocation effects. All of these might have different impacts on different individuals within the household, which suggests individual-based welfare analysis of water infrastructure interventions.

A Appendix: Profile of the communities surveyed

This Appendix provides the profile of the communities surveyed by UNDP's Water and Sanitation Survey - Burkina Faso, and a table of information on the sample according to the survey design.

Bissighin is a suburban area in the district of Sig-Nonghin. It is located in the north-west of Ouagadougou, about 15 km from the city center. The population density is about 79 inhabitants/km^2. Residents complain about water price. Small businesses for instance pay as much as 400 CFA for 200 liter of water (January 2012 figures). The community reports that in order to assure water, women must leave jerricans at night at the water collection point, to be sure that they will have water quickly in the morning. Sometimes, however, jerricans are stolen overnight.

Nioko II is a suburban area in the district of Nongremassom. It is located in the East of Ouagadougou, about 15 km from the city center. The population density is about 27 inhabitants/km^2. The community complains that lack of water hampered many income-generating activities such as farming. Water availability is so low that animals can only be given a drink once a day.

Polsogo is an informal settlement in the district of Nongremassom. It is located in the North of Ouagadougou, about 10 km from the city center. According a survey presented at the AIMF (International Association of Francophone Mayors) training workshop in 2012, the village had 12 boreholes, seven of them broken. Five boreholes served the entire population, forcing most families to commute to Ouagadougou to collect drinking water from public standpipes. Some people resell water from these standpipes to households in Polsogo for a high price. As water is very expensive, several households prefer to collect water from non-protected sources during the rainy season.

Toukin is a suburban area in the district of Nongremassom. It is located in the North of Ouagadougou, about 8 km from the city center. Population density is about 146 inhabitants/km^2. Inhabitants with no access to piped water declare having to commute 5 km to fetch water from a public standpipe, even at night after work. Residents state that women often need to collect water as early as 4 a.m. for children's morning bath before school.

Zongo is a suburban area in the district of Boulmiougou. It is located in the west of Ouagadougou, about 8 km from the city center. The population density is about 44 inhabitants/km^2. It is one of the four villages of the district of Boulmiougou. There are not enough water points. Residents complain that frequent arguments among the public are observed around the water points.

Table 8: Demographic profile of households by water supply and community, Ouagadougou

Community	Years in community	Household size	Head literate	Head age	Head education[1]	Female head	Floor[2]	Owner	Income per capita	Income in a typical month
Households using piped water										
total	5.64	5.47	.548	38.3	2.94	.04	.584	.912	34	161
min	1	1	0	0	0	0	0	0	2.71	10.9
max	33	16	1	63	7	1	1	1	158	368
Bissighin	4.79	6.32	.353	40.6	2.18	.0882	.5	.882	30.1	166
Nioko II	5.43	4.78	.667	35.9	3.37	0	.735	.898	37.4	158
Toukin	6.55	5.6	.571	39.2	3.07	.0476	.476	.952	33.2	160
Households using alternative supply										
total	9.6	5.15	.375	38.7	2.23	.0595	.896	.851	22.1	108
min	0	2	0	0	0	0	0	0	2.65	16.8
max	67	15	1	75	9	1	1	1	132	643
Bissighin	9.52	5.27	.273	39.7	1.73	.0303	.879	.879	23.1	104
Nioko II	6.94	4.86	.417	37.2	3	.0612	.816	.837	20.8	93.9
Toukin	8.62	5.33	.436	38	2.48	.0238	.905	.81	21.2	113
Polsogo	14	5.04	.364	38.6	2.16	.0741	.889	.889	23.8	116
Zongo	6.69	5.34	.371	40	1.84	.0781	.969	.828	21.1	107

Source: WSHS-Burkina Faso, 2012. Notes: (1) Head years of education. (2) Dummy if cemented floor.

Table 9: Survey design by community and water supply technology

Community	Pop.[1]	Households[2]	Participated in OBA project?	Ideal sample size (12.5% of hh)	Sampling frame (prop. community)	Effective household sample		
						Total	Piped water	Alternative supply
Bissighin	6,426	1,071	yes	134	1/2	67	34	33
Nioko II	4,172	780	yes	98	1	98	49	49
Toukin	18,727	2,687	yes	336	1/4	84	42	42
Polsogo	5,178	647	no	81	1	81	0	81
Zongo	5,812	1,025	no	128	1/2	64	0	64
Total	40,315	6,210		776		394	125	269

Source: WSHS-Burkina Faso, 2012.
Notes: (1) RGPH: Recensement Général de la Population et de l'Habitat, Institut National de la Statistique et de la Démographie, 2006. (2) ACMD: Atelier de Construction Metallique Génerale (Partenaire de l'ONEA). (3) ONEA: Office National de l'Eau et de l'Assainissement, 2010.

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