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Affordability of Water Supply in Mongolia

Empirical Lessons for Measuring Affordability

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Abstract

Affordability of water services is a pressing water policy issue for both the developed and in particular the developing world. Despite its well-known theoretical shortcomings affordability analysis for water supply is up to now widely based on the ratio of a household's water expenditure and income (CAR). However in the housing sector alternative concepts of measuring affordability have been developed among them the potential affordability approach (PAA) and the residual income approach (RIA).

Against this background the article compares three prominent affordability measures (CAR, PAA, RIA) on the basis of an empirical case study of a 'ger', i.e. low income area in the Mongolian city of Darkhan using household data from a survey conducted in 2009. Thus we gain insight into both the water-related affordability situation of people in Mongolia checking the World Bank's thesis of missing affordability problems in this country as well as the comparative functionality of different affordability measures. Additionally, institutional as well as access-driven problems of water supply are introduced into the analysis. It is shown that affordability problems quite occur for considerable parts of the households but have to be distinguished depending on the economic causation: We argue that none of the regarded measures gives a satisfyingly contoured notion of affordability properly distinguished from the adjacent problems of poverty and access. A mere CAR analysis does not provide sound recommendations for water policy at all. In particular, problems of access entailing non-pecuniary costs of water provision have to be taken into account and might explain both problems of underconsumption and given CAR-affordability at the same time.

Keywords: Affordability, Mongolia, water supply, water access, potential affordability approach, residual income approach, non-pecuniary cost

1. Introduction

Cost-recovering prices for water resources are considered to be a key prerequisite of sustainable development. At the same time prices are expected to be affordable for social reasons. In course of an increasing establishment of a 'right to water' (see *Smets* 2000, *Salman/McInerney-Lankford* 2004, *Riedel/Rothen* 2006, *Gawel/Bretschneider* 2011b) the question of affordability gains more and more in importance for water policy. With regard to affordability of water supply particularly developing countries are affected hardly being able to compensate payment restrictions of private households by a system of social security.

A number of empirical studies is available broaching the issue of water affordability in developing (and emerging) countries.[1] However, for the measurement of affordability almost all of these studies rely on the ratio of water expenses and income, a measure we call the conventional affordability ratio (CAR).[2] Thus unaffordability is used to be indicated for households whose percentaged burden of water expenses exceeds a certain target ratio. This also applies for a recent statement of the *World Bank* on water affordability in Mongolia (*World Bank* 2010: 26). As noted in the literature, the CAR suffers from severe theoretical shortcomings yet (see *Gawel/Bretschneider* 2011a for an overview). Therefore, alternative measures have been examined in theoretical affordability research for many years now mainly in the housing sector (*Hancock* 1993; *Chaplin/Freeman* 1999; *Thalmann* 1999, 2003; *Kutty* 2005). In any case a sound concept of affordability with a dependable indicator is the indispensable base for an effective and pinpoint policy of water supply taking into account social concerns. Especially in the light of the 'right to water' debate further research on water affordability in developing countries is needed and of vast political relevance.

Up to now, the state of the art of theoretical affordability research has hardly penetrated the water domain. It has been mainly the housing sector on that theoretical considerations have been executed (see *Lerman/Reeder* 1987; *Stone* 1990, 1993, 2006; *Hancock* 1993; *Chaplin/Freeman* 1999; *Thalmann* 1999, 2003; *Kutty* 2005; *Lux* 2007). Only in recent years these considerations have also been applied – to a very modest extent – to utility markets. *Miniaci* et al. (2008) have worked on the affordability theory in the context of utility services, inter alia water services, and

[1] See *Ryneveld* 1995: South Africa, *Tiltnes* 1998: Palestine, *Morris/Parry-Jones* 1999: Uganda, *Foster* et al. 2000: Panama, *Anand* 2001: India, *Al-Ghuraiz/Enshassi* 2005: Gaza-Strip, *Bayrau* 2005: Ethiopia, *Smith*/*Green* 2005: South Africa, *Foster/Yepes* 2006: Latin America, *Israel* 2007: Bolivia, S*mets* 2009: developing countries in general, *Banerjee/Morella* 2011: Africa, *Lee* 2011: Malaysia.

[2] *Foster/Yepes* (2006) use a Potential Affordability Approach (PAA), i.e. related to a certain standard level of water consumption. *Ryneveld* (1995) uses a 'Residual Income Approach' (RIA). For the differentiation see section 3.1.

involve empirical figures of Italy.[3] *Kessidy* et al. (2009) have applied these considerations to developing countries but without any empirical figures. So far there has not yet been presented any inquiry in the domain of water provision for developing countries examining comparatively different indicators of affordability with the help of empirical data. For this purpose, this article uses household data of an empirical case study conducted in a ger area of the city of Darkhan, Mongolia. The empirical material will be used to analyse the performance of different indicators of affordability theory. Comparisons of different affordability measures have already been done by *Hancock* (1993) for the housing domain showing that the CAR has only little value. Moreover *Miniaci* et al. (2008) have provided a study in a similar manner for utility services, for water inter alia in Italy. *García-Valiñas* et al. (2010b) have also compared two different affordability measures for water consumption in Southern Spain but did not connect their framework to the theoretical progress achieved in housing economics. Hence, for developing countries where problems of water affordability are by far more existential such a comparative analysis is still lacking so far. This article intends to close this gap. Moreover we try to shed light on some institutional problems of measurement that may lead to a "wrong" indication of unaffordability. Thus our contribution aims at two objectives: On the one hand – for empirical value – the conditions of water supply in Mongolia will be examined. On the other hand – for theoretical value – different affordability measures will be comparatively evaluated. This analysis is done with the help of micro-level data for each household concerned.

The paper is organised as follows: In section 2 the framework of the case study and methods of the data collection are presented. In section 3 the affordability analysis is conducted - as a theoretical discussion of indicators at first (3.1), then with a concrete normative framework for our case study (3.2), and finally with the empirical results of our case study (3.3). Section 4 then discusses the findings of the comparative affordability analysis: 4.1 within our framework, and section 4.2 regarding additional aspects beyond the applied model. Section 5 eventually concludes.

2. Case Study about Water Supply in Ger Areas in Darkhan (Mongolia)

This paper is based on empirical research about water supply and sanitation in Darkhan, Mongolia. The focus is on peri-urban, low-income, largely informal settlements, known as ger areas, where

[3] *Miniaci* et al. (2007, and 2008) derived their approach – like the study on hand – from the discussion in housing economics. Even more studies examining water affordability in developed countries do not come back to the theoretical housing affordability literature - like *Fitch/Price* (2002, England and Wales), *Sawkins/Dickie* (2001, Scotland and 2005, Great Britain), *OECD* (2003, OECD countries) *Reynaud* (2006, France), *García-Valiñas* et al. (2010a and 2010b, Spain). Water affordability in transition countries is considered by *Fankhauser/Tepic* (2007).

people live in gers – the traditional Mongolian portable felt tent – and/or in simple, detached houses. In Mongolia, today, more than 50 percent of the urban population lives in ger areas. This not only holds for the capital Ulaanbaatar, but also for secondary cities like Darkhan or Erdenet. In ger areas, water is generally distributed via water kiosks and residents use self-built, unsealed pit latrines with negative impacts for environmental and public health.

Current literature reveals that ger residents in Mongolia consume 5 to 10 litres per capita per day (see *City of Ulaanbaatar* 2006, *NDIC* 2009, *UNDP* 2003: 26, 2010; *UNDP/UNICEF* 2004, *World Bank* 2010). This raises the question if they can meet their basic drinking water needs because this is significantly below the minimum norm which is considered to be 15 and 25 litres per day (*UNICEF/WHO* 2008) or 30-50 litres per day (*UNICEF/UNDP* 2008). Why do not the ger residents consume more water from the water kiosks? Non-affordability might be an important reason. According to a study conducted in Ulaanbaatar in 2002, poor and very poor families sometimes do not collect water from the water kiosks due to income restrictions, or else they often limit the family's consumption to 20-30 litres per day (*UNICEF* 2003). In a current report titled "Mongolia – Enhancing Policies and Practices for Ger Area Development in Ulaanbaatar" which has been developed by the World Bank the authors argue the converse. According to them "affordability of water purchased at kiosks is not a significant issue for residents" (*World Bank* 2010: 26). They show that household expenditures for water represent less than 3 percent of ger residents' average income, thus using a CAR measurement and presenting the data in income quintile. From their point of view the only reason for the low water consumption is inconvenient transportation, which means non-pecuniary cost or a so-called "problem of access" (Isreal 2007; Smeets 2009).

Against this background we want to follow up the question whether or not affordability of water supply is a significant issue for ger residents in Mongolia and whether or not the internationally recognised 3 percent rule for CAR is a reasonable approach for measuring affordability. This will be done on the basis of empirical data which has been collected within the framework of two German research projects[4].

In September 2009 a household survey has been conducted in a selected peri-urban ger area subdistrict in Darkhan, the second-largest city of Mongolia with a population of around 75,000 (see *Sigel* 2010, and *Sigel* et al. 2011). One of the aims was to assess household water supply and sanitation practices and household's socio-economic characteristics. A total number of 139

[4] IWAS (International Water Research Alliance Saxony) and MoMo (Integrated Water Resources Management in Central Asia: Model Region Mongolia). For more information see http://www.iwas-sachsen.ufz.de and http://www.iwrm-momo.de.

residents were surveyed in their homes. This corresponds to about 9% of all households in the study area. A stratified sampling procedure was utilised to select random samples from 9 microdistricts. Care was taken to ensure that roughly the same number of households was surveyed in each microdistrict and that the spatial distribution of the households within the microdistricts was as even as possible.[5] A first version of the household questionnaire was piloted with 3 households, and a second version with 14 households. The household survey was carried out within 10 days in September 2009 by a German researcher and three enumerators working in two groups working bilingually each, in Mongolian and in English.

3. Affordability Analysis

3.1 Measuring Affordability: Theoretical Approaches

The conventional and still widely applied measure for affordability is the conventional affordability ratio (CAR).[6] For the good water *w* this burden ratio *r* might be defined as the share of a household's expenditure for water ($p^w q^w$) in total income (equals total expenditure, budget *b*):

(1) $$r = \frac{p^w q^w}{b}$$

If the budget can be spent on either water *w* or a representative second good *c*, the ratio *r* can be graphically described as a ray from the origin in a microeconomic household model (fig. 1).

[5] Details on the organisation of the survey and on the process of questionnaire definition can be found in *Sigel* 2010; *Sigel* et al. 2011.

[6] For water in developing countries see *Tiltnes* (1998), *Morris/Parry-Jones* (1999), *Foster* et al. (2000), *Anand* (2001), *Al-Ghuraiz/Enshassi* (2005), *Bayrau* (2005), *Smith/Green* (2005) *Israel* (2007), *Smets* (2009), *Banerjee/Morella* (2011). For water affordability in developed countries see *Fitch/Price* (2002), *OECD* (2003), *Sawkins/Dickie* (2005), *Reynaud* (2006), and Lee (2011).

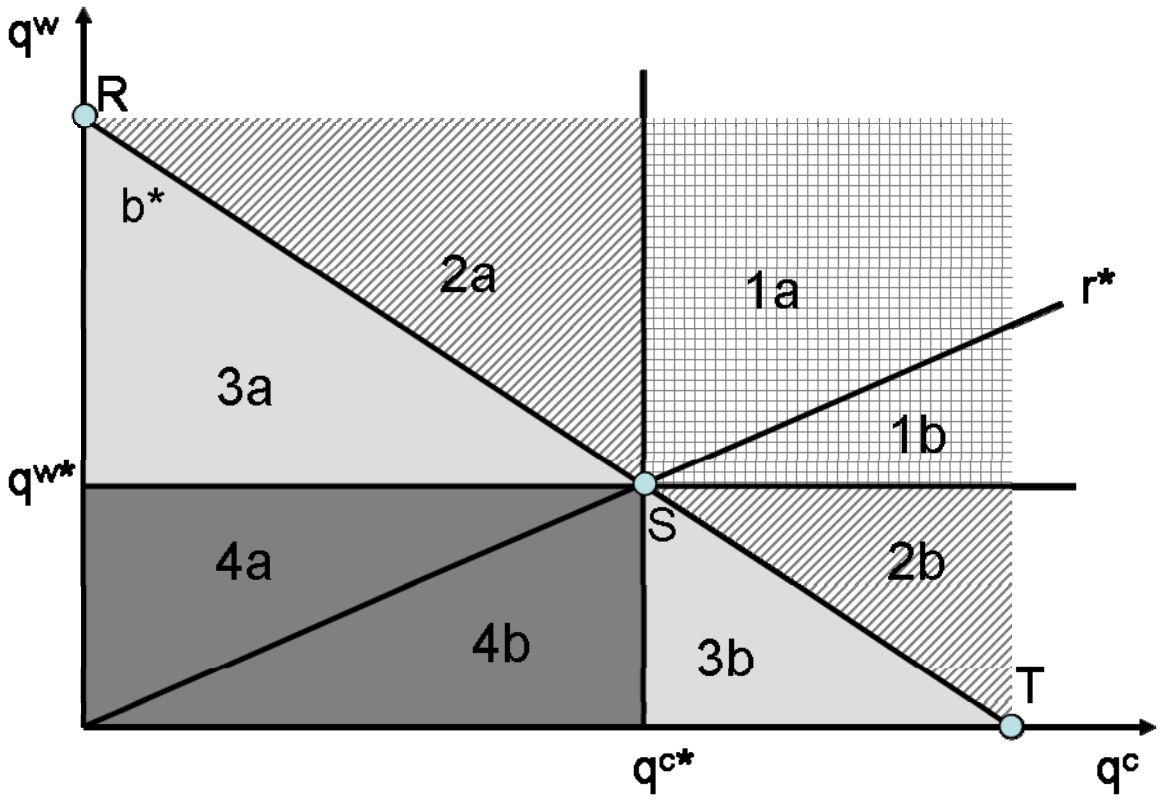

Fig. 1: Household model of affordability: Case differentiation of indigence.

In such a (q^c,q^w) diagram the ray of constant burden ratio follows the equation:

(2) $$q^w = \frac{r}{(1-r)} \frac{p^c}{p^w} q^c$$

For a given price vector p^c/p^w the ray indicates all consumption combinations of water and other goods that result in a certain but constant burden share in budget for water. The affordability ray intersects the budget line (e. g. in S) and thus divides it in two parts. According to the theorems on intersecting lines the amount of the burden ratio *r* can be described graphically as follows (fig. 1):

(3) $$r = \frac{\overline{ST}}{\overline{RT}},$$

that is lower part of intersected budget line divided through its total length. The higher the ray's slope the larger the burden share *r*.

To identify a state of (un)affordability a target ratio r* is set normatively. Prominent are the target ratios 3-5% set by the World Bank (see table 1), which is applied by various studies of water-affordability (e.g. *Bayrau* 2005 and *Smith/Green* 2005). Accordingly the CAR identifies problematic situations for households whose burden ratio is higher than the target ratio. Since in

the diagram a household's consumption decision shows up as one point, for all households ending up above the r*-line the CAR would indicate an affordability problem.

Source	Target Ratios for Water
World Bank	3-5%
UK Government	3%
US Government	2,5%
Asian Development Bank	5%

Table 1: CAR benchmarks for measuring water-affordability (in per cent of total household income/expenditure). Source: *Fankhauser/Tepic* (2007: 1040).

When using CAR for measuring the definition of a certain target ratio is a particular problem. *Lux* e.g. differentiates – working on the field of housing policy – between historical, statistical, and pragmatic approaches to define the ceiling ratio (see *Lux* 2007: 1110). However, in the microeconomic theory this normative definition can be seen as based on *two* normatively defined quantities within the household model (see again fig. 1): First, a sort of minimum quantity of the index good, "necessary to reach a decent standard of living" (*Kessides* et al. 2009: 11), represented by q^w* in the diagram. Second, a minimum quantity of all consumer goods except the index good, represented by q^c*. This forms a point S, the subsistence bundle and graphically the intersection point of the two minimum quantities q^w* and q^c*. To meet exactly this subsistence bundle we obtain an *implicit target ratio r** that shows us, for a given price vector, the "basic" burden to be born by the poorest. Therefore, the ray of *implicit* (or internal) target burden ratio r* exactly intersects point S. Pursuing the simple logic of the burden ratio, the diagram says: If a household chooses a consumption bundle above the ray given by *r**, it is facing affordability problems considering good *w*. The other way around, if a household chooses a consumption bundle below this target ray, it is not facing affordability problems in this respect.

For $r = r^*$ equation (2) simplifies to

$$q^w = \frac{q^w *}{q^c *} q^c . \quad (4)$$

A fourth normative straight line in the model is the minimum budget b*, called 'poverty (budget) line' (e.g. by *Kessides* et al. 2009: 11). This minimum budget b* is necessary to reach the subsistence bundle S. Thus S determines its position, while its slope depends on the relative prices of *w* and *c*. All households falling below the minimum budget are considered to be poor. Just like

r*, b* is actually a secondary normative term, derived from the minimum quantities (multiplied with the given price vector).

With these four straight lines there arise eight areas, from 1a to 4b in fig. 1. Thus this model differentiates eight situations in which a household may end up in. For their description we use two basic differences: firstly, under-consumption vs. non-underconsumption; and secondly, reasons for under-consumption, namely ability deficiency (due to budget constraints) vs. willingness deficiency (due to differing preferences). As a result we obtain four relevant areas 1 to 4 (see fig. 1):

(1) *Non-underconsumption* (grided area 1): Households therein are not facing any under-consumption problem. This is caused by two conditions: First, the household has a budget in his disposal which is greater than the target budget *b**. Second, on his budget line the household chooses a consumption bundle which avoids an underconsumption for both water w and the representative other good *c*. One might argue that there is no problem for social policy.[7] But the CAR (r) tells us that in area 1a unaffordability is incurred – wealthy households spend more than the target share on consumption of the index good. This misleading indication could be seen as 'wasting-related unaffordability'. In the housing domain *Lerman/Reeder* talk about a "taste for penthouse living" (*Lerman/Reeder* 1987: 390). In *Thalmann* (1999: 1935) this wrong indication is called 'type I misclassification' of the CAR.

(2) *Willingness deficiency-related underconsumption* (striped area 2): One of the goods is under-consumed but not due to budget constraints but following accordant preferences. Households in this area possess a sufficient income enabling them to reach an appropriate consumption level for both goods. However, they just do not choose accordingly. *Hancock* (1993: 131) calls it the case of 'perversity of preferences'. Though the CAR (r) tells us that for consumption points in area 2a again we face unaffordability: One might argue that this (pseudo) problem turns out to be a preference-driven (that is: voluntary) 'unaffordability'. But it is necessary to be careful: This is a willingness-driven underconsumption only in the microeconomic household model. However, in fact there might be certain 'non-income constraints' (see *Hancock* 1993: 131), that force a household to such a consumption decision. Thus these households are the most interesting for the affordability research (see *Miniaci* et al. 2008: 208) and at that point the theoretical research on affordability has to move on (see *Bretschneider* 2012).

[7] On the contrary there may arise the problem of overconsumption with respect to scarce resources like water. In this article we have to leave this unconsidered.

(3) *Underconsumption due to both a deficiency of willingness and of ability* (light grey area 3): Here the households have an available income smaller than the target budget *b**. These households cannot reach the subsistence bundle, but they are somehow making a wrong decision anyway: They are underconsuming one good but, at the same time already consuming more than necessary from the other. Here we are facing a deficiency of both ability and willingness. Accordingly, meritoric and distributional problems arise at the same time. Considered graphically the paternalistic third party would like the household to shift on his budget line at least until the point where the dark grey area starts. That is to say, to reduce the consumption of the 'overconsumed' good in favour of the underconsumed one; to underconsume the latter less intense. Systematically after this motion – that is the difference to the same scenario in the striped area – the problem of ability could be tackled. Regarding the CAR (*r*) in this field we get a diagnosis of 'unaffordability' for the top left area 3a ignoring the mixed-conditioned underconsumption. On the other hand the 'affordable'-diagnosis for households down left (area 3b) ignores the deficiency of ability, they have to deal with.

(4) *Pure ability deficiency-related underconsumption* (dark grey area 4): Those households ending up in area 4 consume insufficient quantities of both goods due to a pure distributional problem with an actual deficiency of ability. This area includes those who "do not even have the opportunity to make [an] inappropriate decision." (*Glied* 2009: 15).[8] According to the CAR (*r*) poor households in area 4b do not face any affordability problems: Since they are consuming a very small quantity of the good they are considered having no affordability problem. But obviously it is not a convincing solution to overcome affordability problems by underconsumption. Rather the critical shortage given in area 4b depicts a severe case of unaffordability. In the housing literature *Lerman/Reeder* talk about 'living in a shack' (*Lerman/Reeder* 1987: 393), and *Thalmann* (1999: 1936) about a 'type II misclassification' of the CAR.

Having described the model we can now consider two prominent alternatives to the CAR: The 'Potential Affordability Approach' (PAA) (see *Lerman/Reeder* 1987; *Thalmann* 1999; *Foster/Yepes* 2006; *Miniaci* et al. 2008; *Kessides* et al. 2009; *García-Valiñas* et al. 2010a, 2010b) driven by the insight that households may underconsume water and be indicated as having no problem (3b and 4b) and conversely may overconsume water and be indicated as having a problem (area 1a and 2a). Thus instead of the factual expenses there are used *potential* expenses for the index good, e.g. water, to display the burden share; i.e. the water price p^w is multiplied with the *standard* consumption level q^w*.

[8] In Figure 1 these are households with a budget equal or smaller than the budget that intersects the ordinate at q^w*.

(5) $$r_p = \frac{p^w q^w *}{b}$$

In fig. 1 fictiously a motion on the household's budget line (parallel to the minimum baudget line b*) is to be made, until the point where the q^w*-line is intersected (see *Gawel/Bretschneider* 2011a: 26). At that point the comparison with r* is made: There is an affordability problem for the household if $r_p > r^*$. This leads to the result that all households ending up under the minimum budget b* are considered to face affordability problems. We have to notice though that affordability in this concept is simply reduced to the problem of low income (see *Thalmann* 2003 and *Gawel/Bretschneider* 2011a: 30). Thus, the PAA goes back to the recommendations of academic welfare economics just to separate allocative and distributive problems. The PAA obviously indicates just problems of income deficits, i.e. problems of general poverty instead of water-related affordability problems.

The second alternative is the 'Residual Income Approach' (RIA), a measure working with a difference instead of a ratio (see *Dolbaere* 1966, *Grigsby/Rosenburg* 1975, *Stone* 1990, 1993, and 2006, *Hancock* 1993, *Thalmann* 1999, and 2003, *Kutty* 2005, *Miniaci* et al. 2008, *Kessides* et al. 2009). Basically the residual income is defined as

(6) $$b_{Res} = p^c q^c = b - p^w q^w .$$

For identifying affordability problems, a minimum residual income b_{Res}* is to be normatively defined. In our model it equates the value of the minimum quantity q^c*. A problem is identified if $b_{Res} < b_{Res}$*. In fig. 1 all households ending up left of the q^c* straight line are considered to face affordability problems.

There are two more variations of the RIA. The first one is a RIA based on standard consumption levels just like the PAA. As shown in *Gawel/Bretschneider* (2011a: 28) the households identified having affordability-problems are exactly the same like those identified by the PAA basing on a ratio. The second variation of the RIA adds a second condition to the one of the simple RIA (see *Hancock* 1993: 135, *Miniaci* et al. 2008: 207f.). Accordingly a household is facing an affordability problem if

(7) $$b - p^w q^w < b_{Res} *$$

or

$$b - p^c q^c < p^w q^w * \text{ with } q^c > q^c * .$$

The intention of such a condition is to include households in the as problematic stated areas that putatively solve affordability problems by underconsuming water (see *Miniaci* et al. 2008: 207 f.). Thus for this definition, a 'double RIA', in fig. 1 all areas except area 1 are considered to face affordability problems. This equates all household which underconsume either water or other goods. In our study we apply this 'double' condition as RIA as presented in equation (7).

If we define the PAA and the RIA like this, the graphical difference between these two criteria is the striped area 2 (see fig. 1). This is the area, where – according the microeconomic model – a deficiency of willingness may be diagnosed. But as mentioned above it is important to see that there may be certain 'non-income constraints' (see *Hancock*: 1993) that force the household to a certain consumption bundle, that appears to be unreasonable from a paternalistic perspective. However the RIA as such is not able to separate 'non-income constraints' from a deficieny of willingness in the striped area 2b. The concern of affordability refers only to the primary.

Appearently there is no final concept and measure for affordability. But these are three prominent concepts of water-related indigence in discussion, which can be generalised to three concepts of indigence and be summed up as follows (see table 3 and fig. 2). The first concept is the burden share, the basic of the CAR (table 2, first row and fig. 2-1). This concept alleges a problem if a household spends more on utility good consumption than the target ratio allows (areas 1a+2a+3a+4a in fig. 1). The second concept indicates income restraints (second row and fig. 2-2). It suggests that areas 3 and 4 are problematic, i.e. households earn less than needed to afford the subsistence bundle. This concerns the potential affordability approaches (PAA).[9] Finally from the meritoric perspective of underconsumption public policy is requested to prevent consumption in areas 2+3+4 (third row and fig. 2-3). The appendant measure is the ('double') RIA.

[9] This also applies, as already mentioned, to a RIA that is based on standard consumption levels of water.

	Concept of Indigence	**Measurement**	**Areas in Fig. 1**	**Problem**
1	Burden Share	Conventional Affordability Ratio (CAR)	1a+2a+3a+4a	Household spends more on utility good consumption than the target ratio.
2	Budget Restraints	Potential Affordability Approach (PAA)	3+4	Household earns less than needed to afford the subsistence bundle.
3	Underconsumption	Residual Income Approach (RIA)	2+3+4	Household consumes less than required.

Table 2: Three concepts of indigence.

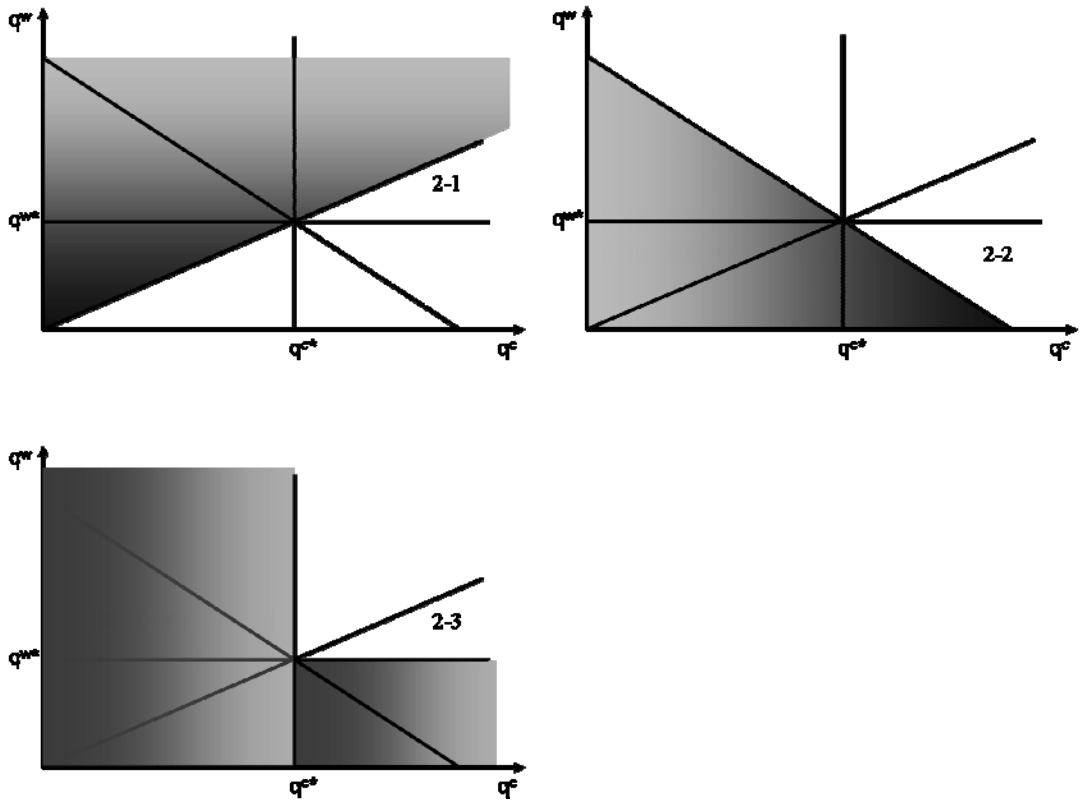

Fig. 2: Three concepts of indigence – graphical analysis.[10]

Comparing these concepts of indigence the CAR appears to be particularly unqualified for indicating potential need for public action. Instead it ignores relevant settings (area 4b) and on the other hand it turns unproblematic consumption patterns into pretended problem cases (area 1a). An affordability analysis relying solely on the CAR like it has been conducted for example by the *World Bank* (2010) in the Mongolian study suffers from severe shortcomings, summarised as follows:

[10] Following the illustration in *Hancock* (1993: 130 f.) and *Gawel/Bretschneider* (2011a: 24).

1. There is no correlation to a certain minimum consumption level of the index good. Poor households consuming a very/too small quantity of the good are considered having no affordability problem (area 4b).

2. Similarly there is no correlation to a maximum consumption level of the index good. Wealthy households 'wasting' the index good are possibly considered having an affordability problem (area 1a).

3. There might be cases of under-consumption which are caused by 'perversity of preferences', not by budget restrictions (area 2a).

4. Households are characterised by different amounts of members (household size), different climatic/regional conditions, and different technological endowments. These non-income conditions lead to a different necessity a fixed ratio measure cannot answer to properly.

5. Another aspect is that the functionality of the CAR depends on certain requirements of the price and income elasticity of demand as well as on the tariff function $p(q)$ (see *Gawel/Bretschneider* 2011a: 18). However, for our case study the latter aspect is not relevant due to p = const.

3.2 Normative Framework for the Case Study

In order to analyse affordability problems in Mongolia and to compare the performance of the three concepts of water-related indigence we need to determine the normative terms b* and r*. Hence, we also have to fix the minimum quantity of water q^w* and the minimum quantity of the reference good q^c*.

For the definition of q^w* we employ an average value of 30 litres per capita per day. This is approximately a mean value of what different international organisations suggest. Standard values of drinking water required to meet basic needs amount to a spectrum of 15 to 25 (*UNICEF*/*WHO* 2008), respectively to 30 to 50 litres per capita per day (*UNICEF*/*UNDP* 2008). Using the value of 30 litres per day, in fig. 3 an amount of 900 litres per month (30 days) is displayed.[11]

Since there is no physical definition of the virtual variable q^c* a minimum budget b* is defined instead: For our purposes we choose a poverty line (i.e. a minimum income) of 92,000 Mongolian Tugrik (MNT) per capita a month.[12] This figure is taken from the Mongolian Statistical Yearbook 2009 (*NSOM* 2010) where a "minimum subsistence level of population per capita a month" is

[11] There are studies that focus on the estimation of basic water need, see *García-Valiñas* et al. (2010a: 2697f.) with further references.

[12] This equates about 73 USD (September 2011).

given for different years and regions.[13] For the "Central Region" where the city of Darkhan is located the "minimum subsistence level" quoted for the year 2010 is 91,700 MNT per capita a month.[14] This number is rounded up to 92,000 MNT. We have chosen to convert the per capita minimum income to the household level by multiplying the monthly per capita minimum income (92,000 MNT) by the number of household members.[15]

Beside these two normative figures the water price at the water kiosks in Darkhan is important which amounts to 2 MNT per litre.[16] Fig. 3 shows the micro-model employing the previously mentioned Mongolian numbers for q^w*, b* combined with a water price of 2 MNT per litre. It is a special feature that we can work here with a constant volumetric price. This allows us to consider price and quantity separated, just like in the traditional microeconomic perspective.[17]

If a household possessing exactly the minimum budget of 92,000 MNT spends the whole amount for water, it is able to purchase 46,000 litres (see the ordinate intercept in fig. 3). If a household consumes the minimum amount q^w* for water it spends 1,800 MNT per month (not displayed in the picture). In this case a household disposing of the minimum budget consumes the subsistence bundle S. In this point the burden ratio for water consumption approximately amounts to r*=2%.[18] This can be considered a derived or implicit target ratio in contrast to the postulated 3%-target ratio used by the *World Bank* (2010: 26).

[13] The minimum subsistence level of population in Mongolia "refers to a minimum consumption level expressed in monetary value; and minimum consumption level refers a scientific estimation on quantity of consumption to satisfy basic survival requirement defined by food and non-food consumption basket" (NSOM 2010: 295).

[14] The differences between the five distinct Mongolian regions are marginal. The minimum value is 91,500 MNT (Khangai region) and the maximum value is 101,600 MNT (Ulaanbaatar region).

[15] This method assumes that all members within the household consume equal shares of the total consumption and costs increase in proportion to the number of people in the household. It neglects that due to economies of scale and different needs mainly based on age and gender the needs of a household do not grow in a proportional way with each additional member. There are other methods that take into account these aspects (equivalence scales) but there is not one accepted method. The National Statistical Office of Mongolia simply uses a per capita adjustment for household composition (*NSOM* 2009: 63-64).

[16] This water price holds for the date of the survey, September 2009.

[17] In contrast *Miniaci* et al. (2008) in their study on water affordability in Italy have worked with expenses, i.e. price and quantity multiplied, due to more complex tariff structures.

[18] Fig. 3 assumes a single-person household. The used figures apply accordingly multiplied for multiple-persons households, whereas the derived target ratio r* of 2% of course remains the same.

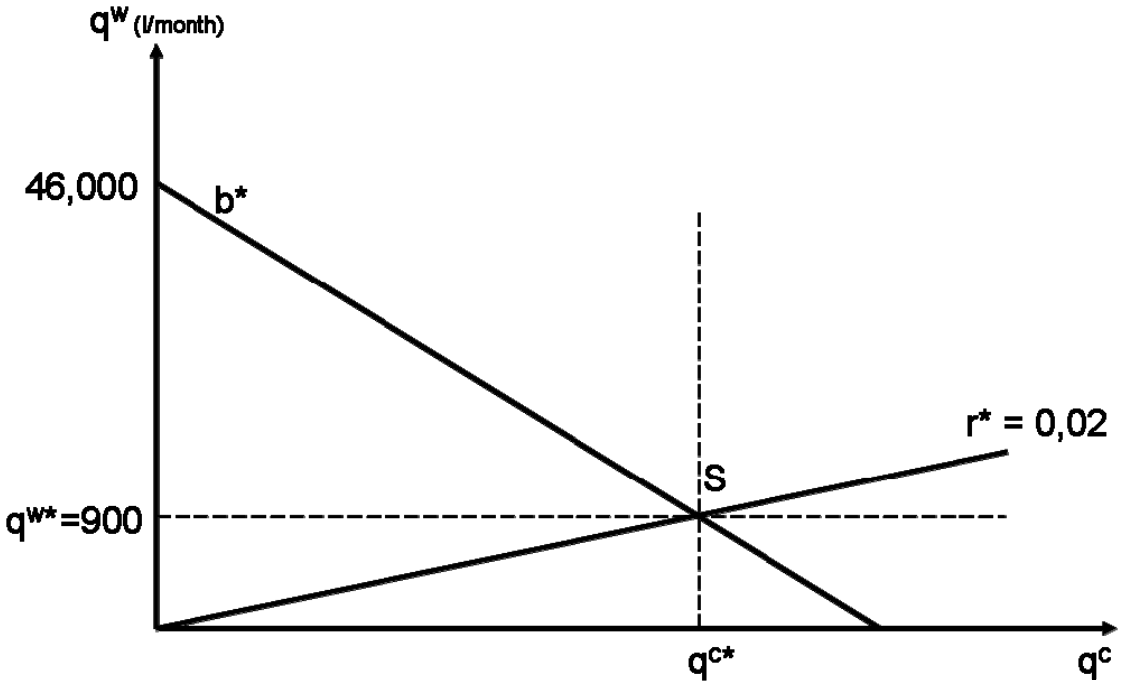

Fig. 3: Household model of affordability: Normative set up for the case study.

3.3 Statistical Evaluation of Affordability Data of the Mongolian Case Study

The household survey which has been conducted in a selected ger area subdistrict in Darkhan (see section 2) entails data about household income, household size and household expenditure on kiosk water.[19] The data of household income and household size show that 82% of the households surveyed are poor, i.e. earn less than 92,000 MNT per capita per month. The least income amounts to 6,500 MNT per capita per month, the highest to 333,333 MNT per capita per month.

The following table 3 shows the household income distribution for all households by ventile of income. For every income group the average annual household income, the average annual household expenditure on kiosk water and the average affordability ratio has been calculated.[20] A household in the lowest ventile of income on average earns 676,000 MNT per year and spends 23,117 MNT per year on kiosk water. This corresponds with a mean CAR of 7,4%. Figure 4 shows the affordability ratio gradient for all 20 income groups.

[19] The household income has been measured by a direct question ("what is the total monthly income of this household?"). The household expenditure on kiosk water has been calculated based on the household water consumption (underlying question: "how many litres of water does your household consume every day?") and the water tariff which was 2 MNT per litre at the date of the survey.

[20] The average affordability ratio of the income groups has been calculated on the basis of the ratio of every single household within every group (and not based on the average values for income and expenditure on kiosk water on group level).

Income Ventile (5% of households each)	Average Household Income [MNT/year]	Avergae Household Expenditure on Kiosk Water [MNT/year]	CAR [%]
1 (lowest)	676,000	23,117	7.4
2	1,016,000	22,265	2.2
3	1,260,000	23,117	1.8
4	1,490,000	28,592	1.9
5	1,620,000	29,565	1.8
6	1,880,000	30,417	1.6
7	2,066,000	45,017	2.2
8	2,174,000	31,633	1.5
9	2,400,000	30,417	1.3
10	2,400,000	54,142	2.3
11	2,600,000	32,242	1.3
12	2,700,000	30,417	1.1
13	2,900,000	43,070	1.5
14	3,480,000	45,017	1.3
15	3,600,000	39,542	1.1
16	3,992,000	45,625	1.1
17	4,610,000	40,758	0.9
18	4,800,000	30,417	0.6
19	5,900,000	29,200	0.5
20 (highest)	8,920,000	49,883	0.7

Table 3: Affordability ratio by ventile of income (n=120)
(Source: Author's calculations from 2009 household survey).

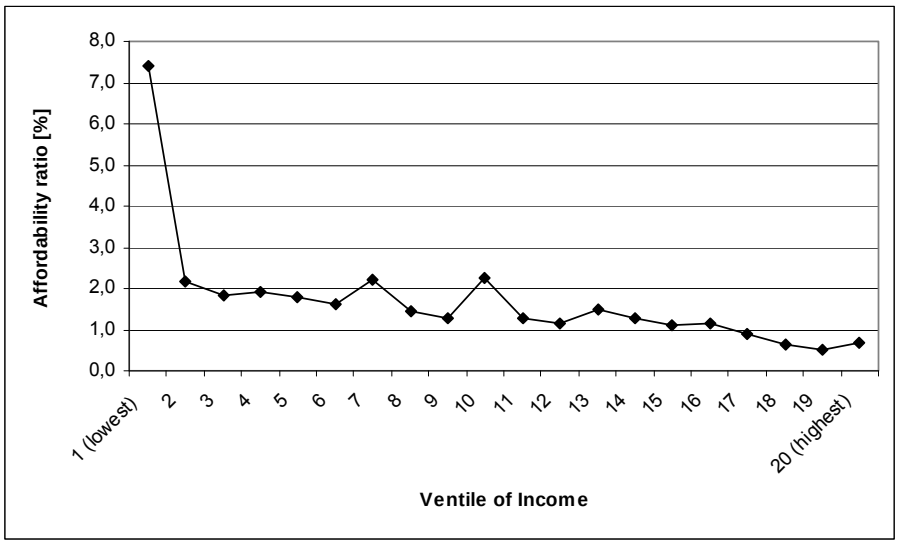

Fig. 4: Affordability ratio gradient for ventile of income (n=120)
(Source: Author's calculations from 2009 household survey).

The – mostly implicit – assumption for the application of the CAR is that the burden ratio declines the higher the income gets. This is of course not a priori the case, it rather depends on the characteristics of the demand function.[21] It becomes even more demanding when complicated tariff functions prevail. In our study it is more simple, as there is a constant price of 2 MNT per litre. In this case the only condition for a declining burden share for increasing income is an income elasticity less than 1 (see *Bretschneider* 2012), i.e. absolute resp. relative inferiority of the water demand. This should be the case for the whole sample, but also for each step of increasing income. But as one can see in fig. 4, the latter is not the case. Five times out of 19 steps the CAR *in*creases moving from left to right in fig. 4. For these steps the water consumption in fact is income elastic.

The affordability ratio for the bottom ventile of 7,4% is conspicuously high. For all other income groups the affordability ratio amounts to less than World Bank's target ratio 3%. If one calculates the affordability ratio for quintiles of income, the affordability ratio of the bottom quintile of income amounts to 3,3%, i.e. almost within the norm of the World Bank. This shows that the result of the 3%-application depends strongly on the number of statistically created income groups: The more detailed the grouping, the bigger the range of affordability ratios. Regarding the World Bank study, the 3% percent limit presumably would have been exceeded if the data had been presented in deciles and not in quintiles (the affordability ratio of the bottom quintile of income earners already is 2,8% i.e. very close to 3%). Thus beside the question of adequate definition od the target ratio r* this is a second aspect than one has to care for, for an internal debate of the CAR.[22]

For further analysis a simple linear regression model was applied to the relationship between water consumption and income (see fig. 5) (for more sophisticated multiple regression models of water demand see with further references *Arbues* et al. 2003, *Dalhuisen* et al. 2003, *Worthington/Hoffman* 2008).

[21] *OECD* (2003: 40) shows examples where the burden ration declines monotonously. On the other hand *Fankhauser/Tepic* (2007) use data applying the CAR where the burden share does not strictly decline with income (see *Gawel/Bretschneider* 2011a: 14 f.).

[22] Here we unfold a discussion that mainly criticises the CAR as such. However, these two internal aspects concern how a CAR has to be treated once it is applied.

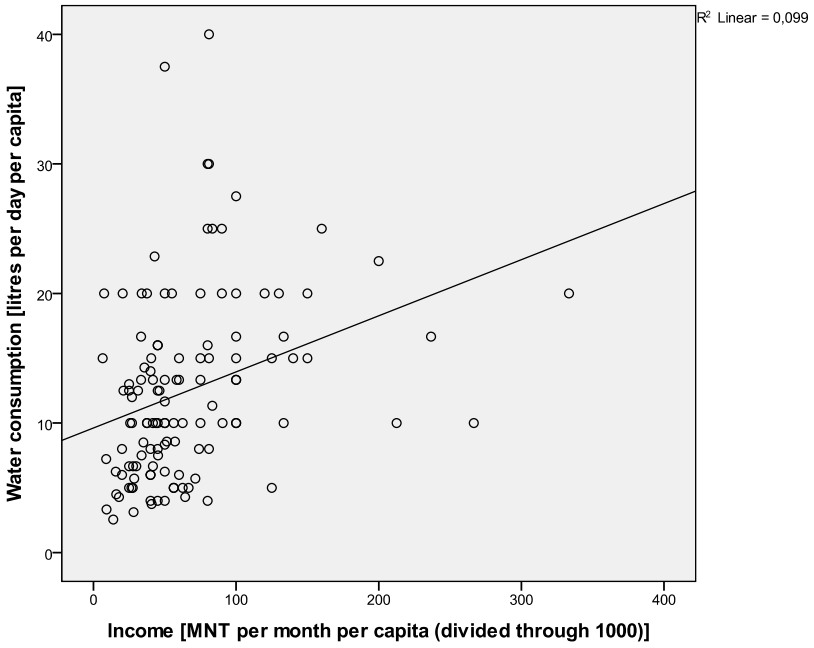

Figure 5: Simple linear regression between water consumption and income (n=120) (Source: Author's calculations from 2009 household survey).

There are two households with an extraordinary high water consumption of 40 and 38 litres per capita per day respectively. A deeper look in the dataset gives a plausible explanation for these households consume a lot of water for horticultural activities or livestock breeding. The very high income of 333,000 MNT per month per capita of another household may be explained by the fact that the dwellers own a lot of animals (100 goats, 100 sheep, horses and yaks).

There is a slight positive correlation between the level of water consumption q^w and the income level (r^2=0,099, Sig. 0,000) (see figure 5). The regression equation is:

$$q^w = 9{,}616 + 0{,}043b \ .$$

According to the regression equation for a mean income (66,228 MNT per month per capita, divided by 1,000) the water consumption amounts to 12,46 litres per day per capita. The overall income elasticity of water demand follows as:

$$\eta_{q^w b} = \frac{dq^w}{db} \times \frac{b}{q^w} = 0{,}043 \times \frac{66{,}228}{12{,}46} = 0{,}23$$

Hence, the water demand is (incompletely) income inelastic: This is a common result for water (see *Worthington/Hoffman* 2008: 862 with further references). This (relative) inferiority actually speaks in favour of the CAR. But such an overall elasticity misses certain details, as we have mentioned in discussion of fig. 4, where we stated that there are indeed income elastic steps when income is increasing.

With our collected data it is now possible to classify each of the 120 households in the microeconomic model we have normatively prepared in section 3.2. We are able to identify in which area a household ends up in (see fig. 6). In the illustration however a second CAR-target ray is illustrated, i.e. the target ray of r*=3% as used by the World Bank (see *World Bank* 2010). Its slope is obviously higher than the one of the derived CAR of 2%. This leads to twelve areas from 1aa to 4b. For each area the percentage of households is displayed, that end up in the accordant field.

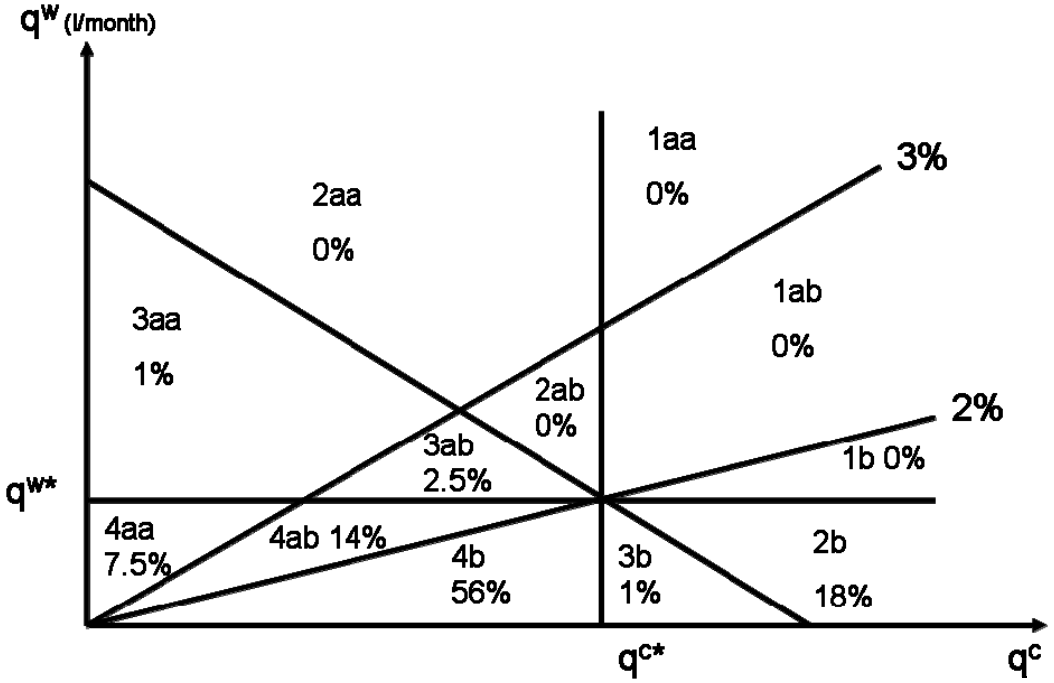

Fig. 6: Household model of affordability: Cases and frequency of occurrence according data of the Mongolian case study.

Along the lines of our theoretical considerations we now can pool a bundle of areas accordant the mentioned concepts of indigence (see table 4). In the head of the table the concepts of indigence are displayed. Now there are two criteria of CAR: the external one used by the World Bank (3%, CAR_1) and the internal one derived from minimum norms for a household's budget and water use (2%, CAR_2). Aside there is the concept of budget restraints being identical with the PAA. Finally we apply the criterion of underconsumption (RIA).

Case Group / Area	Features	Indication according to external target ratio 3% (CAR_1) ($r > r^*_1$)	Indication according to derived (internal) target ratio 2% (CAR_2) ($r > r^*_2$)	Indication according to household's budget restraints (PAA) ($b < b^*$)	Indication according to under-consumption (RIA) ($q^w < q^{w*} \vee q^c < q^{c*}$)	Share of households in the case group
1aa (grided)	$q^w \geq q^{w*}$ $q^c \geq q^{c*}$ $r > r^*_1$ $b \geq b^*$					**0%**
1ab (grided)	$q^w \geq q^{w*}$ $q^c \geq q^{c*}$ $r^*_1 \geq r > r^*_2$ $b \geq b^*$					**0%**
1b (grided)	$q^w \geq q^{w*}$ $q^c \geq q^{c*}$ $r \leq r^*_2$ $b \geq b^*$					**0%**
2aa (striped)	$q^w \geq q^{w*}$ $q^c < q^{c*}$ $r > r^*_1$ $b \geq b^*$					**0%**
2ab (striped)	$q^w \geq q^{w*}$ $q^c < q^{c*}$ $r^*_1 \geq r > r^*_2$ $b \geq b^*$					**0%**
2b (striped)	$q^w < q^{w*}$ $q^c \geq q^{c*}$ $r \leq r^*_2$ $b \geq b^*$					**18%**
3aa (light grey)	$q^w \geq q^{w*}$ $q^c < q^{c*}$ $r > r^*_1$ $b < b^*$					**1%**
3ab (light grey)	$q^w \geq q^{w*}$ $q^c < q^{c*}$ $r^*_1 \geq r > r^*_2$ $b < b^*$					**2,5%**
3b (light grey)	$q^w < q^{w*}$ $q^c \geq q^{c*}$ $r \leq r^*_2$ $b < b^*$					**1%**
4aa (dark grey)	$q^w < q^{w*}$ $q^c < q^{c*}$ $r > r^*_1$ $b < b^*$					**7,5%**
4ab (dark grey)	$q^w < q^{w*}$ $q^c < q^{c*}$ $r^*_1 \geq r > r^*_2$ $b < b^*$					**14%**
4b (dark grey)	$q^w < q^{w*}$ $q^c < q^{c*}$ $r \leq r^*_2$ $b < b^*$					**56%**
Sum of households with identified indigence		**8,5%**	**25%**	**82%**	**100%**	

Table 4: Affordability case groups and their frequency of occurrence (grey areas indicate an affordability problem)

In the rows we find the twelve areas as they can be differentiated according to fig. 6. Each concept of indigence identifies for each area whether there is an affordability-problem for the household (grey) or not (white). So far this is just a different illustration of the fact, that the concepts vary a lot in their respective diagnosis (see again fig. 2). Only for three areas they show the same result (1b, 3aa, and 4aa).

In the very right column the empirical data of our case study is added, i.e. the percentage values already displayed in fig. 6. The bottom row then sums up the percentage of households for which an affordability problem can be diagnosed, according to a certain concept. The difference of diagnosis is astonishing at first sight. One indicator identifies problems for 8.5% of all households, another one for all (100%).

4. Discussion

4.1 Problems of Contradicting and Misleading Measures and the Role of Non-Pecuniary Cost

As seen in section 3.1 the contradiction between the three concepts of indigence are already remarkable from a theoretical point of view. With the help of empirical figures, as seen in section 3.3, these contradictions turn out to be even more relevant in practice. The number of households facing an affordability-problem is quite small for the CAR (8.5% and 25%) whereas for the 'improved measures' of PAA and RIA the corresponding shares are much higher (82% and 100%).

With a share of 8.5% of unaffordability (applying an external CAR of 3%) the *World Bank*'s (2010: 26) findings (no affordability problems at all) no longer hold true. Moreover, the application of an internal target ratio (2%), meeting the local conditions, even shows an increase of households facing affordability problems up to 25%.

In addition, 82% of the households face affordability problems according to the PAA. As explained in section 3.1 the PAA basically gives information about income poverty. There might be a genuine affordability problem underneath, which is superimposed by the problem of general poverty, though. Finally, all of the households face affordability problems according the RIA (100% of the sample). These are all households identified according the criterion of underconsumption; i.e. the PAA plus the area 2 in fig. 1. Empirically there are 18% of the households ending up in area 2b. These are households that possess the necessary minimum budget b* (i.e. 92.000 MNT per month) but do underconsume water anyway. In section 3.1 it was already mentioned that it is theoretically unclear, whether households of that type 'do not want' to

consume an amount that is paternalistically considered to be at least necessary (willingness deficiency) or whether this decision is due to certain non-income constraints.

For our case study we empirically find that *all* households that are not poor (income higher than b*) in fact do underconsume water (area 2b). This might be considered as indication that there is a somehow dominant non-income constraint. Especially for problems of water provision in developing countries non-income constraints of access are widely discussed (see e.g. *Anand* 2007, *González-Gómez* et al. 2011, *Sorenson* 2011). This problem is also considered by the World Bank*:* It is argued here that underconsumption was due to "inconvenient transportation" (*World Bank* 2010: 26). Obviously, we face in this field potentially superjacent problems of poverty, affordability and non-pecuniary cost of access. Fig. 7 displays a systematic framework that shows how the problems of affordability and of access interact (see *Gawel/Bretschneider* 2011b: 22).

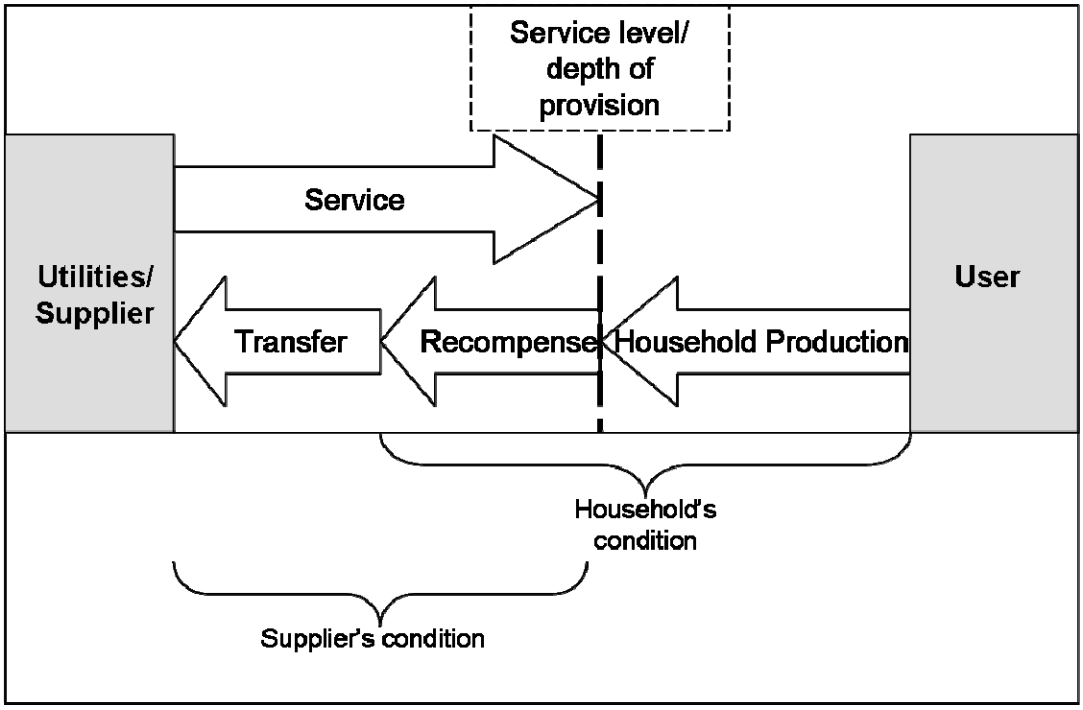

Fig. 7: Contractual relation between water supplier and user.

This framework is based on the contractual relation between water supplier and user. The crucial category is the service level, i.e. how far the service approaches the household. If there is no home delivery of water – typical for many areas in developing countries, e.g. in our case study – there will arise certain costs of "household production" (see *Becker* 1965). This is the effort to go to the kiosk and carry water (problem of costly access).

However, the service fulfilled by the utilities has to be financed in some way. Economic reasons speak up for a coverage by consumers' recompense. In case of absence of public subsidies the

consumers' recompenses remain the *only* source for financing the service. The recompense – raising the question of affordability – and the household production – raising the question of access – in conjunction represent the 'household's condition', i.e. pecuniary and non-pecuniary costs for water consumption. The 'supplier's condition' on the other hand, i.e. the costs of supply, however depends on the service level. For developed countries the service is (partly) financed by transfers – in order to keep the pecuniary costs for users affordable.

If one imagines the arrows in fig. 7 as flexible in their length, it becomes plausible how recompense and household production can substitute each other. Factually (not necessarily normatively) this is the solution for water provision of financially poor households as many households in developing countries. To keep the service affordable, the service level is reduced and the household production, the cost of access is raised at the same time.

The considerations on the PAA and the RIA show that we face a complex constellation of social policy problems in which a genuine affordability problem is not easy to be identified. The intense problems of poverty (referred to by PAA) and of underconsumption and access (addressed by RIA) appear to superimpose the actual problem of affordability which is still not yet defined in a theoretically consistent way. Contrariwise a clear denial of affordability problems cannot be confirmed here either.

4.2 Institutional Pitfalls of Measuring Water-Related Affordability: The Case of Mongolia

Affordability analysis is additionally compromised by some institutional pitfalls of empirical data collection. First of all, the figures of water expenses include some pitfalls. One source of error is obviously the household's ambivalent awareness of what it consumes of and spends on water. In the household survey the data on water expenses based on the question "how much money does your household usually spend on water?" is significantly higher than the calculated data based on the water price and the enquired data on water consumption (underlying question: "how many litres of water does your household consume every day?"). In this paper we have used the calculated data because we assume that the residents are much more aware of how much water they consume than how much money they spend on water.

But also regarding water consumption quantity we face several stumbling blocks for sound empirical work: The household survey revealed that 43% of the residents interviewed not only use water from the water kiosk but also additional water sources like water from rainwater harvesting or water from other households with private wells (presumably households located outside the study area). Furthermore, the low water consumption in the study area can partially be explained

by the fact that only 19% of the respondents reported having their shower or bath, at least sometimes, at home. Usually they go to other people's homes, mainly those of relatives (58%), and/or to the public bathhouse (54%) located close to the study area to have a shower or bath (see *Sigel* et al. 2011). Last but not least the water purchased at the water kiosk (or gained through additional water sources) is not only used to meet basic human needs. Some households also use water for horticultural activities or livestock breeding (see section 3.3). We have tried to account for these distortions in our affordability analysis but we do not have enough data about the water quantities and costs linked to the different water practices.

In the previous section the role of non-pecuniary cost and accordingly the costs of "household production" (access) have been described. In the Mongolian case study the location of the water kiosks is such that most residents (62%) need up to 10 minutes (in total) to fetch water, 33% need 11 to 20 minutes and 2% need 21 to 30 minutes. Only 3% need 30 minutes or longer.[23] Beyond the effort to go to the kiosk and carry water the residents have to cope with constraints regarding water availability. Water is only available during opening hours, i.e. every day except for Wednesdays and Sundays, from 9 am to 8 pm, with a mid-day lunch break. Furthermore, 2 out of the 11 water kiosks are still delivered by truck (truck-fed kiosks) and not connected to the central water supply network (pipe-fed kiosks). Water availability and the quality of water from pipe-fed water kiosks is much better than that from truck-fed kiosks.[24] Sometimes the water supply service breaks completely down, for example during winter time, when the risk occurs that the water in the pipes is freezing.

Certainly, a sound affordability measurement has to take these institutional pitfalls into account in order to avoid distorted results. As far as security of kiosk water supply is at risk and costly in terms of inconvenience (and certain alternatives for water provision are at hand such as bathhouses) underconsumption of kiosk water is unsurprising - so is the lack of a relevant burden derived from kiosk water expenses. But the excess burden imposed by non-pecuniary cost or substitutions cannot be measured only regarding expenses spent on kiosk water. Thus underconsumption by the poor may render unaffordability invisible but not inexistent.

[23] Hence, the time needed to collect water generally does not exceed the maximum standard of 30 minutes as defined by the Joint Monitoring Programme for Water Supply and Sanitation which aims to monitor the achievement of the Millennium Development Goals.

[24] According to the local service provider USAG, water consumption in the study area has increased fivefold since the 9 water kiosks have been connected to the central grid (interview statement September 2010).

5. Conclusions

A theoretically consistent affordability criterion is needed to derive sound recommendations for water policy. For empirical measurement however the conventional affordability ratio (CAR) is still widely used although especially housing affordability literature has shown its shortcomings: CAR is theoretically defective and hence practically misleading. Consequently, some alternative affordability measures have been developed among them the 'potential affordability approach' (PAA) and the 'residual income approach' (RIA) trying to overcome the weaknesses of a simple CAR measurement. Applications of new approaches and in particular empirical comparisons of alternative measures for affordability have hardly been conducted in the water domain so far. The PAA can be considered theoretically consistent but it goes back to the recommendations of academic welfare economics suggesting just to separate allocative and distributive problems of water use: Once social policy succeeds in easing relevant income restrictions resource prices can be set in an efficient way. In practice, this 'Nirvana' condition cannot be fulfilled even less by authorities or firms that decide on utility tariffs. For practical water or energy resources management the problem of affordability of utility service prices cannot be solved this way. The RIA, as considered here, is identical with the notion of underconsumption. Additionally to households already identified by the PAA, households are presumed by the RIA to have problems that underconsume water (or the 'other' goods) although possessing a sufficient budget. For these households it is crucial to identify whether they just prefer such a consumption bundle (matter of willingness) or whether there face certain 'non-income constraints' (matter of ability). One important non-income-constraint is the problem of access. The household data of our case study indicates that this is (beside the problem of poverty) a second problem superposing the actual problem of affordability.

PAA and RIA are rather parts of the picture to create a sound definition of affordability. A reliable notion of affordability has not yet been found so far. As *Muennig* et al. (2011) put it: "We all want it, but we don't know what it is." And in the approximation of affordability issues the simple CAR appears to be least helpful.

Although the notion and the measuring of a genuine affordability is that difficult we feel that a premature denial of affordability problems might be wrong as well. Thus the World Bank's Statement that there is no affordability problem in Mongolia at all (*World Bank* 2010: 26) cannot be confirmed. In our perspective such a statement is wrong first and the foremost because of conceptual flaws of the CAR in general. Additionally the way how this measure is applied can be criticised. First, using income *quintiles* may be not detailed enough; secondly, an 'internal' target

ratio may be more appropriate. On the other hand our results show that the problem of access resulting in non-pecuniary cost is effectively a problem for many households and has to be taken into account. Expense-oriented affordability analysis neglects the excess burden imposed by access problems and runs the risk of deeming underconsumption as a proof for (pecuniary) affordability.

It remains still the task of further affordability research to come closer to a theoretically meaningful and contoured notion of affordability itself and to take into consideration non-pecuniary reasons for underconsumption. This would also help to give relevant practical advice for water policy in order to get closer to an implementation of the 'right to water'.

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