Measuring water affordability in developed economies : the added value of a needs-based approach

Measuring water affordability in developed economies. The added value of a needs-based approach.

JOSEFINE VANHILLE[*], TIM GOEDEMÉ[*], TESS PENNE[*], LEEN VAN THIELEN[‡], BÉRÉNICE STORMS[‡]

*Herman Deleeck Centre for Social Policy

‡ Belgian Centre for Budget Advice and Budget Research

Abstract

In developed countries, water affordability problems remain up on the agenda as the increasing financial costs of water services can impede the realisation of an equal access to water. More than ever, public authorities that define water tariffs face the challenge of reconciling environmental and cost recovery objectives with equity and financial accessibility for all. Indicators of water affordability can be helpful in this regard. Conventional affordability indicators often rely on the actual amount that households spend on water use. In contrast, we propose a needs-based indicator that measures the risk of being unable to afford the amount of water necessary to fulfill essential needs, i.e. needs that should be fulfilled for adequate participation in society. In this paper we set forth the methodological choices inherent to constructing a needs-based affordability indicator. Using a micro-dataset on household in Flanders (Belgium), we compare its results with the outcomes of a more common actual expenses-indicator. The paper illustrates how the constructed needs-based indicator can complement existing affordability indicators, and its capacity to reveal important risk groups.

Key words: water affordability, reference budgets, basic needs, adequate social participation, affordability indicator.

Highlights:

- within a context of increasing pressure on limited environmental resources, water pricing policies that ensure equity principles become increasingly important;
- it is possible to develop needs-based indicators of affordability risks, i.e. indicators that assess whether households can afford a minimum necessary volume of water;
- a needs-based affordability indicator reveals different risk groups in the population compared to the more commonly used affordability indicators based on actual water expenses.

Acknowledgement: We thank Ellen Wailly for her helpful advice and Pascale Geulleaume for her attentive examination of the final text. We have received useful feedback from the participants of a seminar at the University of Antwerp (February 2016) on an early version of

this paper, and gratefully acknowledge three anonymous reviewers for their valuable comments and suggestions. This research benefitted from a study grant by the Flemish Environment Agency (Vlaamse Milieumaatschappij – VMM).

Corresponding author: Josefine Vanhille

Principal investigator: Tim Goedemé

1. Introduction

Equal access to drinking water and sanitation of good quality is explicitly recognized as a human right by the United Nations (2010). In this context, the importance of an affordable and fair water tariff, including for socioeconomically disadvantaged groups, was emphasised[1] (United Nations, 2003). In developed countries, a non-negligible group of households experiences limited access to drinking water and sanitation due to affordability problems rather than infrastructural inaccessibility. This manifests itself through self-restraint or, more visibly, as arrears, debts, and discontinued supply (e.g. García-Valiñas et al., 2010a; OECD, 2003, Mack & Wrase, 2017).

Guarding the affordability objective in water pricing policy is not straightforward. On the one hand water is identified as an economical and scarce good whose price should reflect 'full cost recovery'. On the other hand, adequate water-related services (safe drinking water provision and adequate wastewater treatment) are proven to be beneficial for the well-being and health of society as a whole. The latter classification of water as a 'merit good', advocates for a certain price regulation or government subsidization, ensuring affordable access to basic water services for all (OECD, 2003; Opschoor, 2006). Thus, (semi-) public water regulators face the exercise of designing water tariff structures that reconcile environmental and cost recovery objectives with equity principles, avoiding real affordability problems while maintaining sufficiently strong incentives for rational water use. In order to evaluate the equity effects of different sorts of water tariffs, a sound definition and measure of 'affordability' is essential.

Notwithstanding extensive research on water affordability both in developing and developed countries, most empirical studies focus on actual consumption patterns while lacking a theoretical concept of how much water use is deemed necessary to fulfill essential needs in a

[1] "Any payment for water services has to be based on the principle of equity, ensuring that these services, whether privately or publicly provided, are affordable for all, including socially disadvantaged groups." (United Nations, 2003; paragraph 27)

given societal context. With this article we want to contribute to the knowledge and measurement of water affordability by proposing a needs-based indicator that is based on reference budgets. While a normative, explicit account of what constitutes a minimally necessary consumption level exists in areas such as housing, energy and food (Boardman, 2010; Haffner & Heylen, 2011; Wong et al., 2011), few studies on water affordability have engaged with this exercise. Reference budgets are priced baskets of goods and services that illustrate the minimum needs of specific household types to attain adequate living standards (cf. Goedemé, Storms, Penne, et al., 2015). The reference budget method, often used in research on the affordability of essential goods and services, defines 'affordability' as households' ability to afford a specific good or service without being forced to under-consume other essential goods and services (e.g. Carruthers, Dick, & Saurkar, 2005; Haffner & Heylen, 2011; Hulchanski, 1995; Moore, 2012; Stone, 2006; Whitehead, 1991). We contend that this indicator is an essential complement to the usual indicators based on observed expenditure patterns and demonstrate its added-value with an empirical assessment of water affordability in Flanders. Although a relatively rich region in Europe, water affordability is prominently present on the policy agenda due to the steady and continued rise in the number of households with payment problems or for whom these problems have led to being cut-off from the water supply network (SERV, 2014; VMM, 2016).

In what follows, we discuss the literature and argue for a needs-based approach to complement conventional expense-indicators. After delineating the reference budget methodology applied to water use in Flanders, we describe the methodological choices inherent to constructing a needs-based affordability indicator. Subsequently, we compare the results of an affordability indicator based on a needs-based cost concept with the outcomes of an actual expenses-indicator in the Flemish context. This allows us to illustrate how a needs-based cost indicator can complement existing affordability indicators, and can reveal different risk groups. In the final sections we briefly summarise the strengths and weaknesses of our approach, and conclude.

2. Literature review

Water affordability is generally defined as 'the ability to pay for water consumption required to fulfill all basic needs' (Miniaci, Scarpa, & Valbonesi, 2008; Smets, 2008). This definition is exclusively concerned with the water needed for the fulfillment of basic needs. At the same

time, the ability to pay is also determined by the structure and components of the water bill (e.g. inclusion of wastewater services, existence of social tariffs), financial capacities of households, the cost of other essential goods and services and the social context. Despite the general emphasis on necessities, most empirical studies do not start from a needs-based concept of 'essential water usage'. While a range of indicators for measuring affordability have been developed for varying contexts (Hutton, 2012; Mack & Wrase, 2017), estimating the percentage of households for which expenses on water as a share of total household income or expenditure exceed a pre-defined threshold, came to be the conventional way to assess affordability risk (Smets, 2008, 2009; OECD 2003; García-Valiñas et al., 2010a, 2010b; Lee, 2011; Miniaci et al., 2008).

However, actual water expenses do not necessarily reflect household needs. Indeed, high water expenses can be the result of 'excessive' use such as a private pool, or reflect uneconomical or inefficient use, for instance due to old-fashioned suboptimal water infrastructure (OECD, 2003). Likewise, low water expenses could be the result of consuming less than needed due to budget constraints. The latter indicates a 'hidden' problem of affordability that cannot be revealed when using actual consumption in the affordability equation.

To avoid that affluent households with high water consumption appear in the affordability statistics, one could restrict the sample to the bottom of the income distribution (e.g. Smets, 2008), or evaluate whether income after water expenses falls below the poverty threshold (e.g. Miniaci et al., 2008). In contrast, we contend that focusing on the affordability of a pre-defined level of water expenses that allows to fulfill a predetermined set of needs, instead of actual expenses, offers an important complementary approach. In doing so, one could automatically and simultaneously filter out above-minimal use, while revealing potential problems of 'under-consumption' of water. This would help to get more insight into the extent and the risks of water affordability within different population groups. A similar suggestion was made by García-Valiñas et al. (2010a, 2010b), who rightly pointed out that it implies a judgment of what should be defined as necessary water consumption - a complex exercise that varies with context and household characteristics and for which no appropriate methodology has been agreed upon yet (Chenoweth, 2008). The exercise of judging what should be defined as necessary water consumption is thereby often cast aside. Instead, studies that do adopt a concept of minimally necessary instead of actual water use have opted for taking (a) the universal standard of 100 litres per person per day developed by Howard and Bartram (2003) for water infrastructure allowing optimal access (García-Valiñas et al., 2010a) or (b) deriving from an assumed demand

function the portion of water use that is statistically estimated to be inelastic, and therefore argued to be corresponding to the quantity required to fulfill basic needs (García-Valiñas et al., 2010b; Sebri 2015).

In contrast, our approach is precisely to assess the quantity of water, minimally needed to live decently in the Flemish societal context (see § 3). This requires many and explicit assumptions, especially regarding the household's ability to use water economically. Such an approach risks to be conceived ad-hoc or overly paternalistic. Reference budgets should therefore be based as much as possible on observable social norms, i.e. (inter)national legal standards and guidelines, complemented by scientific and experientially grounded knowledge. In the construction process, sufficient room should be allowed to develop various options where valid alternatives exist, emphasizing the illustrative (non-paternalistic) character of reference budgets (cf. Goedemé, Storms, Penne et al., 2015).

Empirical analyses with normative underpinnings concerning what constitutes an adequate minimum are more prevalent in research on energy affordability (Boardman, 2010; Hills, 2012; Sefton, 2002), housing (Haffner & Heylen, 2011) and nutritious food (Wong et. al., 2011; Wodon, 1997), These studies suggest that need-based standards offer interesting possibilities in pinpointing households facing affordability problems, enabling a more multifaceted approach to measure affordability problems. For water use, less than a handful of studies have tried to delineate needs-based estimates. Gleick (1996) estimates the necessary water use for domestic purposes at 50 litres per person per day, with minimum amounts for drinking (3 litres), sanitation (20 litres), bathing (15 litres) and food preparation (10 litres) in the case of 'typical' circumstances. Gleick (1996) explicitly aims to estimate a "universal" basic amount for physical survival, irrespective of location, climate context and living conditions.[2] Howard and Bartram (2003), on the other hand, emphasise that the necessary amount of water usage depends on the available water infrastructure. In a society with "optimal access conditions"[3] they estimate an essential domestic water use of 100 litres per person per day, yet without further refinement for varying context or household characteristics. A number of other studies estimate per capita quantities of minimally necessary water required to run a modern society

[2] "While the amount of water required to maintain survival depends on surrounding environmental conditions and personal physiological characteristics, the overall variability of needs is quite small." (Gleick, 1996; p . 83)

[3] Optimal access conditions imply that water supply is continuous and available through (multiple) tap(s) in the dwelling (Howard & Bertram, 2003; p. 22)

(Falkenmark, 1986) or for human health, economic and social development (Chenoweth, 2008) – thereby going beyond household needs as envisaged here.

Although drinking water and sanitation are necessary to fulfill the universal needs of health and autonomy everywhere (cf. Doyal & Gough, 1991), we argue in line with Chenoweth (2008), García-Valiñas et al. (2010a, 2010b), Sebri (2015) and others that the amount of water needed at the minimum to fulfill these needs does differ across geographical areas (climate, environment), cultures (varying social norms on hygiene, existing infrastructure), and household characteristics (demographic profile, employment status, health situation). The next section details how we draw on reference budget research to determine the minimally necessary water use for Flemish households.

3. A needs-based concept of minimally necessary water use

The methodology to operationalize the concept of minimally necessary water use is drawn from Belgian reference budget research. These reference budgets illustrate what people need minimally to participate adequately in society. Adequate social participation is defined as the ability of people to adequately fulfill the various social roles one should be able to play as a member of society (cf. Goedemé, Storms, Penne et al., 2015)[4]. Starting from a theoretical framework inspired by the Theory of Human Need (Doyal & Gough, 1991), two universal (health and autonomy) and ten intermediate needs or baskets are identified, which are further concretised into priced lists of necessary goods and services using a variety of information sources (cf. Goedemé, Storms, Stockman, et al., 2015). Water, one of the essential goods, is part of the basket representing the need for food, clothing and housing. In contrast to Gleick (1996) and Howard & Bartram (2003), a minimal necessary water budget for domestic use is identified for specific household types, which allows us to take account of economies of scale at the household level. Our exercise requires to make several assumptions:

1) Given the developed country context, we assume that households have access to water services and good quality tap water.
2) We assume that tap water at home fulfills 100% of the estimated minimally necessary water needs for adequate social participation. This implies not taking into account (a) possible daily water use outside the home (e.g. at work, in the sports club, when visiting

[4] Please note that this concept is somewhat broader than what some would consider ‘basic needs’.

friends) and (b) possible use of rainwater for domestic purposes such as toilet flushing or laundry[5]. Both assumptions are made to reflect a situation in which households are compared on equal terms, and to avoid assumptions that cannot be reasonably assumed for all households (rainwater infrastructure, an outside-the-home job, etc.). If the affordability of the water budget would depend on being able to consume part of it elsewhere or being able to use rainwater, affordability problems are arguably still a risk.

3) We assume that all household members are healthy and well-informed. In other words, we estimate minimal water use for 'standard' families, without special needs.
4) We assume the household has the capacity to use water economically, without sacrifices that could undermine their social participation (cf. Gilg & Barr, 2006). This assumption includes e.g. turning water off while brushing teeth, taking showers instead of baths and running full washing machines.

It is important to stress that these assumptions do not always correspond with the situation and characteristics of real families, especially not in the context of socioeconomically disadvantaged groups (cf. section 6). However, it is even harder to identify in some robust way what the minimally essential volume of water consumption should be with different assumptions (e.g. in case of non-economical water consumption). Sensitivity tests could be carried out with stricter or more relaxed assumptions.

Similar to Howard and Bartram (2003), we make a distinction between three functions of essential water use: *consumption*, *hygiene* and *other usage* such as home maintenance. These are translated in minimal frequencies based on existing (inter)national guidelines and recommendations regarding economical water use. When normative guidelines are lacking, data on actual consumption patterns are used which are adjusted downwards when more economical use is feasible. To make sure that the minimum budget accurately reflects the context in Flanders, we started whenever possible from local guidelines and recommendations, and complemented these with international recommendations.

To determine minimally necessary water use for human *consumption*, we started from recommendations of the Belgian 'Superior Health Council' (2016). The concrete amount is

[5] The latest figures indicate that rainwater accounts for 12% of the total water consumption of Flemish households. (De Nocker et al., 2017). Nowadays, the installation of a water tank is mandatory for new buildings. Nevertheless, a significant number of households do not have access to appropriate infrastructure with sufficient capacity (VMM, 2014). Moreover, the investment costs for infrastructure are likely to be a barrier for households with below-average income levels, especially when renting accommodation. Obviously, if the exercise would be repeated in the future or for a region where such infrastructure is more commonly available, the minimum necessary amount of tap water may be lower.

adjusted to the Flemish context based on available applied research, which takes account of available technologies, actual consumption patterns and practical considerations, aiming for efficient water use at minimal cost (Ecohuis, 2016; VMM, 2017). The minimal amount of water needed for *personal hygiene* is assessed through (1) medical and ecological recommendations regarding the duration of daily showers, combined with the most efficient water use (e.g. assuming economical showerheads) (2) data on actual water consumption of Dutch households (van Thiel, 2014)[6] for shaving, washing (sink) and brushing teeth, which was corrected if more economical use was considered feasible, (3) empirical evidence on the average frequency of toilet use for people in a good health (Friedler, Butler, & Brown, 1996; Gilg & Barr, 2006; Randolph & Troy, 2008), assuming economical flush buttons (Praktisch Duurzaam, 2015), (4) the minimally required water use to clean the dwelling in an efficient way and, (5) data on the average water use of economical washing machines and their actual number of water cycles, adjusted for efficient use (Kruschwitz et al., 2014; Pakula & Stamminger, 2010). Finally, we add a small amount of water for *other functions.*

[6] At the time of writing, no similar research for Flanders was available. Patterns of water use in the Netherlands can be expected to be a rather good proxy for those in Flanders with regard to the items included in the water budget.

Table 1 Average amount of minimally necessary water use per day in Flanders

Function	*Calculations*	*Single person daily amount*	*Couple with 2 children daily amount*	*Ratio of the amounts for a 4p. family and a single person*
Drinking	1.35 litres p.p.p.d.	1.35 litres 0.36 US gal	5.40 litres 1.44 US gal	4.00
Preparing food	1.4 litres p.p.p.d.	1.40 litres 0.37 US gal	5.60 litres 1.48 US gal	4.00
Dishes	12.8 litres/cycle + 2 litres per extra household member	12.80 litres 3.38 US gal	18.80 litres 4.97 US gal	1.47
Shower	5 min/shower: 8 litres/minute >12 years: 1/day <12 years: 1/two days*	40.00 litres 10.57 US gal	140.00 litres 36.98 US gal	3.50
Washing, shaving, brushing teeth	4.2 litres p.p.p.d.	4.20l litres 1.11 US gal	16.80 litres 4.44 US gal	4.00
Toilet	3 litres for toilet n°1 (*5) + 6 litres for toilet n°2 (*2)	27.00 litres 7.13 US gal	108.00 litres 28.53 US gal	4.00
Cleaning	27 litres/week + 1 litres/day per extra child	3.80 litres 1.00 US gal	5.80 litres 1.53 US gal	1.53
Washing clothes	1.5 cycles/week + 0.5 for each extra household member 42.5 litres per cycle	9.08 litres 2.39 US gal	18.16 litres 4.77 US gal	2.00
Other	4 litres p.p.p.d.	4.00 litres 1.06 US gal	16.00 litres 4.23 US gal	4.00
Total per day		**103.00 litres 27.20 US gal**	**333.00 litres 87.97 US gal**	**3.23**

Notes: p.p.p.d. = per person per day. *In order to prevent dry skin and eczema, it is recommended that children do not shower daily (Kind en Gezin, 2017).

The total necessary water usage for a single person in Flanders is estimated at 103 litres a day, close to the estimate by Howard and Bartram (2003) in case of 'optimal access conditions'. This amount increases when more members are added to the household, but not proportionally due to economies of scale (e.g. for preparing food, dishes, cleaning and washing clothes). Hence, a couple without children needs about 185 litres a day (rather than 206 litres), while a

couple with two children (8 and 15 years old) needs about 333 litres. The largest share of this budget (81% to 86%) is required for personal hygiene, followed by personal consumption (9% à 15%) and other usage (4% à 5%). Obviously, these amounts should not be considered absolute, as they required additional judgment on our side. Nonetheless, we are convinced that they broadly reflect what could be considered an acceptable minimum for Flanders. Furthermore, small changes in the quantities are unlikely to affect the main conclusions that can be drawn from our proposed needs-based indicator. Furthermore, as emphasised below, for empirical applications it is important to carry out sensitivity checks.

4. Methodological considerations regarding water affordability indicators

As argued in Section 2, the conventional ex ante "risk" indicators usually compare the financial capacity of the household with the water cost[7]. When the ratio water cost vs financial capacity of the household exceeds a certain threshold (e.g. 1%, 3% or 5%), the household is estimated to be at risk of facing affordability problems. In other words, affordability indicators typically consist of three parameters, which we review in turn in this section: the cost concept (4.1), the financial capacity concept (4.2), the threshold value (4.3). Subsequently, we anticipate the strengths and weaknesses of the two indicators used in the empirical illustration (the default indicator based on actual expenditures- and our needs-based indicator) (3.4). In the final part, we briefly discuss the data used for the empirical illustration (3.5).

4.1 Cost concept

While the theoretical concept of water costs can include all costs related to water consumption (also indirect costs related to accessing water, such as time and equipment, cf. Hutton, 2012), this is often impossible to quantify due to data constraints. Most studies reviewed in the previous sections approach water costs as direct expenditures for water-related services, i.e. the amount billed.[8] In line with this practice, we construct a cost concept corresponding to what

[7] The ex-ante / ex-post distinction is frequently used to categorize affordability indicators. *Ex post* water affordability indicators can be constructed by means of administrative data on delayed payments, debts and the amount and duration of disconnections. This type of information is often produced by water suppliers (e.g. VMM, 2014). However, in order to detect risks of affordability before acute problems of arrears and debts manifest themselves, it is necessary to construct *ex ante* indicators that aim to capture the risk of affordability *before* actual payment problems arise. The latter are the focus of this paper.

[8] In the referenced studies this is often - in line with OECD recommendations (OECD, 2009) – the combined costs of drinking water and wastewater services.

each household would pay for the normatively determined volume of water (cf. Section 3) that should cover all basic household needs.

For Flanders, the water bill components are (1) the cost of the production and distribution of drinking water – including a fixed charge and a volumetric fee per m^3; (2) the cost of the wastewater sewerage and treatment – consisting of a municipal and a regional volumetric fee; and (3) a VAT-tax of 6% applied on components (1) and (2).

While this general tariff structure is applied throughout Flanders, the rate of the fees varies across the 9 area-based water supply companies (these determine the fixed charge and the volumetric fee for drinking water) and across the 308 municipalities (that determine the municipal wastewater sewerage and treatment volumetric fee). The difference between the least and the most expensive water municipality (for an average volume of water consumption) amounted to 63% in 2015 (authors' calculations). Between these extremes, most households in Flanders pay a relatively comparable water bill: the difference between a municipality at the 10^{th} percentile and one at the 90^{th} percentile in terms of water costs, amounted to a more modest 18%.

4.2 Assessing the financial capacity of households

In order to assess the risk of affordability problems, the cost of water should be compared with the household's financial resources. In the literature on affordability risks, studies differ in their choice of indicator for financial capacity, depending among others on data availability (Hutton, 2012). Usually, the financial capacity of households is measured with an indicator of their total gross or net income, before or after housing costs, or by looking at total household expenditures. For the purpose of our exercise, we start from disposable household income, which includes benefits and allowances, as well as deductions of taxes and social contributions (but not housing costs), following the dominant practice in most (inter)national research on poverty and inequality in developed countries (e.g. OECD; Eurostat, …).

4.3 The choice of a threshold value

The main difficulty for constructing a water affordability indicator is defining a realistic threshold that identifies the risk of affordability problems in societies with a large variation in resources and needs across households. Fankhauser & Tepic (2007) review the existing thresholds adopted by governments and international institutions for what is considered an acceptable level of utility expenditures, covering water, electricity and heating. Lacking

consensus on how to determine an appropriate threshold value, led to the adoption of mostly ad hoc rules on this matter. While thresholds commonly used in Latin America, (Central) Asia and Africa (Smets, 2008; 2009; Banerjee et al., 2011; Lee, 2011; Hutton 2012), put water and sanitation expenditures at around 5% of household income, the threshold of 3% is the most common value to assess a risk of water affordability problems in developed economies (e.g. Fankhauser & Tepic, 2007; Reynaud, 2008; Sawkins & Dickie, 2005; Vanhille, 2015), with the exception of the US, where a 4.5% threshold is applied (Mack & Wrase, 2017). Households spending more than 3% of their resources on water, are considered to have a problem of water affordability. This threshold is also used by the government of the UK and international organisations such as the UNDP, even though both institutions use a different underpinning for this choice[9]. Some authors argue that this 3% threshold is too high in the context of developed countries (e.g. Miniaci et al., 2008). In contrast, these authors propose to use the median share that is actually spent on water by households in poverty[10] as threshold value (resulting in a threshold of 1.8%). They argue that "lacking a specific measure of the minimum basket of utility services in physical terms, this seems to be the most reasonable alternative available" (Miniaci et al., 2008, p.213).

Also in the Belgian context a 3% threshold is rather high, especially without further conceptual underpinning. In comparison with Italy in 2005 (year of the Miniaci et al., 2008 study), in 2015, the median of Flemish households with an income below the at-risk-of-poverty threshold spent a slightly lower percentage of its disposable income on water: 1.4% (own calculations on EU-SILC, cf. below). In contrast to Miniaci et al. (2008), for Flanders we do have a minimum basket of water services in physical terms: the needs-based concept of minimally necessary water use presented above. In addition, we have an indication of the minimum cost of the other essential goods and services, as identified by the reference budgets for adequate social participation developed for Flanders (cf. Storms et al., forthcoming). The share of the water budget in the total reference budgets offers a good indication of a valid threshold: if a larger share of household income is spent on the needs-based budget, the household is probably unable to afford the other essential goods and services covered by the reference budgets.

[9] UNDP (2006) justifies the use of the 3% threshold as a "rule of thumb", and refers among others to the UK practice. The UK government grounds the 3% in the empirical observation that households belonging to the lowest three income deciles (the 30% poorest households) spent on average 3% of their income on water charges in the period 1993-2001 (Fitch & Price, 2002).

[10] Defined as households with an equivalent disposable household income below 60% of the median in Italy.

Not surprisingly, the share of the water budget in the total reference budgets depends on the households' circumstances, and in particular the housing budget. It ranges from 1.2% (single person with two older children) to 1.6% (couple with two young children) for families renting on the private market and from 1.6% (single or couple with one child) to 2% (single) for families paying reduced social housing rent.

Although it is possible in principle to use these shares to define household-specific thresholds, these thresholds make the empirical exercise rather complex (note that the needs-based cost concept already varies by household composition). Therefore, for the empirical illustration we prefer working with two threshold values, applied to all household situations: 1.4% (the weighted average share based on the reference budget method, applicable for households renting on the private market) and 3.0% (allowing international comparisons). The application of two threshold values helps to illustrate the sensitivity of the results to the choice of the threshold, and to gain more insight into the 'depth' or 'severity' of the affordability risk: spending or having to spend more than 3.0% of disposable income on water clearly indicates a more severe affordability risk than crossing the 1.4% threshold.

4.4. 'Actual expenses' versus 'needs-based' indicator

Incorporating all findings, we can compose a needs-based indicator of water affordability, which defines an affordability problem as having a disposable household income that is too low to spend maximum 1.4% or 3.0% of the income on the needs-based water budget[11]. We will compare our indicator with a conventional actual expenses indicator that defines an affordability problem as spending more than 1.4% or 3.0% of the disposable household income on actual water consumption.

Neither of these indicators fully captures water affordability. The actual expenses indicator includes households with relatively high water consumption that could be reduced without jeopardising needs for adequate social participation; while the needs-based indicator includes households that might benefit from more efficient infrastructure (e.g. using rainwater for sanitation) and therefore do not have an affordability risk. Also, both indicators may be missing some households: the actual expenses indicator omits households underspending on water because of budget constraints; the needs-based indicator omits those with specific needs (e.g. bathing needs because of disability, specific job requiring more frequent washing cycles) or

[11] In other words, the needs-based indicator effectively coincides with a low-income indicator, of which the threshold is equal to the household-specific water budget divided by 0.014, respectively by 0.03.

lacking efficient infrastructure (e.g. without economical showerhead, leaking installations, apartments with shared water bills). Therefore, we regard both indicators as complementary, which together provide a more complete picture of water affordability problems.

4.5. Data

Data requirements to construct the needs-based indicator are threefold: (1) a needs-based water budget, detailing the estimated minimally necessary water use for different household types (cf. above); (2) a representative households sample with information on basic demographic characteristics and disposable household incomes. (3) a model to simulate the water tariff structure and its parameters, in order to calculate the hypothetical needs-based water bill for each dataset's household. For the empirical illustration, we make use of the Flemish component of the survey on Income and Living Conditions (EU-SILC), which contains detailed information at the microlevel for a representative sample of about 3000 households on their demographic characteristics, income and water expenses,. We refer to our accompanying Data In Brief contribution (Goedemé & Vanhille, submitted) for more information on this dataset and how we treated it to satisfy the above criteria.

Given local variations in the exact tariff of water (cf. section 4.1) and lack of information regarding the municipality of respondents in the dataset, we have assumed that each household faces the 'average' tariff in Flanders in our model for simulating the needs-based water bill. A sensitivity analysis documented in the supplementary material reports the results under alternative assumptions.

5. Empirical illustration

The two indicators compared in this empirical illustration differ only in their concept of the water cost. The measurement of the financial capacity of households and the threshold values of the affordability indicators remain unchanged. Thus, households will be identified as having a risk of water affordability problems when (A) they spend more than 1.4% (3.0%) of their net disposable household income on water; (B) the needs-based water budget (adapted to the household size and composition) exceeds 1.4% (3.0%) of their net disposable household income. We emphasize that these indicators measure *a risk* of affordability problems, since the heterogeneity of the population cannot be fully captured (see above).

Table 2 presents the percentage of individuals that live in a household at risk of water affordability problems, according to the two different indicators (needs-based and actual expenses) (2) and the two thresholds (indicating the "depth" of the affordability risk).

Table 2 The percentage (with 95% confidence interval) of individuals living in a household at risk of water affordability problems by two dimensions (indicator and threshold), EU-SILC 2015

Indicator	3.0% threshold estimate (95% C.I.)	1.4% threshold estimate (95% C.I.)
1. Actual expenses > threshold	6.1% (4.8%-7.8%)	18.7% (16.8%-20.8%)
2. Needs-based costs > threshold	1.4% (0.9%-2.1%)	21.5% (19.6%-23.5%)
3. Intersection of (1) and (2)	0.6% (0.3%-1.0%)	10.8% (9.3%-12.5%)

Note: Figure based on authors' calculations on SILC 2015 data. The reported 95% confidence intervals take the sample design into account as much as possible (cf. Goedemé, 2013).

The population groups identified as "at risk of affordability problems" (hereafter: at risk) can thus be split up into different risk groups:

1. A group at risk because of spending a large share (3.0% / 1.4%) of income on water consumption: 6.1% / 18.7% of the total population.
2. A group at risk because budget constraints prevent them to afford a minimum necessary consumption of water without limiting the consumption of other essential goods and services: 1.4% / 21.5%
3. A group that spends a large share of income on water consumption, even though it probably cannot do so without endangering an adequate consumption level of other essential goods and services: 0.6% / 10.8%.

These estimates reveal that water affordability problems are a significant risk for a sizable group of Flemish population. Despite their relatively high incomes on average, the group of households at risk of affordability problems is of comparable size as in other European countries with microdata-based estimates available.[12]

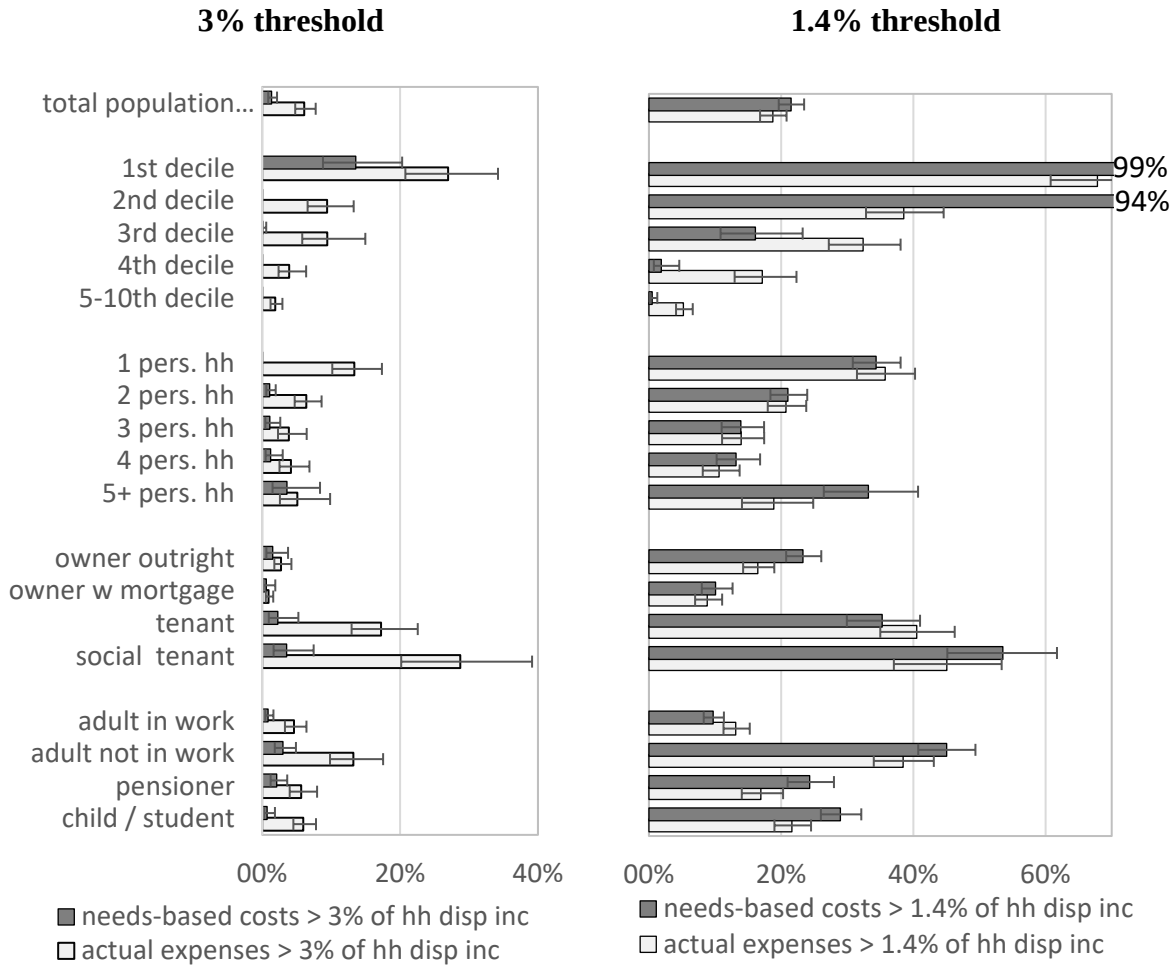
[12] For the 6% of Flemish population that we estimate to be at risk according to the actual expenses indicator with 3.0% threshold, we can compare with France (4.3% of the population at risk in 2001 as estimated by Reynaud, 2008) and Great-Britain (9% of the population for 2002-2003; Sawkins & Dickie, 2005). However, comparability is hampered because the concept measuring the financial capacity of the household differs significantly (for the UK, this is disposable income after fixed housing costs are deducted). For the actual expenses indicator with lower threshold value we can broadly compare the 13% of Italian households at risk in 2005 (1.8% threshold) (Miniaci et al., 2008) to our 2015 estimate of 19% for the Flemish population (1.4% threshold). Again, the point estimates are not strictly comparable because of the difference in the threshold value and financial capacity concept (total expenditures for Italy vs. disposable income for Flanders).

Comparing our estimates for both the 1.4% and 3% thresholds gives an indication of the "depth" of the affordability risk: for the actual expenses, about one third of those identified to spend more than 1.4% of their income on water, also spend more than 3.0% (about 6% of the population). The needs-based budget almost never exceeds the 3% of income threshold (only for 1.4% of the population).

The overlapping population identified by both indicators amounts to about half of the households identified by each indicator in the case of the 1.4% threshold. The population group exclusively identified by only one of both indicators is also interesting: these would be left out in an analysis choosing one indicator over the other. For about 8% of the Flemish population, water expenditures exceed 1.4% of disposable income, contrary to the needs-based budget: this confirms that for a significant group of households, actual water use seems to be above-minimal. This can indicate different factors, both behavioural (e.g. longer showers) and infrastructural (e.g. uneconomical taps, toilets, leaks). Analogously, for about 10.7% of the Flemish population, the actual water bill does not exceed the 1.4% threshold while the needs-based budget does. This points to the potential existence of a sizeable group of "underspenders" in the bottom deciles of the income distribution, which consumes less water than considered the essential minimum.

More insight into which groups are more prone to unaffordability risks can be gained from Figure 1, presenting the risk rates split out over various demographic and socio-economic background variables. In the left-hand panel, the bars depict the share of Flemish households for whom the needs-based water budget or the actual expenses exceed 3.0% of disposable income. In the right-hand panel, this is repeated for the 1.4% threshold.

Figure 1. The percentage of individuals living in a household at risk of water affordability by household characteristics, comparing the needs-based with the actual expenses indicators using two different thresholds (Flanders, 2015)

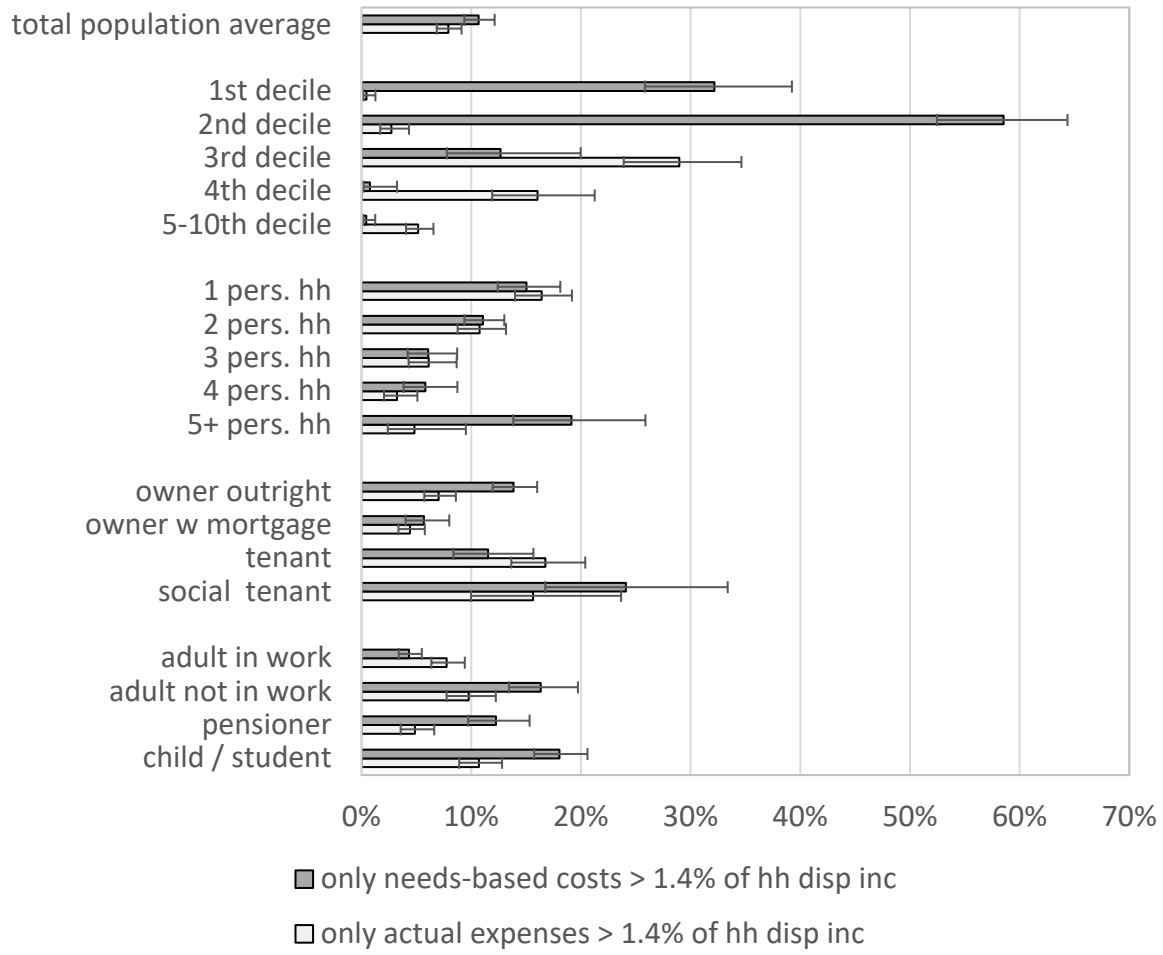


Note: Authors' calculations on the SILC 2015 data. Capped lines depict the 95% confidence intervals, taking the sample design into account as much as possible (cf. Goedemé, 2013)

The population categories with an above-average risk include: the low(est) income groups (more pronounced in the needs-based indicator), jobless adults, pensioners, and social tenants (according to both indicators). Interesting patterns highlighting differences between both indicators relate mainly to affordability risk by income: while the needs-based indicator quickly drops to almost zero higher up the income distribution, the proportion of households with water bills that exceed 1.4 resp. 3.0% of their disposable income remains sizeable - 5.4% (1.9%) in the upper income deciles. High water bills due to high consumption volumes thus appear to occur relatively frequently, to the extent that the bill regularly rises above 3.0% of household income, even for households higher up in the income distribution. This includes households for whom the validity of the label "affordability problem" is questionable (cf. Introduction).

It is interesting to elucidate the risk of facing a water affordability problem considering only one of both indicators. Figure 2 shows that low-income households (first two deciles) are overwhelmingly more at risk of affordability problems according to the needs-based indicator, while not actually being billed this amount. Large families with children, pensioners and jobless adults, are more likely to underspend in comparison to their needs-based budget. Conversely, those spending more than the threshold value without exceeding their needs-based budget, are more likely situated in income decile three or higher, to be working (remarkably, as they spend less time at home), and to be private tenants. Finally, persons staying more at home during the day (adults not in work and pensioners) face a higher risk of crossing the 1.4% threshold for the needs-based indicator compared to other groups, while actually spending less than that percentage on water.

Figure 2. The risk of facing a water affordability problem according to only one of both indicators, 1.4% threshold (Flanders, 2015)



Note: Authors' calculations on the SILC 2015 data. Capped lines depict the 95% confidence intervals, taking as much as possible the sample design into account (cf. Goedemé, 2013).

6. Discussion

This brief illustration demonstrates the empirical added-value of a needs-based indicator, alongside an actual expenses indicator. It draws attention to the group of "underspenders": households that are likely to face a water affordability problem, despite relatively low observed water expenses. The results show that this group is of significant size and thereby relevant to policy-makers, especially when designing 'social' water pricing policy aiming to address affordability issues. In Flanders, eligibility rules for social tariffs are narrowly defined, while the price reduction is significant. Monitoring affordability risks with both needs-based and actual consumption indicators can reveal a more nuanced picture of the groups at risk – so that eligibility rules and price reductions can be adjusted accordingly. Therefore, we are convinced

that more in-depth water affordability evaluations too will benefit from combining expenditure-based indicators with a needs-based indicator. Moreover, the indicators can also be used to simulate effects of alternative tariff structures on water affordability, especially so for the needs-based indicator. It simply implies the recalculation of the water cost budget under alternative assumptions regarding the tariffs that households (would) face. For the actual expenses indicator such an exercise would require access not only to their expenses, but also the volume of water consumed, and a behavioural model that incorporates the price elasticity of water use.

Nonetheless, the approach we developed and applied is subject to a number of methodological and conceptual limitations, implying that the estimates need to be interpreted taking a certain margin of error into account.

(1) Because we use representative survey data, the accuracy of both actual and needs-based indicators depends on the quality of the data. As it is typically very difficult to accurately and representatively sample the "tails" of the income distribution, we expect our estimates for both indicators to be affected downwardly by the probable underrepresentation of vulnerable groups such as homeless people or people not speaking the local language. Using an alternative data source such as administrative data could partly alleviate this problem, as these in principle cover the full population of legal Belgian residents. These data however have their own shortcomings, such as the difficulty to compile actual, sociological households or to construct a comparable concept for net disposable income.

(2) The impact of the assumptions made for our needs-based indicator (cf. section 3) are significant as well as difficult to quantify. We opted to assume that all water is tap water, used at home. However, part of the water use will also take place when outdoors, be it for work or leisure. In addition, we ignore alternative sources of water, while in reality it is estimated to account for 12% of water use in Flanders (De Nocker et al., 2017). However, this is not always used for domestic purposes (rather for outside use such as gardening)[13]. More fundamentally, we argue that the question about whether these assumptions hold in individual cases is not of primary concern. With the needs-based cost concept, we assess whether the minimum would be affordable, irrespective of the characteristics of the actual dwelling. Furthermore, the indicator is meant to assess the

[13] It is reassuring that we do not find evidence of overestimating the needs-based water indicator because of this reason. The risk profile of the groups who would be most affected by these assumptions, i.e. adults in work and homeowners respectively, is broadly similar according to both indicators.

overall impact of (changes in) tariff structures, rather than to evaluate whether or not a particular household is confronted with an affordability problem. In these cases, a biased estimate is only problematic insofar it can be expected that the bias would be different when the tariff structure changes or with (relatively mild) population changes over time.

(3) A more challenging source of inaccuracies in the needs-based water budget, are the assumptions that households are well-informed, healthy, have a separate water meter, and are able to use water efficiently (implying adequate infrastructures without leaks, economical showerheads, efficient washing machines ...). When adequate infrastructures are lacking, expected to occur more often in low-quality housing or occupied by poor households, the cost of minimum adequate water consumption can be higher. Collecting more and better data, should make possible to carry out a more fine-grained analysis that could, for instance, take account of the actual availability and distribution of efficient water infrastructure in the house.

More fundamentally, the usefulness of water affordability indicators depends to some extent on one's views regarding the most appropriate policy instruments to ensure adequate access to water. In developed welfare states water affordability could be seen as a concern for social policy, rather than water policy. In this view, water policy should define tariffs primarily reflecting economic and environmental concerns. In contrast, it is the responsibility of tax-benefit regulations and employment policy to ensure that households have access to adequate incomes sufficient enough to cover (among others) the cost of essential water consumption. In this view, policy makers just need valid indicators of adequate incomes, rather than indicators focused specifically on the affordability of specific goods or services such as water.

In reality, though, minimum incomes are often not adequate (e.g. Marx & Nelson, 2013), while households under financial stress may also (have to) spend their resources in ways leaving them with insufficient resources for consuming an adequate amount of water. As a result, water regulators can have legitimate concerns about ensuring minimum access for vulnerable households, providing legitimacy to the use of water affordability indicators. Water affordability indicators can be very helpful to assess the potential impact of changes to (social) tariff structures. Still, water regulators should be aware that, by focusing on the affordability of one specific good, these indicators risk downplaying the importance of the affordability of other essential goods and services, which co-determine the affordability of water.

7. Conclusions

In developed countries, the right to drinking water is compromised for certain population groups because of affordability problems. The increasing pressure on limited natural resources adds importance to water pricing policies that ensure equity principles. In this paper, we emphasize the necessity for an appropriate measure of water affordability, which takes account of household needs.

Conventionally, water affordability risks are measured by the proportion of people with water expenditures above a certain percentage (generally 3% in OECD-countries) of their total disposable income. Despite agreement on the relevance of monitoring the affordability of being able to fulfill essential needs, the absence of a solid methodology mostly leads to using actual expenses or statistical estimates as a proxy in empirical operationalisations. This implies including households with a preference for high water consumption as "at risk of facing affordability problems" and omitting households who cut back on their essential water consumption due to budget constraints. This paper proposes a needs-based indicator, sensitive to the societal context and characteristics of households to measure the risk of being unable to afford the minimum amount of water required for fulfilling needs for adequate social participation. We define this minimum amount of water use, through reference budget research illustrating the cost of essential goods and services that specific household types need at the minimum to adequately participate in society. In the empirical illustration, we apply actual expenses and needs-based indicators to a representative sample of Flemish households, using both a 1.4% and a 3.0% threshold to gain more insight into the 'depth' or 'severity' of the affordability risk.

A comparison of the needs-based indicator with a more common expenditure-based indicator has shown that both indicators identify partially different socio-economic groups in Flanders. While we believe it remains relevant to monitor actual expenses, the needs-based indicator reveals that focusing solely on actual water use implies missing a significant, precarious group of about 10% of the Flemish population, with very low water bills, reflecting self-restriction to below-minimal levels because of limited means. We argue that these households face an affordability risk because the cost of minimally necessary water use exceeds 1.4% or 3.0% respectively of their disposable income. They should therefore be considered when designing policy measures geared at alleviating affordability risks. We conclude that for in-depth

evaluations of water affordability, the two indicators can best be used in a complementary approach.

References

Banerjee, S. G., & Morella, E. (2011). *Africa's water and sanitation infrastructure: access, affordability, and alternatives*. Washington: World Bank Publications.

Boardman, B. (2010). *Fixing fuel poverty: challenges and solutions*. London: Earthscan.

Carruthers, R., Dick, M., & Saurkar, A. (2005). Affordability of public transport in developing countries. *Transport papers* (pp. 23). Washington: The World Bank Group.

Chenoweth, J. (2008). Minimum water requirement for social and economic development. *Desalination*, 229(1-3), 245-256.

Doyal, L., & Gough, I. (1991). *A Theory of Human Need*. Houndmills: Macmillan.

De Nocker, L., Broekx, S., Vanhulsel, M., Botterman, S., Moris, A., Debusscher, M. (2017). Watergebruik 2016 door huishoudens in Vlaanderen. Studie uitgevoerd in opdracht van de Waterregulator. Mol: VITO & Gfk, mimeo.

Falkenmark, M. (1986). Fresh water: Time for a modified approach. *Ambio*, 192-200.

Fankhauser, S., & Tepic, S. (2007). Can poor consumers pay for energy and water? An affordability analysis for transition countries. *Energy Policy, 35*(2), 1038-1049.

Fitch, M., & Price, H. (2002). *Water poverty in England and Wales*. London: Centre for Utility Consumer Law and Chartered Institute of Environmental Health.

Friedler, E., Butler, D., & Brown, D. M. (1996). Domestic WC usage patterns. *Building and Environment, 31*(4), 385-392.

García-Valiñas, M. Á., Martinez-Espineira, R., & Gonzalez-Gomez, F. (2010a). Measuring water affordability: a proposal for urban centres in developed countries. *International Journal of Water Resources Development, 26*(3), 441-458.

García-Valiñas, M. Á., Martínez-Espiñeira, R., & González-Gómez, F. (2010b). Affordability of residential water tariffs: Alternative measurement and explanatory factors in southern Spain. *Journal of Environmental Management*, *91*(12), 2696-2706.

Gilg, A., & Barr, S. (2006). Behavioural attitudes towards water saving? Evidence from a study of environmental actions. *Ecological Economics, 57*(3), 400-414.

Gleick, P. H. (1996). Basic water requirements for human activities: Meeting basic needs. *Water international, 21*(2), 83-92.

Goedemé, T. (2013). How much confidence can we have in EU-SILC? Complex sample designs and the standard error of the Europe 2020 poverty indicators. *Social Indicators Research, 110*(1), 89-110. doi:10.1007/s11205-011-9918-2

Goedemé, T., Storms, B., Penne, T., & Van den Bosch, K. (Eds.). (2015). *Pilot project for the developement of a common methodology on reference budgets in Europe. The development of a methodology for comparable reference budgets in Europe - Final report of the pilot project*. Brussels: European Commission.

Goedemé, T., Storms, B., Stockman, S., Penne, T., & Van den Bosch, K. (2015). Towards cross-country comparable reference budgets in Europe: First results of a concerted effort. *European Journal of Social Security, 17*(1), 3-30.

Goedemé, T. & Vanhille, J. (submitted). Water expenses by households living in Flanders: data availability in the Belgian EU-SILC. *Data In Brief*. Submitted.

Haffner, M., & Heylen, K. (2011). User costs and housing expenses. Towards a more comprehensive approach to affordability. *Housing Studies*, 26(04), 593-614.

Hills, J. (2012). *Getting the measure of fuel poverty: Final Report of the Fuel Poverty Review.* CASEreport, 72. London: Centre for Analysis of Social Exclusion, London School of Economics and Political Science.

Howard, G., & Bartram, J. (2003). *Domestic water quantity, service level, and health.* Geneva: World Health Organization.

Hulchanski, J. D. (1995). The concept of housing affordability: six contemporary uses of the housing expenditure-to-income ratio. *Housing studies, 10*(4), 471-491.

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

Kind en Gezin. (2017). Verzorging. Elke dag. Accessed 6/11/2017 via https://www.kindengezin.be/verzorging/elke-dag

Kruschwitz, A., Karle, A., Schmitz, A., & Stamminger, R. (2014). Consumer laundry practices in Germany. *International Journal of Consumer Studies, 38*(3), 265-277.

Lee, C. (2011). Privatization, water access and affordability: Evidence from Malaysian household expenditure data. *Economic Modelling*, 28(5), 2121-2128

Mack, E. A., & Wrase, S. (2017). A burgeoning crisis? A nationwide assessment of the geography of water affordability in the United States. *PloS one*, 12(1), e0169488.

Marx, I., & Nelson, K. (Eds.). (2013). *Minimum Income Protection in Flux*. Houndmills: Palgrave Macmillan.

Miniaci, R., Scarpa, C., & Valbonesi, P. (2008). Measuring the affordability of basic public utility services in Italy. *Giornale degli Economisti e Annali di Economia*, 185-230.

Moore, R. (2012). Definitions of fuel poverty: Implications for policy. *Energy Policy,* 49, 19-26.

OECD. (2003). *Social Issues in the Provision and Pricing of Water Services.* Paris: Organisation for Economic Co-operation and Development.

OECD. (2009). *Managing water for all: an OECD perspective on pricing and financing.* Paris: Organisation for Economic Co-operation and Development.

Opschoor, J. H. (2006). Water and merit goods. *International Environmental Agreements: Politics, Law and Economics, 6*(4), 423-428.

Pakula, C., & Stamminger, R. (2010). Electricity and water consumption for laundry washing by washing machine worldwide. *Energy Efficiency, 3*(4), 365-382.

PraktischDuurzaam. (2015). Waterbesparing in het toilet. Accessed 20/07/2017 via http://www.praktischduurzaam.nl/waterbesparing-in-het-toilet/

Randolph, B., & Troy, P. (2008). Attitudes to conservation and water consumption. *environmental science & policy, 11*(5), 441-455.

Reynaud, A. (2008). Social policies and private sector participation in water supply–the case of France. In N. Prasad (Ed.), *Social Policies and Private Sector Participation in Water Supply*. Basingstoke & New York: Palgrave.

Sawkins, J. W., & Dickie, V. A. (2005). Affordability of household water and sewerage services in Great Britain. *Fiscal Studies*, 225-244.

Sebri, M. (2015). Water affordability and social equity in Tunisian governorates: a distributive approach. *Water Policy*, *17*(1), 26-45.

Sefton, T. (2002). Targeting fuel poverty in England: is the government getting warm? *Fiscal Studies, 23*(3), 369-399.

SERV. (2014). Tarifering van drinkwater. Analyse en aanbevelingen. Brussel : Sociaal-Economische Raad Vlaanderen.

Smets, H. (2008). *De l'eau potable à un prix abordable.* Paris: Johanet.

Smets,H. (2009). Access to drinking water at an affordable price in developing countries. *Options Méditeranéennes*, *88*, 57-68.

Stone, M. E. (2006). What is housing affordability? The case for the residual income approach. *Housing policy debate*, 17(1), 151-184.

Storms, B., Van Thielen, L., Penne, T., & Goedemé, T. (forthcoming). *Hoeveel inkomen is minimaal nodig? Referentiebudgetten voor maatschappelijke participatie*. Brugge: Die Keure.

Superior Health Council. (2016). Voedings- aanbevelingen voor België - 2016. Advies nr. 9285. Brussel: HGR.

United Nations. (2003). General Comment No. 15: The Right to Water (Arts. 11 and 12 of the Covenant): Committee on Economic, Social and Cultural Rights, available at: http://www.refworld.org/docid/4538838d11.html [accessed 20 July 2017].

United Nations. (2010). Resolution adopted by the General Assembly on 28 July 2010: The human right to water and sanitation (Vol. Resolution 64/292).

UNDP. (2006). Human Development Report 2006. Beyond scarcity: Power, poverty and the global water crisis*.* New York: United Nations Development Programme.

van Thiel, L. (2014). *Watergebruik Thuis 2013*. Uitgevoerd in opdracht van de Vereniging van waterbedrijven in Nederland. Amsterdam: TNS NIPO.

Vanhille, J. (2015). *Consumption-based water charges and public water regulators' equity concerns - an empirical evaluation of alternative tariff structures for Flemish households.* Paper presented at the International Conference on Public Policy, Milan, Italy.

VMM. (2014). *Watermeter 2014 – Drinkwaterproductie en -levering in cijfers*. Aalst: Vlaamse Milieu Maatschappij.

VMM. (2016). Statistieken toepassing Algemeen Waterverkoopreglement 2015. Aalst: Vlaamse Milieu Maatschappij.

VMM. (2017). Minder verbruiken en betalen? Accessed 20/07/2017 via http://www.vmm.be/waterloket/minder-verbruiken-en-betalen.

Whitehead, C. M. (1991). From need to affordability: an analysis of UK housing objectives. *Urban studies, 28*(6), 871-887.

Wodon, Q. T. (1997). Food energy intake and cost of basic needs: Measuring poverty in Bangladesh. *Journal of Development Studies*, 34(2), 66-101.

Wong, K. C., Coveney, J., Ward, P., Muller, R., Carter, P., Verity, F., & Tsourtos, G. (2011). Availability, affordability and quality of a healthy food basket in Adelaide, South Australia. *Nutrition & Dietetics*, 68(1), 8-14.

Supplementary Material: Sensitivity analysis

As briefly mentioned in Section 4.1, the variation in the tariffs for water between different water companies and different municipalities in Flanders should be marked. Depending on which water company (water companies are area-based) is supplying the drinking water and in which municipality the household lives and is therefore charging the fee for wastewater sewerage and treatment, Flemish households will pay a more or less expensive water bill for consuming the same volume of water. Water company area and municipality are unfortunately variables that we cannot observe or derive from the available data. In order to test the sensitivity of our results to the assumption that everyone pays the "average" Flemish price, we carried out two sensitivity analyses. Table A.1 reports results from a first sensitivity analysis that tests the difference in results for both the needs-based and the actual expenses water affordability indicator, under the assumption that all households live in the 20th percentile region in terms of water costs - thereby facing a cheap water bill according to the Flemish norm. The second sensitivity analysis reports the outcomes on water affordability under the assumption that all households live in the 80th percentile region – thus facing a relatively expensive water bill (Table A.2). We can assume that these form the lower and upper boundaries of the actual size of potential water affordability problems in Flanders.

A water bill in a municipality ranked at the 80th percentile in terms of water costs is about 14% higher than in a municipality at the 20th percentile (for the same average volume of water used). In the resulting figures for the affordability indicators, the estimated proportion of individuals living in a household facing an affordability risk changes between +/- 1% (0.1 percentage points) up to +/- 18% (or 4 percentage points) in comparison to the results reported in section 5 on the basis of the assumption of an average Flemish tariff. Given that in our exercise only the needs-based costs are simulated while actual expenses are observed, only the needs-based affordability indicator shifts when a different tariff structure is assumed, while distributional patterns and risk profiles remain more or less stable. This shows that the purpose of this exercise is not to estimate with precision the extent to which needs-based affordability problems occur in Flanders, but rather to show that, no matter against which threshold one measures, assessing affordability on the basis of needs-based costs draws a different picture of the problem than an exercise based on actual water costs.

Table A.1. The percentage (with 95% confidence interval) of individuals living in a household experiencing a risk of water affordability problems by two dimensions (indicator and

threshold), EU-SILC 2015 - Estimates for a water region at the 20th percentile in terms of cost of water and comparison with estimates for a water region at the average water costs.

Indicator	3.0% threshold estimate (95% C.I.)	Relative (absolute) change in comparison with average	1.4% threshold estimate (95% C.I.)	Relative (absolute) change in comparison with average
1. Actual expenses > threshold	6.1% (4.8%-7.8%)	(none)	18.7% (16.8%-20.8%)	(none)
2. Needs-based costs > threshold	1.1% (0.7%-1.8%)	-19% (-0.3pp)	17.6% (15.8%-19.5%)	-18% (-4pp)
3. Intersection of (1) and (2)	0.4% (0.2%-0.9%)	-22% (-0.1pp)	9.7% (8.2%-11.3%)	-11% (-1pp)

Note: Authors' calculations on the SILC 2015 data. 95% confidence intervals calculated taking the sample design into account as much as possible (cf. Goedemé, 2013)

Table A.2. The percentage (with 95% confidence interval) of individuals living in a household experiencing a risk of water affordability problems by two dimensions (indicator and threshold), EU-SILC 2015 - Estimates for a water region at the 80th percentile in terms of cost of water and comparison with estimates for a water region at the average water costs.

Indicator	3.0% threshold estimate (95% C.I.)	Relative and (absolute) change in comparison with average	1.4% threshold estimate (95% C.I.)	Relative and (absolute) change in comparison with average
1. Actual expenses > threshold	6.1% (4.8%-7.8%)	(none)	18.7% (16.8%-20.8%)	(none)
2. Needs-based costs > threshold	1.7% (1.1%-2.5%)	+23% (+0.3pp)	25.1% (23.1%-27.2%)	+17% (+3.6pp)
3. Intersection of (1) and (2)	0.6% (0.3%-1.1%)	+10% (+0.1pp)	12.4% (10.8%-14.1%)	+14%(+1.6pp)

Note: Authors' calculations on the SILC 2015 data. 95% confidence intervals calculated taking the sample design into account as much as possible (cf. Goedemé, 2013)