Unpacking Piped Water Consumption Subsidies: who benefits? New evidence from 10 countries

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Abstract: This paper provides new evidence on the recent performance of piped water consumption subsidies in terms of pro-poor targeting for 10 low and middle-income countries around the world. Our results suggest that in these countries, existing tariff structures fall well short of recovering the costs of service provision, and that, moreover, the resulting subsidies largely fail to achieve the goal of improving the accessibility and affordability of piped water among the poor. Instead, the majority of subsidies in all 10 countries are captured by the richest households. On average, across the 10 low and middle-income countries examined, 56% of subsidies end up in the pockets of the richest 20%, but only 6% of subsidies find their way to the poorest 20%. This is predominantly due to the most vulnerable segments of the population facing challenges in access and connection to piped water services. Shortcomings in the design of the subsidy, conditional on poor households being connected, exist but are less important.

JEL Classification: D3, H220, L95, O13, O2

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1 INTRODUCTION

Universal access to water and sanitation is a stated international development goal (SDGs, UN 2015).[2] However, many countries around the world are still struggling to achieve this goal. In 2015, 29% of the world population lacked access to safely managed water and 61% lacked safely managed sanitation (WHO/UNICEF, 2017).[3] Well-designed subsidies stand out as a key instrument to achieve these SDGs, alongside other policies such as investment, technological innovations or better governance and planning. In the context of high levels of poverty, where markets alone do not result in the desired levels of service provision and consumption, targeted subsidies can help address affordability and equity issues. Additionally, water and sanitation subsidies are generally advocated because access to and consumption of water and sanitation services are associated with rising productivity and living standards, positive externalities related to public health, and may free up time spent collecting water (WWAP, 2016, and Hutton and Chase, 2017).[4] For example, Hutton and Chase (2017) show that health and non-health associated costs due to poor water and sanitation are estimated to be over 5% of GDP in 6 of the 30 countries included in their study.

A subsidy represents the difference between the supplier's cost of providing the service and the actual price or tariff paid by a user. Consumption subsidies reduce the cost of consuming water and, as such, are only available to existing customers. These can be distinguished from connection subsidies, which are a one-time reduction in connection charges and hence only available to new, previously unconnected, customers. Water consumption subsidies can take different shapes and sizes: untargeted subsidies (general underpricing of water supply that benefits all consumers); implicit subsidies (generated by flat fees for unmetered services, low meter coverage or low revenue collection); or explicit subsidies (e.g. quantity targeting using increasing block tariffs (IBTs) or subsidies using administrative selection, such as means-tested or geographic targeting). The funding for these subsidies comes from one or a combination of the following two sources: government transfers and rate funds (that arise from charging other users more than the cost of the service, also called cross-subsidies). Finally, the transfer mechanism could be implemented in different ways. In a demand-side subsidy, usually the most transparent type of subsidy, the government provides a monetary transfer directly to the user, who uses this transfer towards their payments to the service provider. In a supply-side subsidy, the government transfers the money to the provider.[5]

[2] The United Nations adopted the SDGs in 2015 with the aim to "achieve universal and equitable access to safe and affordable drinking water" and to "achieve access to adequate and equitable sanitation and hygiene for all" by 2030.

[3] The cost of meeting these gaps are estimated to be around $100 billion a year (Hutton and Varughese, 2016).

[4] Both WWAP, 2016 and Hutton and Chase, 2017 provide good summaries of the different studies investigating these issues and quantifying the returns to investment in water and sanitation in terms of different outcomes.

[5] Andres et al (2019) and Komives et al (2005) discuss the different types of WASH subsidies in more detail.

The design and performance of piped water subsidies hinges on the industrial structure and technology of piped water production and delivery and is a contentious area, heavily influenced by political economy considerations. An important challenge for policymakers is to design a subsidy scheme that allows for the recovery of capital and expenditure costs of providing the service (WWAP, 2019). Piped water is usually considered a local natural monopoly. The supplier faces large upfront (fixed) costs (resulting in increasing returns to scale) on assets that are long-lived. This feature of water supply, as with other similar public utilities, makes pricing difficult. Allocative efficiency requires prices to be set equal to marginal cost, i.e. the good is consumed up to the point where the benefit consumers obtain from the last unit consumed equals the additional cost incurred by the supplier to produce it. However, pricing at marginal cost in a context of high fixed costs would not allow for full cost recovery (as the marginal cost is lower than the average costs). This feature generates heated debates around how to implement low water tariffs (i.e. close to the marginal cost) while ensuring cost recovery and avoiding financial unviability of utilities.[6] This, in part, is because it is really difficult to estimate the cost of providing each customer with the service, as costs vary across consumers, depending on geographic location, topography, distance to the source, etc. This situation translates into a high degree of discretion on how to allocate provision costs.

In practice, this often means subsidization of the service across the board. Most countries, whether rich or poor, end up putting in place subsidies schemes funded by the government or designing tariffs so that richer consumers cross-subsidize poorer ones (GWI, 2004, Komives et al., 2005, and Andres et al, 2019). New estimates by Andres et al (2019) put total subsidies for networked water and sewerage services at around 0.5% of GDP worldwide, and over 1.5% of GDP for non-advanced economies. In developing countries, this subsidization across the board does not fully address the objectives of universal access to clean water and the affordability of the service, and additionally may distort consumption patterns. Furthermore, high subsidization levels have often undermined the financial sustainability of the system, inducing managers to face soft budget constraints and lowering their financial performance.[7]

In this paper, we provide new evidence on the distributional incidence and pro-poor targeting of subsidies for piped water consumption for 10 low and middle-income countries around the world: Ethiopia, Mali, Niger, Nigeria, Uganda, El Salvador, Jamaica, Panama, Bangladesh, and Vietnam. We also document the gap between estimates of actual paid tariffs and tariffs that would be needed to recover the full cost of providing the service (also called cost-recovery or cost-reflective tariffs). All these countries capture relevant heterogeneity since they reflect different levels of gross domestic product per capita, connection rates, tariff structures and cost-recovery tariffs. The cases considered include quantity-based tariffs and flat rates. Importantly, in these countries there is availability of household surveys with

[6] In the context of lower income countries, it is recommended that tariffs cover at least the operating expenditures incurred by suppliers, but even this is often not achieved (see, for instance, Baietti and Curiel, 2005 and Andres et al, 2019).

[7] This, in turn, could reduce the ability of service providers to access commercial finance, which could enable utilities' ability to maintain and expand the service in an affordable manner to new, likely poorer customers (see, for instance, Goksu et al, 2017).

measures of water expenditure and overall consumption expenditures, as well as administrative data on tariffs from the utility and new estimates of country-specific cost-reflective tariffs.[8]

Our results suggest that, in all the countries analyzed, mean unit prices charged are, on average, lower than the overall cost of producing and distributing piped water, resulting in substantial water consumption subsidies. In addition, subsidies tend to be regressive, with the amount of resources allocated to water consumption subsidies increasing over the expenditure distribution, and richer households in the top deciles usually capturing the lion's share. On average, across the 10 low and middle-income countries examined, 56% of subsidies end up in the pockets of the richest 20% but only 6% of subsidies find their way to the poorest 20%.

Our findings also highlight the importance of access to the service in explaining the regressive nature of these subsidies. In particular, i) poor households live in areas that are not covered by piped water networks,[9] ii) poor households live in areas with coverage but are not connected to the network, and iii) poor households that are connected to the network appear to be consuming smaller quantities of water than the general population. This implies that there are high errors of inclusion (i.e. households not among the 40% poorest receiving subsidies) and even higher errors of exclusion (households among the 40% poorest not receiving subsidies). This issue is particularly pronounced in the considered African countries, where errors of exclusion fall between 90 and 100 percent.

Our study contributes to a vast and growing literature on the distributional incidence of fiscal policy in low- and middle-income countries, including a large sub-literature on the distributional incidence of water subsidies. Our findings are consistent with a number of previous studies that use a similar methodology. Key examples of this literature—such as Komives et al. (2006) and Angel-Urdinola and Wodon (2007b)—have shown that quantity-based, targeted subsidies in Nicaragua, Cape Verde, the city of Kathmandu (Nepal), Bangalore (India), and Sri Lanka are usually regressive, with a smaller share of benefits accruing to the poor than the general population. These studies also indicate that poor targeting is mostly associated with low rates of access to water networks in poor neighborhoods, as well as low connection rates for poor households in neighborhoods with access. More recently, the World Bank (2017) found that Tunisian households in the bottom quintile of the income distribution receive 11 percent of water subsidies, while the top quintile receive 27 percent. Our study provides systematic cross-country evidence, using a novel and more robust estimate of cost-recovery tariffs based on actual country-specific water providers' data.

Lack of access to the service by the poor has been identified as an important driver of regressive subsidies in other sectors. There are numerous studies documenting similar patterns in the electricity sector as documented by Komives et al (2006).

[8] These estimates are calculated using an improved methodology and new data presented in Andres *et al* (2019).
[9] Poor households are defined as belonging to the first four deciles of the countrywide national expenditure (or income) per capita distribution in each country.

Recent studies conducted as part of the Commitment to Equity (CEQ) initiative looking at the distributional incidence of fiscal policy in a range of low- and middle-income countries also confirm these findings using a different methodology (see for instance, Hounsa et al, 2019, for energy subsidies in Mali). CEQ studies, discussed in Inchauste and Lustig (2017), find that lack of access by the poor to tertiary education is one of the reasons why public education expenditure is regressive in Ethiopia, Ghana, Guatemala and Indonesia. Access also plays a role in the distributional incidence of health subsidies. For example, Chen et al, 2015, find that Chinese government healthcare subsidies are pro-rich and regressive, and that lack of access plays an important role. O'Donnell et al (2008) show the distribution of public health care subsidies in Vietnam is pro-rich, although the impact varies by type of health care facility.

Finally, quantity-based consumption subsidies have been found to be regressive, even conditional on having access and being connected to the network. For example, Cardenas and Wittington (2019) use data for connected households in Addis Ababa, Ethiopia and find that water and electricity quantity-based subsidies are large and regressive. They use improved measures of quantities consumed by accessing administrative utilities billing data and matching it to household survey data. In contrast, when subsidies are targeted using administrative-based mechanisms (i.e. geographic targeting or means-testing), the evidence suggests that these are likely to be more progressive and pro-poor (Komives et al., 2006).

The rest of the paper is structured as follows: section 2 presents the methodology, the data used, and related statistics; section 3 presents the findings; and the last section summarizes the findings and discusses the policy implications.

2 DATA AND METHODOLOGY

In order to estimate consumption subsidies for piped water at the household level, we need a measure of the cost of delivering a unit (cubic meter, m_3) of piped water, a measure of the unit price actually paid by each household and the quantity consumed. To do this, we combine several data sources spanning different periods within and across countries. We use a methodology that closely follows Komives et al. (2005) and Angel-Urdinola and Wodon (2007a), to estimate the distributional and targeting performance of subsidies in each country.

We first describe the multiple data sources used, and then explain the methodology and its implementation. We subsequently provide some descriptive statistics before discussing the limitations of the data and methodology used in this study.

2.1 Data sources

2.1.1 Household surveys (source 1)

Household level data comes from the latest available socio-economic (or income and expenditure) household surveys collected in each country. Most surveys are from 2015 or 2016, but some surveys are from earlier periods, the earliest being 2012 for

Jamaica. Information about the household surveys used for each country considered in the analysis is provided in the Appendix (Table A1).

These are general socio-economic surveys that cover a range of dimensions of a household's characteristics and income and spending patterns, and hence are not focused specifically on water and sanitation. Nonetheless, they provide useful self-reported information on water access, connection, and water expenditure in the last month or last year, depending on the survey. Details about the exact variables used in each survey are also provided in the appendix. Quantities of consumed water and prices or tariffs paid by each household are usually not reported. Consequently, we combine household survey data on water expenditure with administrative data from providers and government programs detailing the tariff structure for water and sewerage services to impute water quantities and tariffs, as below.

This approach has been used in other studies, such as in Komives et al (2006) and Angel-Urdinola and Wodon (2007b). However, it is not without limitations. In particular, water expenditure in the last month (some surveys asked about expenditure over the last 12 months) can provide an imperfect proxy for the expenditure on piped water if: i) households use multiple water sources, including technologies for treating non-piped water (in which case it could overestimate piped water expenditure); ii) meters are not read, shared[10] or do not work; or iii) the water bill includes pro-rated connection charges and arrears (Whittington et al, 2015). Importantly, these surveys also enable the construction of total expenditure (and/or income) variables for each household.

2.1.2 Administrative data on tariff structures (source 2)

Information about tariff structures comes from the International Benchmarking Network for Water and Sanitation Utilities (IBNET) database. Some countries list most of their water providers in IBNET while others list only a few. For example, IBNET has data on the tariff structures of all water providers in Jamaica, Mali and Niger, since these have only one piped water provider. Meanwhile, for countries such as Ethiopia, Nigeria, Uganda, and Bangladesh—where the provision of services is decentralized and there are a multitude of piped-water utilities—IBNET data covers a subgroup of these providers. An additional limitation is that the tariff structure data available to the authors for this study may cover a period that is different than the one covered in the household survey for each country, even though tariffs may not be regularly updated. More information about dates covered for each utility in each country is provided in the Appendix.

2.1.3 Data on cost-reflective tariffs (source 3)

Cost-reflective tariffs cover the capital and recurrent costs of providing service, including not only the efficient economic cost but also costs arising from

[10] Table A2 in the Appendix shows the proportion of households that use the neighbor's tap as their main source of drinking water for the 4 countries for which the data is available: Mali, Niger, El Salvador and Panama. The proportion is low and varies between 1% for all households in Panama and rural households in Niger, to 10% for urban households in Niger and 7% for urban households in Mali.

inefficiencies of the service provider. We use estimates of cost-reflective tariffs (defined as CRT) that cover both operating expenditure (OPEX) and capital expenditure (CAPEX), obtained from Andres et al (2019).

Their approach entails answering the following question “What is the long-run incremental cost of providing water and sanitation services for a given company?”. It is based on a simple, utility-wide, bottom-up model used by regulators in many utility sectors. In the water and sanitation sector the model firm approach is used in Chile and a few other Latin-American countries. The authors choose efficient firm estimates from Chile as a benchmark[11] to determine the capital stock per customer. Using information on operation and maintenance costs for the period 2010-15 from the IBNET dataset, they estimate efficient cost-reflective tariffs. In addition, this approach accounts for inefficiencies arising from employees and losses, to obtain a total cost-reflective tariff. Despite its stringent assumptions and simplifications, this comprehensive approach improves on the existing estimates that have been used in the literature.[12]

2.2 Methodology

2.2.1 Definition of variables of interest

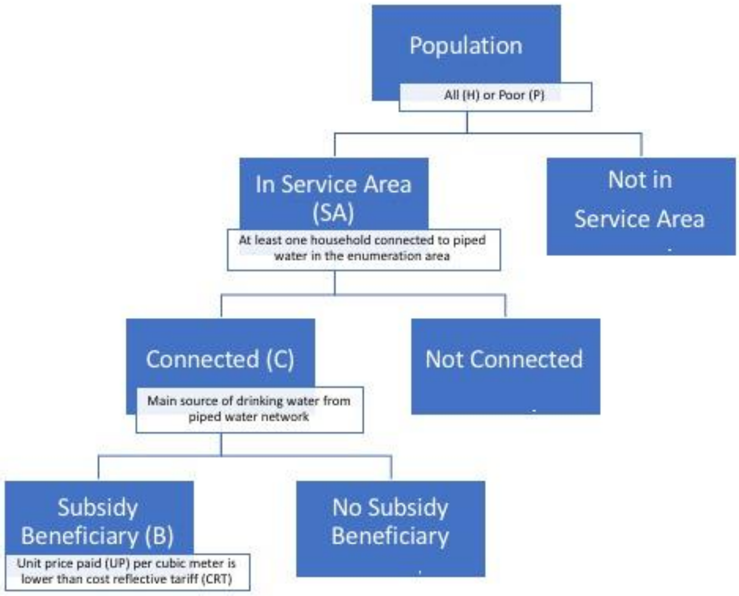
In the following subsections we describe how we classify households by economic status (i.e., poor or not), identify whether they benefit from water consumption subsidies, and estimate the magnitude of the subsidies they receive. All household level statistics are calculated using sampling weights to correct for the bias inherent in representative household surveys (Deaton, 2019). Further information on how each variable is constructed for each country is provided in the appendix.

Figure 1 summarizes how we classify households and Table 1 defines the main variables.

[11] The Chilean tariff law seeks to induce efficiency through the use of incremental cost of development pricing. Decree - D.F.L. No 70/1988 – defines this tariff as the “value equivalent to a constant per unit price which, when being applied to the incremental forecasted demand, generate revenues to cover incremental operation efficient costs and the required investment from an optimized project of expansion of the firm, such that it should be consistent with a net present value (NPV) of the project equal to zero.” As pointed out by Bitran et al (2005): “In Chile, to avoid transferring the cost of inefficiencies to users, the rate setting process emulates competitive conditions by using a fictitious company that would theoretically meet demand over the next five years in the most efficient way.”

[12] For example, the Price Gap Approach uses a single uniform CRT value for all countries of 1,27 USD/m3. There are a range of papers by IMF staff that have used this approach to calculate implicit subsidies to public utilities. Recently Kochar et al. (2015) have applied it to networked water while Ebeke and Ngouana (2015) used it to estimate energy subsidies. Another methodology, known as the Hidden Cost Calculator (Ebinger, 2004), uses book values of gross assets instead.

Figure 1. Classification of households according to piped water access, connection and consumption subsidy beneficiary



2.2.1.1 POOR HOUSEHOLDS (P) AND ALL HOUSEHOLDS (H)

Poor households are defined as belonging to the first four deciles of the countrywide national total expenditure (or income) per capita distribution in each country, and are denoted by the subscript *p*. All households in each country are denoted by the subscript *h*.

Total expenditure includes expenditure on all goods and services, including the water bill, which is a common methodology to rank households according to their resources in developing countries.[13] Annual expenditure figures are converted to equivalent monthly figures. It is important to note that although we conduct our analysis at the household level, we construct deciles of expenditure (or income) on the basis of a household's per capita expenditure, not overall household expenditure. Because we conducted our analysis of expenditure at the household level—and average household size may vary across deciles, particularly in Africa—average total expenditure at the household level may not increase as expected when moving across the household per capita expenditure distribution.

[13] See, for example, Abramovsky and Phillips (2015).

Table 1. Main variables of interest

Variable	Definition	Sources
P (Poor)	=1 if a household belongs to the first four deciles of the countrywide national total expenditure (or income) per capita distribution in each country. Subscript p is to indicate it is a poor household. Letter P is the total number of poor households.	1
H (All)	=1 for all households. Subscript h indicates any individual household. Letter H is the total number of all households.	1
Service area (SA_h)	= 1 if a household *h* is located in a neighborhood with at least one other household with a water connection as self-reported in the household survey. Neighborhood is proxied by the enumeration area.	1
Connected C_h	=1 if a household *h* is connected to the water network, and zero otherwise. This is determined by the self-reported main source of drinking water.	1
$E_{h\|C}$	Monthly water expenditure for household h, conditional on being connected	1
Quantity of water consumed ($Q_{h\|C}$)	Estimated monthly water consumed (in m^3) conditional on being connected	1 & 2
$UP_{h\|C}$	Unit price for a m^3 of water for a household *h*: $E_{h\|C}$/ Q_h	1 & 2
B_h	=1 if a household *h* receives a subsidy: $UP_{h\|C}$<CRT	1,2 & 3
B_P	Total number of poor households receiving a subsidy (poor beneficiaries)	1,2 & 3
B_H	Total number of households receiving a subsidy (all beneficiaries)	1,2 & 3
R_h	The rate of subsidization for a household *h*: 1-UP_h/CRT	1,2 & 3
S_h	Amount of subsidy received by a household *h*: Q_h|B x (CRT-Up_h)	1,2 & 3
S_P	Total amount of subsidies accrued to the poor	1,2 & 3
S_H	Total amount of subsidies accrued to all households	1,2 & 3
Variables to construct Omega		
SA_P	% of poor households that are located in a service area	1,2 & 3
SA_H	% of all households that are located in a service area	1,2 & 3
$C_{P\|SA}$	% of poor households that are connected conditional on being located in a service area	1,2 & 3
$C_{H\|SA}$	% of all households that are connected conditional on being located in a service area	1,2 & 3
$B_{P\|C}$	% of poor households with a subsidy, conditional on being connected	1,2 & 3
$B_{H\|C}$	% of all households with a subsidy, conditional on being connected	1,2 & 3
$R_{P\|B}$	Average rate of subsidization for poor households, conditional on receiving a subsidy	1,2 & 3
$R_{H\|B}$	Average rate of subsidization for all households, conditional on receiving a subsidy	1,2 & 3
$Q_{P\|B}$	Average quantities consumed by poor households, conditional on receiving a subsidy	1,2 & 3
$Q_{H\|B}$	Average quantities consumed by all households, conditional on receiving a subsidy	1,2 & 3
Ω	$\Omega = \frac{\frac{S_P}{P}}{\frac{S_H}{H}} = \frac{SA_P}{SA_H}\frac{C_{P\|SA}}{C_{H\|SA}}\frac{B_{P\|C}}{B_{H\|C}}\frac{R_{P\|T}}{R_{H\|T}}\frac{Q_{P\|T}}{Q_{H\|T}}$	1,2 & 3

2.2.1.2 Service area (SA)

Following Angel-Urdinola and Wodon (2007a), households are considered to have potential access to a network if they are located in a service area (*SA_h*).[14] A

[14] The variable *service area* (*SA*) is equivalent to the variable *access* (*A*) in Komives et al. (2005) and Angel-Urdinola and Wodon (2007a). In this paper we prefer to use *service area*, because it better reflects the variable we are measuring.

household's service area takes the value of 1 if at least one household in their neighborhood self-reported having a water connection in the household survey. We assume that households in a *SA* have the option of connecting to the piped-water network present in their neighborhood. The neighborhood is proxied by the enumeration area where the household is located, according to the household surveys. However, this assumption may not always be correct. If a neighborhood covers a large geographical area, or if the presence of an adjacent water main varies by household, the survey figures may overestimate the actual number of households with potential access to the piped water network.

2.2.1.3 CONNECTED (C)

We set this variable to 1 if a household is connected to the water network, and to zero otherwise. This is determined by the self-reported main source of drinking water in the household surveys.

2.2.1.4 QUANTITY OF WATER CONSUMED AMONG THOSE CONNECTED (Q)

We construct $Q_{h|C}$, the monthly water quantity consumed (measured in m^3) by imputing water consumption volumes from self-reported household monthly water expenditure, $E_{h|C}$, conditional on being connected to the network. The conversion is undertaken using the corresponding tariff structure from the IBNET data.[15]

In the first round of calculations, we impute quantities for households for which (i) the total monthly bill for water consumption depends on quantities consumed, (ii) the value of self-reported expenditure on water is greater than zero, and (iii) we can map the household to a specific provider for which we have tariff structure information. For households that pay a fixed rate per cubic meter, the monthly quantity of water consumed equals the total expenditure on water divided by the rate. For households facing unit prices that vary by quantity consumed (such as increasing block or volume-differentiated tariffs), each block within the tariff structure is assigned a maximum expenditure level and associated quantity of water consumed. Then quantities are assigned to the household sample by matching self-reported household water expenditure with the corresponding level of the tariff structure data.

For the remainder of the households for which (i) the bill is a flat rate unrelated to water quantities consumed; or (ii) self-reported expenditure on water equals zero,[16] we assume consumption quantities at the median of those households in the same country for which we could impute quantities.

For those households that report being connected to the piped water network but are located in areas for which we cannot map them to a specific provider, we use the median water quantity consumed for those we could impute the quantity

15 Information on how this match is done for each country is provided in the appendix.
16 In many countries, and particularly Ethiopia and Nigeria, many households appear to be connected to the network and use piped water as their main source of drinking water but report paying zero for their water. Anecdotal evidence supports the fact that many households are connected illegally to the network or that utilities do not invoice and collect revenues as they should.

(disaggregated by rural/urban and income deciles if enough observations are available).

Table A1 in the Appendix shows the breakdown of the sample according to whether connected households are matched to corresponding volumetric tariffs and have positive water expenditures, allowing for the estimation of quantity consumed, or whether water quantities and unit price paid have to be assumed using the information from other households in the data. The proportion of observations relying upon requiring the latter approach varies across countries significantly, with Nigeria and Bangladesh exhibiting the highest proportions.

2.2.1.5 AVERAGE UNIT PRICE OF WATER PAID AMONG THOSE CONNECTED (UP)

We define the unit price for a household *h* (UP_h) as the ratio of self-reported water expenditure from household surveys and quantity consumed. For a household with a water expenditure of zero, the unit price would also be zero.

2.2.1.6 SUBSIDY BENEFICIARIES AMONG THOSE CONNECTED (B)

We define variable B_h as equal to 1 if a household is connected and pays a unit price (UP_h) for water that is lower than the cost-reflective tariff. That is, a household is a subsidy beneficiary.

2.2.1.7 VALUE OF THE SUBSIDY (S)

The monthly value of the subsidy (S_h) is constructed using the variables described above; for each household, this is equal to $S_h = Q_{h|B} \times (CRT - UP_h)$, conditional on $UP_h < CRT$ (i.e., $B_h = 1$).

2.2.1.8 RATE OF SUBSIDIZATION (R)

The rate of subsidization for a household *h*, conditional on receiving a subsidy, is $R_{h|B} = 1 - E_{h|B}/(Q_{h|B} \times CRT) = 1 - UP_h/CRT$.

2.2.2 Distributional incidence of subsidies

Having identified beneficiary households (B_h) and the size of subsidies (S_h) they receive, we estimate the share of total subsidies accrued to each expenditure (or income) decile and consider whether they are progressive or not.[17]

1) *Progressive subsidies*: Subsidies are considered progressive when the share of subsidies accrued to each decile tend to decrease over the expenditure (or income) per capita distribution. This means that poor households capture a higher portion of the subsidy pie.
2) *Regressive subsidies*: Conversely, subsidies are considered regressive when the share of subsidies accrued to each decile tend to increase over the expenditure (or income) distribution.

[17] This methodology is arithmetic, nonbehavioral, and express a partial equilibrium, which is well suited to investigate the incidence of subsidies at a point in time or with small marginal changes to prices or subsidies. This approach has limitations related to bigger changes in prices or subsidies. See, for instance, Abramovsky and Phillips (2015) for a description of various microsimulation models for tax and benefits using household survey data.

This relationship can sometimes be non-monotonic. In those cases, it is useful to compare the share of subsidies that the top decile receives relative to, for example, the bottom 40% of the distribution, which is known as the Palma ratio and widely used in developing countries (Cobham et al, 2016). Or the 20/20 ratio, the share of subsidies the top two deciles receive relative to the bottom 20% of the distribution. The higher the ratio, the more regressive the subsidies are.

We also estimate the share of overall countrywide household-level expenditure on goods and service captured by each decile to contrast with the share of piped water subsidy captured by each decile. This helps understand whether the subsidy is inequality reducing – that is, whether a greater percentage of subsidies is allocated to households in poorer deciles than is the case for overall country-wide expenditure. When the subsidy distribution is more skewed toward richer deciles than the distribution of expenditure or income, the subsidy regressive and increases inequality. However, if subsidies are less regressive than the distribution of expenditure or income, they still can reduce inequality.[18]

2.2.3 Targeting performance of subsidies and underlying mechanisms

Following Angel-Urdinola and Wodon (2007a), we define the targeting performance indicator (Ω), which relates to a subsidy's distributional incidence, as the ratio between the amount of subsidies the poor receive (S_P) and the amount of subsidies accrued to all households (S_H), divided by the proportion of poor households in the total population (P/H).

The targeting performance indicator (Ω) can be split into factors related to water network access and factors related to subsidy design, using the variables defined in the previous section and listed in Table 1:

$$\boldsymbol{\Omega} = \frac{\frac{S_P}{P}}{\frac{S_H}{H}} = \frac{SA_P}{SA_H}\frac{C_{P|SA}}{C_{H|SA}}\frac{B_{P|C}}{B_{H|C}}\frac{R_{P|B}}{R_{H|B}}\frac{Q_{P|B}}{Q_{H|B}} \qquad \textbf{(Equation 1)}$$

Access factors (SA and C) are fixed in the short term, since they are determined by network expansion and households' decisions, and will affect the distributional incidence of the subsidy, regardless of the consumption subsidy's type or structure.

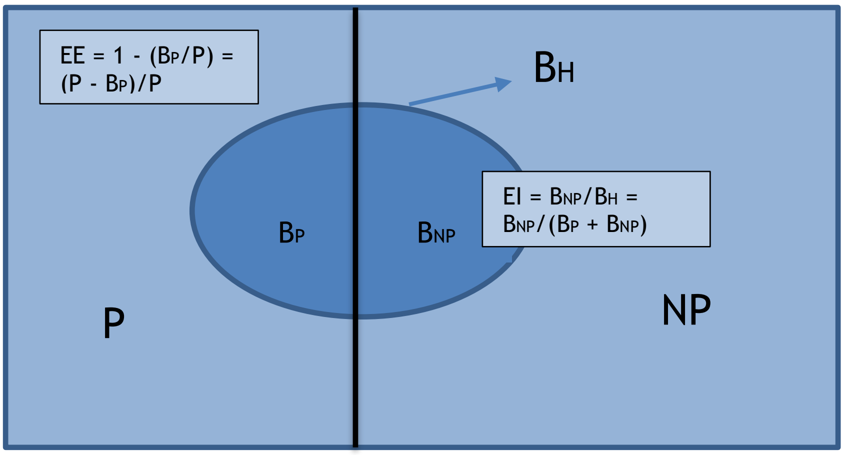
Two additional measures to assess the targeting performance of subsides are the errors of inclusion and exclusion.

The error of exclusion (EE) is the share of households in poverty that are not benefiting from the subsidy: EE = 1 - (B_P/P) = (P - B_P)/P

The error of inclusion (EI) is the share of beneficiary households that are not in poverty: $EI = B_{NP}/B_H = B_{NP}/(B_P + B_{NP})$. Figure 2 shows graphically how these errors are defined.

18 These measures are simple statistics that can be easily displayed in bar charts, and are conceptually similar to the quasi-Gini coefficients, described for example in Komives et al. (2005: 140–41).

Figure 2. Illustration of the errors of inclusion (EI) and exclusion (EE)



Note: B_P = number of targeted (beneficiary) households in poverty; B_{NP} = number of targeted (beneficiary) households not in poverty; B_H = number of total beneficiary or targeted households; P = number of poor households; NP = number of households not in poverty. The error of exclusion is $EE = 1 - (B_P/P) = (P - B_P)/P$. The error of inclusion is $EI = B_{NP}/B_H = B_{NP}/(B_P + B_{NP})$.

2.3 Descriptive statistics

Table 2 presents some descriptive statistics regarding household connection to piped water for each country analyzed. Countries are ordered by descending levels of GDP per capita (column 1). The figures reported in columns 2 to 6 are from household surveys, and are therefore nationally representative, with the exception of Vietnam.[19] Overall, richer countries tend to have a lower proportion of households living in rural areas and a higher proportion of households that report using piped water as their main source of drinking water.[20] Despite wide variation in coverage across countries, all countries demonstrate higher connection levels in urban households than both rural and poor ones.[21] Notably, Nigeria's connection rates are quite low given the country's income per capita, but disparities among different population segments are smaller. Latin American countries have substantially higher connection rates, between 70 and 95 percent for the general population, and around 50 percent or over for rural and poor households. Vietnam falls in the middle, with a connection rate of 53 percent for the whole population and 70 percent for urban households.

[19] In Vietnam, the survey includes only five regions: Hanoi City, Da Nang, Dak Nong, Thu Dau Mot City and Bình Dương Province, and Ho Chi Min City.

[20] There may be slight differences from the Joint Monitoring Program (JMP) data for each country, due to some minor differences in variable definitions in most cases and differences in sources in others. One common difference between our computation and JMP's computation is that we define a household as connected to piped water if it uses piped water as its main source of drinking water either in the dry or wet season. JMP also includes public standpipes as part of its piped water definition in some countries such as Ethiopia and Mali, whereas we include only house connections. Thus, our figures may be easily compared against JMP figures showing house connections only. For example, figures for Ethiopia and Nigeria are slightly higher in Table 2 (19.8 percent and 13.6 percent, respectively, in column 3) than those presented by JMP (15.2 percent and 12.2 percent, respectively).

[21] As one might expect, there are also wide variations across the administrative geographic areas covered in the household surveys within each country, which are not shown in this paper.

Table 3 summarizes the number of providers from the IBNET dataset whose service areas are also covered in the household surveys, the average cost-reflective tariffs, and imputed unit prices (conditional on the reporting of positive expenditure on water). More information about IBNET data for each country can be found in the appendix. Most countries have IBT structures, though two African countries – Nigeria and Uganda – have fixed rates. In Bangladesh some service providers charge a flat water-consumption rate while others use IBT. El Salvador is the only country that has a volume-differentiated tariff (VDT) structure. Some countries or providers also add a value added tax (VAT) on tariffs. For the analysis carried out in the following section, we use all the households included in every country's household survey, coupled with information from the corresponding utilities. As explained earlier in this section, when a household is located in an area or region with no available tariff structure, we use information from other households in that country to impute quantities and unit prices paid.

Table 2. Households connected to piped water

Country (Year of household survey)	GDP per capita in USD PPP 2016	Households living in rural areas (%)	Households connected to network water (piped water on plot) (%)			
	(1)	(2)	(3)	(4)	(5)	(6)
			Total	Rural	Urban	Poor
Panama (2015)	29,446	30	91.9	79.3	97.3	82.6
Jamaica (2012)	9,551	47	69.7	49.0	88.9	57.4
El Salvador (2016)	8,288	36	79.3	64.1	88.0	67.9
Vietnam[22] (2015)	6,768	41	53.0	28.8	70.2	50.4
Nigeria (2016)	5,285	60	13.6	9.9	19.0	10.5
Bangladesh[23] (2016)	3,920	72	13.6	2.8	41.3	4.7
Mali (2014)	2,198	67	11.1	2.2	29.6	0.9
Ethiopia (2016)	1,896	73	19.8	3.5	63.9	2.4
Uganda (2014)	1,753	75	8.7	1.8	29.1	0.9
Niger (2014)	838	83	9.1	0.8	49.7	0.1

Source: Authors' own elaboration using several socio-economic household surveys, detailed in Table A1 in the appendix, and World Bank Data series.
Note: These are countrywide figures. Poor households are defined as belonging to the first four deciles of the expenditure (or income) distribution in each country. All figures are calculated using sample weights. Water connection and public tap variables are derived from questions about main source of drinking water—but some countries have information about source of water for other uses (like Bangladesh), which are then also used to construct water connection. More information can be found in the appendix. Column 1 refers to GDP per capita, PPP (constant 2017 international U.S. dollars), GDP = gross domestic product; PPP = purchasing power parity (World Bank Data series accessible at https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD).

Remarkably, all countries show higher cost-reflective tariffs than the average unit price paid by all households that report paying a positive amount for piped water. This already shows that all countries' providers operate in a way that, on average, subsidizes residential consumers. However, six out of the ten countries show a unit price higher than the estimated CRT-Opex, suggesting that they can at least cover operating expenditures.

22 The figures for rural Vietnam using the 2015 Vietnam Household Registration Survey (VHRS) are much higher than the figures presented in JMP, using the Household Living Standards Survey (HLSS) 2012 that shows a rural rate of 13 percent. This is likely due to differences in the regional coverage of each survey. The VHRS 2015 has a sample that is representative of the population in five provinces—Ho Chi Minh City, Ha Noi, Da Nang, Binh Duong, and Dak Nong—while the HLSS 2012 is supposed to be nationally representative.

23 The figures for urban and total are higher than the figures published in JMP for the latest year. The data for Bangladesh used in this analysis differ from the data used in JMP. We use the Household Income and Expenditure Survey 2016, and the figures presented here are consistent with the official figures published in the Preliminary Report on Household Income and Expenditure Survey 2016, page xiii (BBS 2016).

Table 3. Tariff data and estimated unit costs and prices

Country	Number of providers covered in the analysis	Type of tariff structure	Estimated cost-reflective tariff (unit cost/m3) CRT ($ 2017)	Estimated OPEX cost-reflective tariff (unit cost/m3) CRT_{opex} ($ 2017)	Estimated effective average price/m3 ($ 2017)
	(1)	(2)	(3)	(4)	(5)
Ethiopia	9	IBT	3.68	0.67	0.23
Mali	1	IBT with fixed charge + VAT	2.29	0.37	1.04
Niger	1	IBT	3.97	0.48	0.37
Nigeria	10	Fixed rate/m3, some with a fixed rate	2.05	0.40	0.80
Uganda	1	Fixed rate/m3	1.89	0.37	0.86
El Salvador	1	VDT, with fixed charge for 10 m3 or less	0.85	0.19	0.32
Jamaica	1	IBT	2.51	0.55	1.69
Panama	1	IBT	1.18	0.26	0.20
Bangladesh	23	Depends on utility (IBT, 16 with flat rate)	0.49	0.12	0.26
Vietnam	3	IBT (+ VAT for some)	2.70	0.62	0.38

Source: IBNET database, World Bank, and other resources.

Note: Column 1: These are providers that covered areas included in the household surveys and for which there are available data online. Most of the data come from IBNET; however, for Nigeria, we use Abubakar (2016). *Ethiopia:* Data are from 2007 for Dire Dawa, and 2014 for Addis Ababa. The estimated cost-reflective tariff (column 3) is an average for the country cost-reflective tariff including both OPEX and CAPEX and is estimated in Andres *et al* (2019), except for (a) Ethiopia (we use averages across the 24 Sub-Saharan African countries included in the estimation of Andres et al (2019)—but excluding Ethiopia, since the values for the cost-reflective tariffs for this particular country seem unrealistically high due to some problems with the raw data from Ethiopia used to estimate cost-reflective tariffs); (b) El Salvador (data from ANDA are used); (c) Panama (data from the Autoridad Nacional de Servicios Públicos are used for OPEX cost-reflective tariffs for the year 2015 in U.S. dollars and divided by 0.22, which is the relationship between the average of the OPEX cost-reflective tariffs across countries from Andres *et al* (2019), and the average of total cost-reflective tariffs across countries from the same paper); and (d) Jamaica (National Water Commission). There are no available data on OPEX cost-reflective tariffs for El Salvador and Jamaica (column 4), thus we use the value in column 3 for the total cost-reflective tariff, multiplying it by 0.22, which is the ratio between the average OPEX cost-reflective tariff and average total cost-reflective tariff from Andres *et al* (2019). Column 5 shows the unit price conditional on paying for water services (i.e., self-reported expenditure on water greater than zero). The figure is calculated using sampling weights. CRT = cost-reflective tariff; CRT_{opex} = OPEX cost-reflective tariff; IBT = increasing block tariff; m3 = cubic meter; OPEX = operating expenditure; VAT = value added tax; VDT = volume-differentiated tariff.

2.4 Limitations and strengths

The study presents limitations that must be taken into account when interpreting the findings, many of which have already been discussed. The study also has important strengths. We summarize them below.

Due to data constraints, the data used spans different periods within each country. For example, household data for Jamaica is from 2012 whereas the tariff data is from 2013. Or within Nigeria, we have data on tariffs structures for 9 regional providers, spanning from 2012 to 2018, while the household data is from 2015/16.

The data on water expenditure is self-reported and can sometimes include expenditure not only on piped water but also other water sources. If the piped water supply is shared with other households, water expenditure figures may not accurately reflect the amount paid by the reporting household. Since this variable is used to impute the quantity of water consumed and the average unit price paid by households, these variables can suffer from inaccuracies. For example, if expenditure is overestimated, then quantities will be overestimated. If the measurement issue varies with the level of income of households, this could be biasing our results for those households that are connected to the network. In addition, in many countries, a significant proportion of households report missing or zero expenditure on water even if they report using piped water on premises as their main source of drinking water. Quantities for these households must be imputed from the other households within the sample.

In some countries, we only have data on tariff structures for some service areas, which means that, for a significant proportion of connected households, we must use average prices and quantities consumed from those areas with data. We have explained how we impute quantities in the sub-section 2.2.1.4, and we have discussed that this limitation is more important in countries like Nigeria and Bangladesh. This could affect the distributional impact of subsidies across deciles, the calculation of omega and the calculation of inclusion and exclusion errors, but it is not clear in which direction. Having said this, the main driver of regressivity is the lack of access or connection. The unavailability of data on expenditure or tariffs would not affect these measures. However, they could affect the magnitude of the regressivity for conditional on being connected.

The definition of service area may be too large and inaccurate, and this may overestimate the actual number of households with potential access to the piped water network. This may affect the calculation of Omega and underestimates the magnitude of the impact of access factors on targeting performance. It will not, however, affect the distributional impact analysis of subsidies nor the calculation of the errors of inclusion or exclusion. Additionally, we are comparing countries with varying proportions of rural populations and differing degrees to which piped water is a feasible solution to close the access gap.

One of the main strengths of this study is that it uses representative samples that cover the poorest households; these households are least likely to have access and be connected to piped water. Studies that restrict their sample to only those households for which water quantity data are available fail to be representative at the country level. If the objective of policy makers is to use limited public funds to help the poorest access safely managed water, then the strengths of our approach outweigh its limitations.

3 Findings

3.1 Distributional performance of existing subsidies

In this section we show the estimated overall distributional incidence of water consumption subsidies across households by expenditure decile (or income decile for El Salvador and Panama).

As explained in Section 2.2.2, each figure shows the percentage of subsidy captured by each decile (i.e., percentage of money spent on subsidies accruing to all households in the given decile, classifying all households in the country along the countrywide expenditure distribution). In addition, we present the share of total household income or expenditure on goods and services in the economy accruing to each expenditure decile and compare it with the share of subsidies accruing to each decile. When the subsidy distribution is more skewed toward richer deciles than the distribution of expenditure or income, it is regressive and increases inequality. If the subsidy shares are less skewed toward richer deciles that total expenditure, but still regressive, they can be regressive but inequality reducing.

Presented in Figure 3, the estimates for the five African countries demonstrate a common trend: richer households appear to enjoy a greater share of subsidies. In Niger and Uganda, households in the top decile are estimated to receive over 60 percent of all water consumption subsidies. In Mali, Niger, and Uganda, the estimates show that the poorest hardly benefit from the subsidy at all. Furthermore, Nigeria seems to be the only country where subsidies reduce rather than increase inequality according to these estimates. Table 4 further shows summary measures of distributional incidence. It shows that the subsidies are most regressive in Niger, with the top 20% of households receiving almost 85% of subsidies and the bottom poorest households receiving 0%.

Figure 4 shows the estimated distribution of beneficiaries (households that receive the subsidy) across expenditure deciles for the same five countries to complement the picture painted by distributional incidence. This figure helps to visualise the poor performance of these susbsidies in targeting the poor by presenting the number of beneficiaries rather than the value of subsidies received across the deciles of total expenditure. Higher deciles appear to show the highest share of total subsidy beneficiaries (dark grey bars) and the highest share of all households within each decile that are beneficiaries (ligh grey bars). The differences between the top three deciles and the remaining ones are remarkable in all countries, although less pronounced in Nigeria. As noted above, in Niger, the poor (first four deciles) do not seem to benefit from the subsidy at all; Uganda shows a similar pattern, and in Mali only the fourth decile shows a very small amount of beneficiaries. We conclude that in the five African countries analyzed, and using the household data, tariff data, and the methodology described, consumption subsidies are regressive (albeit relatively less so in Nigeria) and not well targeted to the poor. This seems to be due to the poor appearing to have less access to piped water and, even when connected, appearing to consume less water generally as shown in Table 5 and discussed in more detail in section 3.2.

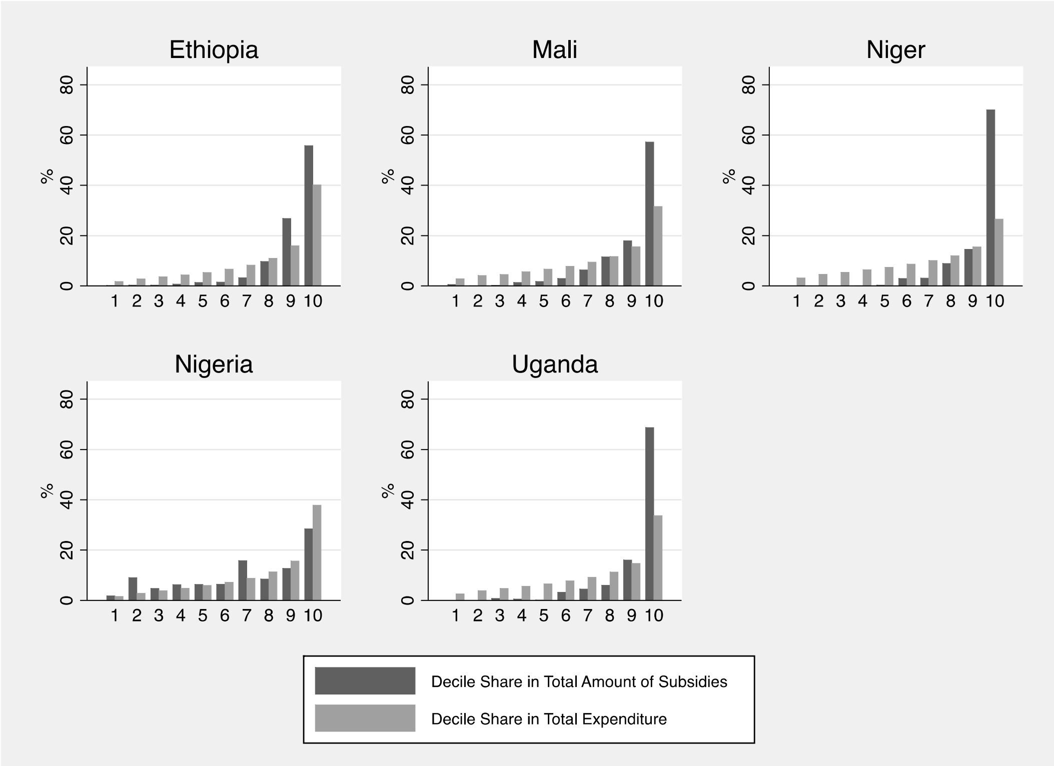
Table 4. Measures of distributional incidence of subsidies

	Percentages of subsidies accruing to each group of deciles of the overall total expenditure distribution					
	Bottom 20%	Bottom 40%	Top 20%	Top 10%	Palma Ratio (Top 10%/Bottom 40%)	20/20 Ratio (Top 20%/Bottom 20%)
Ethiopia	0.54	1.56	82.60	55.76	35.71	153.87
Mali	0.65	2.26	75.13	57.17	25.24	115.39
Niger	0.00	0.12	84.54	70.00	577.43	22315.38
Nigeria	10.82	21.79	41.15	28.44	1.30	3.81
Uganda	1.27	1.27	84.76	68.69	54.16	66.83
Average in 5 African countries	*2.66*	*5.40*	*73.64*	*56.01*	*138.77*	4531.06
El Salvador	6.03	17.81	37.88	21.85	1.23	6.28
Jamaica	7.46	19.70	41.78	24.65	1.25	5.60
Panama	12.44	27.29	32.66	17.67	0.65	2.62
Average in 3 Latin American countries	*8.64*	*21.60*	*37.44*	*21.39*	*1.04*	*4.84*
Bangladesh	4.57	12.36	52.70	32.28	2.61	11.54
Vietnam	12.62	30.30	26.19	14.20	0.47	2.07
Average in 2 Asian countries	8.60	21.33	39.45	23.24	1.54	6.81
Average across all countries	5.64	13.45	55.94	39.07	70.01	2268.34

Source: Authors' own elaboration based on household surveys, IBNET and administrative data on tariff structure, and cost-reflective tariff data. See the section on Methodology and Data and the Appendix for more detail.

Note: All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories of goods and services. The distribution of expenditure refers to the countrywide distribution of expenditure per capita, i.e., households are ranked according to their expenditure per capita.

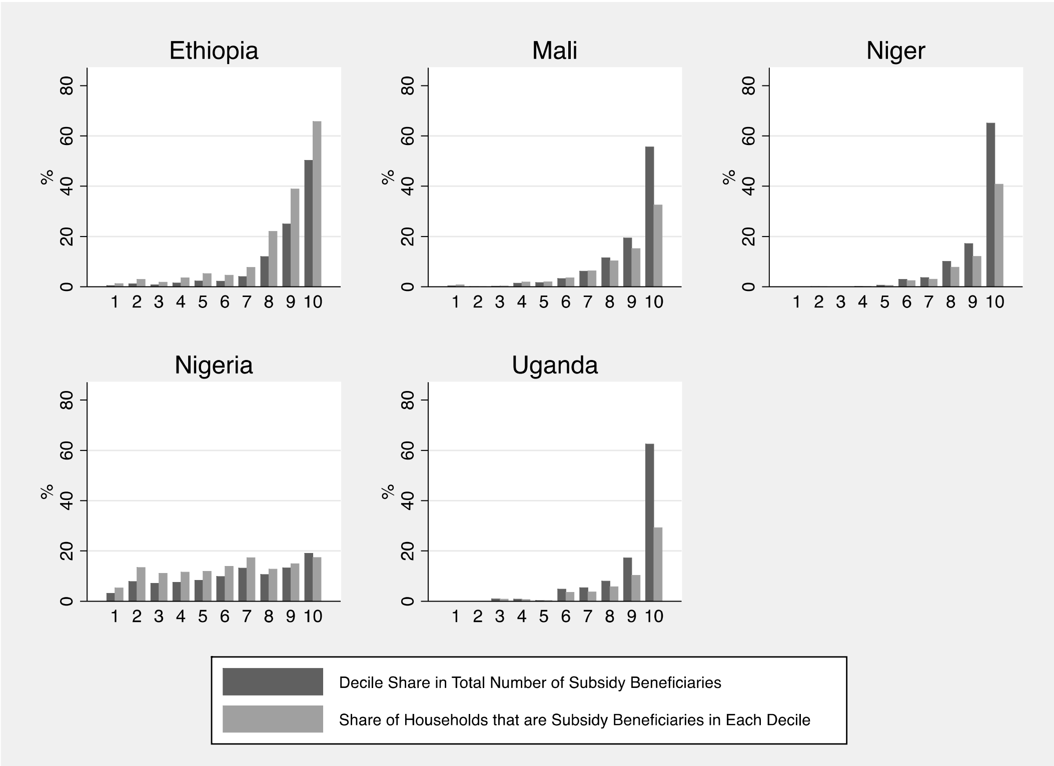
Figure 3. Distributional incidence of subsidies (by decile) for five African countries



Source: Authors' own elaboration based on household surveys, IBNET and administrative data on tariff structure, and cost-reflective tariff data. See section on Methodology and Data and the Appendix for more detail.
Note: All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories of goods and services. The distribution of expenditure refers to the countrywide distribution of expenditure per capita, i.e., households are ranked according to their expenditure per capita.

Presented in Figure 5, the results for Panama, Jamaica, and El Salvador have a similar pattern, demonstrating subsidies' regressivity. However, the figures suggest that subsidy schemes in all three Latin American countries reduce inequality since subsidy incidence is less skewed towards richer deciles than total expenditure/income. The degree of subsidy regressivity in Latin American countries is lower than in African countries, as evidenced by the average Palma and 20:20 ratios shown in Table 4. As explored in section 3.2, this is partly because both a greater number of poor households reside in service areas, and that, conditional on this potential access, a greater percentage of poor households are connected to the network.

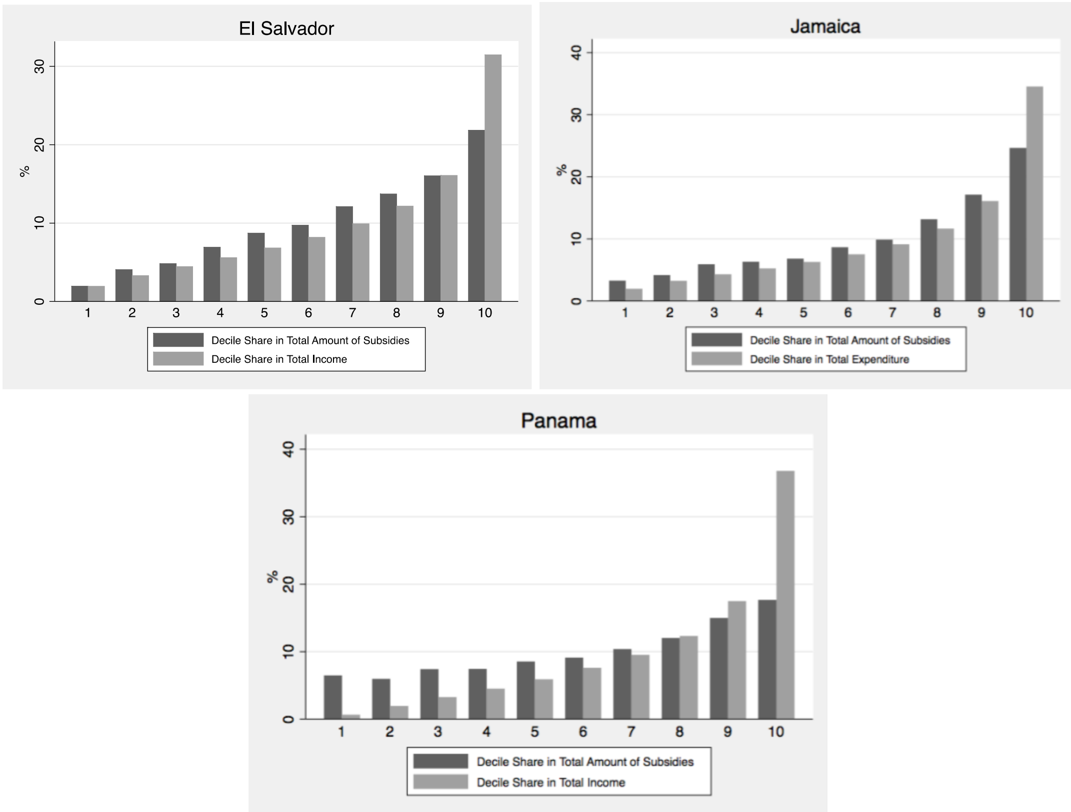
Figure 4. Distributional incidence of subsidy beneficiaries (by decile) for five African countries



Source: Authors' own elaboration based on household surveys, IBNET and administrative data on tariff structure, and cost-reflective tariff data. See the section on Methodology and Data and the Appendix for more detail.
Note: Subsidy beneficiaries are households. All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories. The distribution of expenditure refers to the countrywide distribution of expenditure per capita, i.e., households are ranked according to their expenditure per capita.

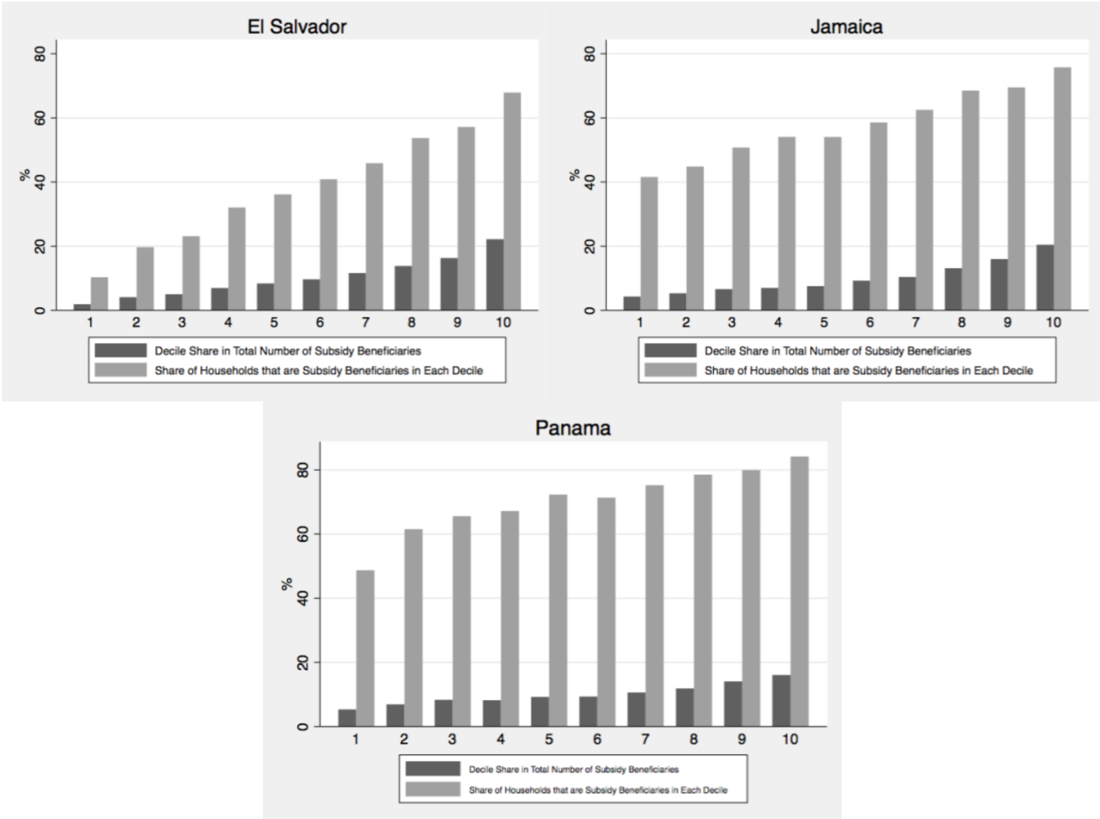
Figure 6 shows the distribution of beneficiaries (households that receive the subsidy) across expenditure or income deciles for the three countries. As with the African countries, it complements the picture painted by the distributional incidence of the amount of subsidies. Higher deciles show the largest share of total subsidy beneficiaries (dark grey bars) and the largest share of all households within each decile that are beneficiaries (light grey bars), although in Panama the pattern is less pronounced.

Figure 5. Distributional incidence of subsidies (by decile) for three Latin American countries



Source: Authors' own elaboration based on household surveys, administrative data, and cost-reflective tariff data. See the section on Methodology and Data and the Appendix for more detail.
Note: All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories. The distribution of expenditure (Jamaica) or income (El Salvador and Panama) refers to the countrywide distribution of expenditure/income per capita, i.e., households are ranked according to their expenditure/income per capita.

Figure 6. Distributional incidence of subsidy beneficiaries (by decile) for three Latin American countries

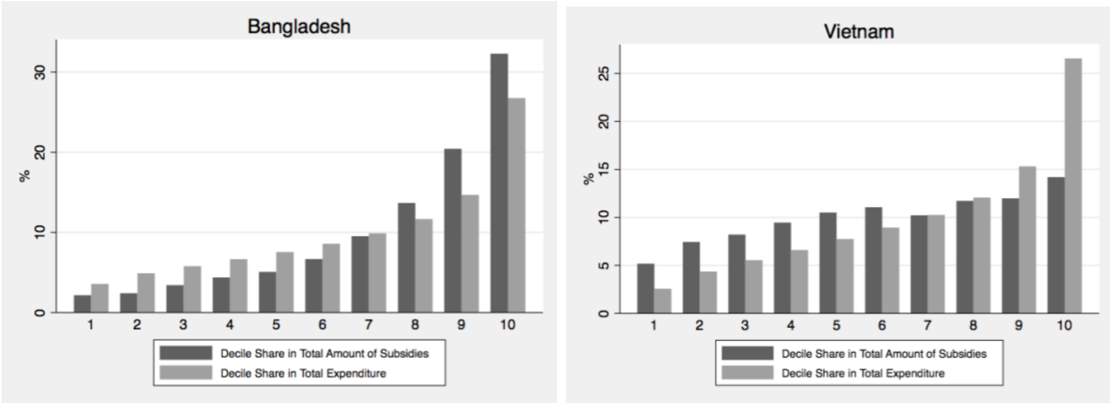


Source: Authors' own elaboration based on household surveys, administrative data, and cost-reflective tariff data. See the section on Methodology and Data and the Appendix for more detail.
Note: All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories. The distribution of expenditure (Jamaica) or income (El Salvador and Panama) refers to the countrywide distribution of expenditure/income per capita, i.e., households are ranked according to their expenditure/income per capita.

Figure 7 shows the results for two Asian countries, Bangladesh and Vietnam. In Bangladesh, water consumption subsidies are strongly regressive and increase inequality. While subsidies in Vietnam are still regressive, albeit less so, they are actually inequality reducing, suggesting slightly better targeting compared to Bangladesh. Figure 8, which depicts the distribution of beneficiary households across deciles, shows strong regressivity in Bangladesh but a more even distribution across expenditure deciles in Vietnam, once again suggesting better targeting.

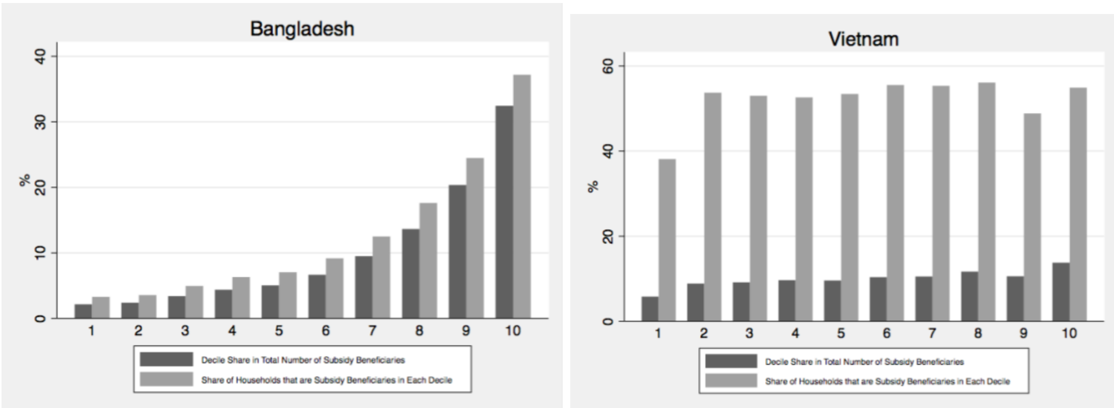
In the next section, we look at a more synthetic measure of targeting performance that complements this analysis and consider both access and subsidy design factors driving this performance.

Figure 7. Distributional incidence of subsidies (incidence by deciles) for two Asian countries



Source: Authors' own elaboration based on household surveys, administrative data, and cost-reflective tariff data. See the section on Methodology and Data and the Appendix for more detail.
Note: All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories. The distribution of expenditure refers to the countrywide distribution of expenditure per capita, i.e., households are ranked according to their expenditure per capita.

Figure 8. Distributional incidence of subsidy beneficiaries (incidence by deciles) for two Asian countries



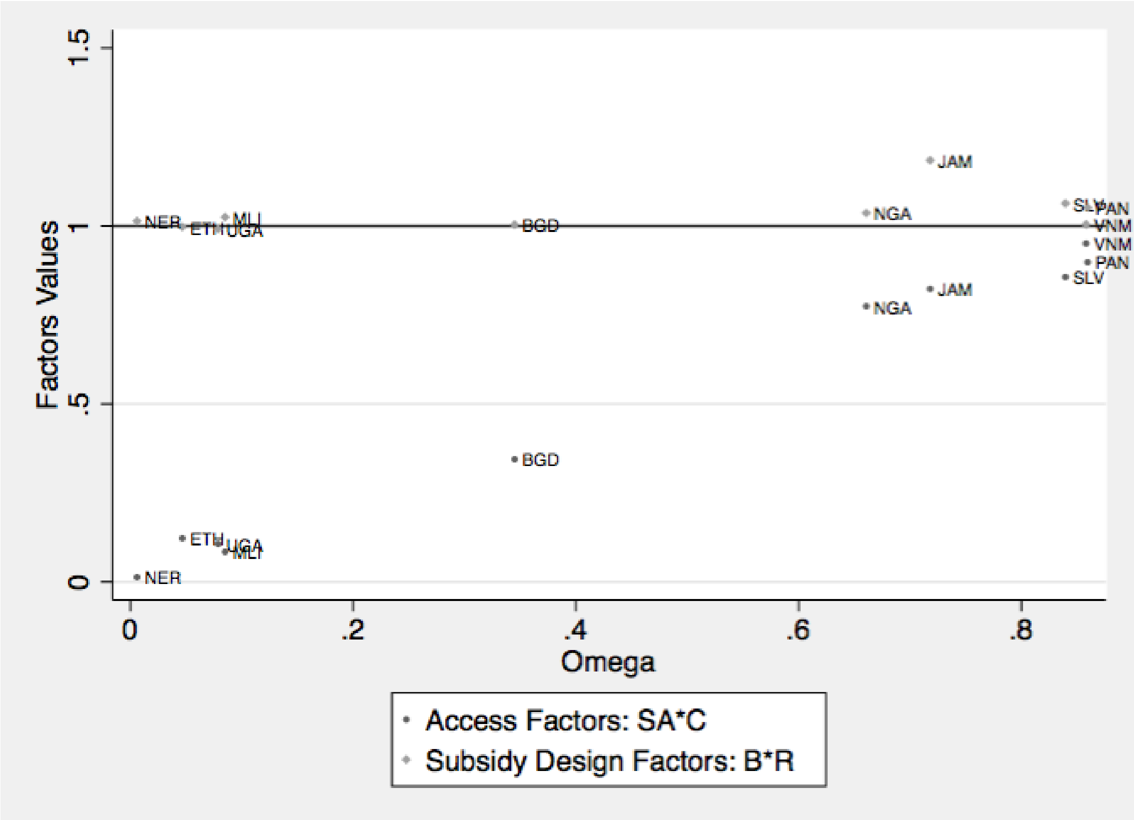
Source: Authors' own elaboration based on household surveys, administrative data, and cost-reflective tariff data. See the section on Methodology and Data and the Appendix for more detail.
Note: Subsidy beneficiaries are households. All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories. The distribution of expenditure (Jamaica) or income (El Salvador and Panama) refers to the countrywide distribution of expenditure/income per capita, i.e., households are ranked according to their expenditure/income per capita.

3.2 Targeting performance of existing subsidies: Are subsidies pro-poor?

Figure 9 and Table 5 show the targeting performance of water consumption subsidies in the 10 countries under analysis. Figure 9 shows how access factors ($SA*C$) and subsidy design factors ($B*R$) drive omega (Ω) across countries. Table 5 presents the values of each factor for each country. Factor values below 1 indicate that the factor contributes to reduced targeting performance, whereas factor values above 1 indicate that the factor contributes to increased performance.

As shown in Figure 9, all African, Latin American, and Asian countries present Ω values below 1, demonstrating that water consumption subsidies are poorly targeted to the most vulnerable populations. Access factors (blue dots) are the driving force explaining low Ω values in most countries. Subsidy design factors (red dots) are in general around or above 1. These indicators suggest that government improvement strategies should mainly focus on increasing access to services (for each country, we explore whether strategies should primarily focus on expanding service areas, increasing the proportion of connected households within existing service areas, or both in detail for each country), although enhancing subsidy design could also be beneficial.

Figure 9. Factors driving the targeting performance of subsidies (Ω) across countries



Source: Authors' own elaboration based on household surveys, administrative data, and cost-reflective tariff data. See the section on Methodology and Data and the Appendix for more detail.
Notes: Country labels: BGD: Bangladesh, ETH: Ethiopia, JAM: Jamaica, MLI: Mali, NER: Niger, NGA: Nigeria, UGA: Uganda, PAN: Panama, SLV: El Salvador, VNM: Vietnam. Access factors: $SA = SA_P/SA_H$ is the share of households located in a service area for the poor relative to the population as a whole; $C = C_{P|SA}/C_{H|SA}$ is the relative share of households that are connected to the service conditional on potential access (being located in a service area). Subsidy design factors: $B = B_{P|C}/B_{H|C}$ is the relative proportion of households with a subsidy conditional on usage; $R = R_{P|B}/R_{H|B}$ is the relative average rate of subsidization. Factor values below 1 indicate that the factor contributes to reduced targeting performance, whereas factor values above 1 indicate that the factor contributes to increased targeting performance.

Different factors influence the severity of poor subsidy targeting performance across countries. In Table 5 we explore the different access and subsidy design factors in more detail.

Four African countries—Ethiopia, Mali, Niger, and Uganda—show an estimated value of Ω lower than 0.1. In all four the main factors that reduce subsidy efficiency in targeting poor households relative to all households include (i) poor households' lower probability of being located in a service area and (ii) their lower probability of being connected to a water network conditional on being located in a service area. Additionally, in Ethiopia and Niger, the relatively low water quantities consumed by the poor significantly decrease the targeting performance.

Nigeria shows an Ω above 0.5, revealing a significant problem, although less acute than in Ethiopia, Mali, Niger, and Uganda. *SA, C,* and *Q* are closer to 1, and B = 1 and R = 1.03. Consistent with the evidence in the previous section, Nigeria's distributional incidence of subsidies by decile is regressive, although less pronounced than in the other four African countries.

In order to improve the targeting performance of water consumption subsidies, these governments should expand the service area (i.e., SA) of their utilities and connect more households within this service area (i.e., C) to the water network. One way to do this is by implementing connection subsidies in areas where there is already network infrastructure present (Andres et al, 2019, discuss different types of connection subsidies and beneficiaries and the relevant considerations when thinking of how to design them depending on the context). Table A2 in the Appendix shows the number of households that are not connected to the network that use a public tap, which could be connected to the existing infrastructure. This varies significantly across countries and across households classified as rural, urban and poor. Such considerations are important when planning connection subsidies for a specific context. Additionally, these countries should improve the design of their water consumption subsidies to better target poor households (increasing *B* to values over 1).

In El Salvador, Jamaica, and Panama, the problem is less acute, with an Ω of 0.84, 0.69, and 0.86 respectively. In these countries the factors lowering Ω to below 1 are different. In all three, the probability of living in a service area is high for both types of households, poor and nonpoor (*SA* is close to 1). However, connection rates conditional on location in a service area and water quantities consumed are both significantly lower for poor households, driving Ω to below 1. These countries would benefit from increasing service connection rates, as well as improving subsidy design to better target the poor (resulting in the increase of variables *B* and *R* further above 1).

Bangladesh falls in between African and Latin American countries, with an Ω of 0.35. Both the variables *SA* and *C* are low in general, and lower for poor households. Water quantities consumed by the poor are similar to those of other households, but this is potentially driven by the lack of information on households' expenditures and the flat rates being charged, which complicates imputing Bangladesh's household-specific water consumption (therefore, a median consumption quantity is assumed for most households). A parameter *Q* close to 1 is potentially reasonable given that any connected household regardless of consumption pays a flat rate. Nonetheless, potentially all factors (*SA, C, B, R*), in addition to the tariff structure, could be improved. In Vietnam, the value for Ω is much higher, though still below 1, and a focus on subsidy design (*B* and *R*) could increase targeting performance.

Table 5. Decomposing the targeting performance of water consumption subsidies

	Ω	SA	C	B	R	Q
	(1)	(2)	(3)	(4)	(5)	(6)
	Ω>1 → pro-poor	Potential access to water connection (service area)	Connection rate (for those with access)	Receipt of subsidy (for those connected)	Rate of subsidization (for those with a subsidy)	Quantities (for those connected)
Ethiopia	0.047					
Poor		0.255	0.095	1.000	0.957	3.275
All		0.446	0.444	0.996	0.964	8.567
Poor/All		0.571	0.214	1.004	0.993	0.382
Mali	0.085					
Poor		0.036	0.263	0.907	0.858	14.491
All		0.239	0.467	0.958	0.793	14.751
Poor/All		0.150	0.563	0.948	1.081	0.982
Niger	0.006					
Poor		0.030	0.040	1.000	0.921	10.453
All		0.209	0.433	1.000	0.909	23.651
Poor/All		0.141	0.093	1.000	1.014	0.442
Nigeria	0.661					
Poor		0.507	0.208	0.997	0.929	3.270
All		0.585	0.233	0.993	0.900	3.972
Poor/All		0.867	0.894	1.004	1.032	0.823
Uganda	0.079					
Poor		0.204	0.045	1.000	0.544	5.173
All		0.332	0.261	1.000	0.549	6.965
Poor/All		0.610	0.17	1.00	0.99	0.740
El Salvador	0.839					
Poor		0.945	0.719	0.996	0.679	19.230
All		0.966	0.821	0.983	0.647	20.863
Poor/All		0.977	0.876	1.013	1.050	0.922
Jamaica	0.718					
Poor		0.998	0.575	0.967	0.764	10.643
All		0.998	0.698	0.955	0.653	14.456
Poor/All		1.000	0.823	1.013	1.170	0.736
Panama	0.859					
Poor		1.000	0.826	1.000	0.872	40.497
All		1.000	0.919	1.000	0.829	44.518
Poor/All		1.000	0.898	1.000	1.052	0.910
Bangladesh	0.345					
Poor		0.286	0.164	0.998	0.999	36.555
All		0.384	0.355	0.998	0.995	36.579
Poor/All		0.745	0.462	1.000	1.003	0.999
Vietnam	0.858					
Poor		0.804	0.627	1.000	0.861	13.863
All		0.840	0.631	1.000	0.858	15.430
Poor/All		0.958	0.993	1.000	1.004	0.898

Source: Authors' own calculations using country-specific household surveys, administrative data, and estimated cost-reflective tariffs.

Note: Access factors: $SA = SA_P/SA_H$ is the share of households located in a service area for the poor relative to the population as a whole; $C = C_{P|SA}/C_{H|SA}$ is the relative share of households that are connected to the service conditional on potential access (being located in a service area). Subsidy design factors: $B = B_{P|C}/B_{H|C}$ is the relative proportion of households with a subsidy conditional on usage; $R = R_{P|B}/R_{H|B}$ is the relative average rate of subsidization; $Q = Q_{P|B}/Q_{H|B}$ are relative average quantities consumed. A factor value below 1 indicates that the factor contributes to reduced targeting performance, whereas a value above 1 indicates that the factor contributes to increased targeting performance. All figures are calculated using sample weights. Poor households are defined as belonging to the first four deciles of the expenditure (or income) distribution in each country.

Table 6 shows the errors of inclusion (the proportion of subsidy beneficiary households that are in the top six deciles, or rich) and the error of exclusion (the proportion of poor households that do not receive a water consumption subsidy). These errors are not conditional on location in a service area or connection, so they differ from those in Table 5. The estimates show that for most countries covered here the errors of exclusion range from 78 percent to nearly 100 percent, except for Jamaica, Panama, and Vietnam (column 2). This is consistent with the very low levels of Ω presented in Table 5. The countries on the lower end of this spectrum exhibit errors of exclusion around 50 percent, suggesting that their level of outreach to the poor could still be improved.

Inclusion errors (column 1 of Table 6) are extremely high in all countries, suggesting a wide margin for the improvement of targeting, consistent with the analysis presented so far. The inclusion errors are particularly high in African countries, with figures close to 100 percent in all countries besides Nigeria. Bangladesh also stands out with figures close to 90 percent.

Table 6. Water consumption subsidies, errors of inclusion and exclusion

	Error of inclusion (%)	Error of exclusion (%)
	(1)	(2)
Ethiopia	96.01	97.57
Mali	97.82	99.15
Niger	99.73	99.93
Nigeria	74.35	89.59
Uganda	98.28	99.60
El Salvador	82.01	78.27
Jamaica	51.78	51.78
Panama	71.20	38.91
Bangladesh	87.67	95.45
Vietnam	66.51	50.28

Source: Authors' own calculations using country-specific household surveys, administrative data, and estimated cost-reflective tariffs.
Note: Poor households are defined as belonging to the first four deciles of the expenditure (or income) distribution in each country. Error of inclusion is measured by the percentage of all beneficiary households that are rich; error of exclusion is measured by the percentage of poor households that do not get a subsidy. All figures are calculated using sample weights.

4 SUMMARY AND DISCUSSION

This paper provides new evidence on the recent performance of piped water consumption subsidies in terms of pro-poor targeting for 10 low and middle-income countries around the world.

We use detailed household survey data with information on whether the households' main source of drinking water is from piped water to define access, and the households' monthly expenditure on water services combined with available information on tariff structures in each country to impute water quantities and unit prices paid by each household. We supplement this information with new estimates of the cost incurred by the supplier of providing piped water to households to calculate the average subsidy per unit of water consumed at the household level.

Our accounting methodology presents some limitations, most importantly due to the lack of information on water quantity consumed at the household level and the tariff structure faced by each household in each country. This means that water quantities have to be imputed. Furthermore, the tariff structures for some households have to be assumed based upon suppliers operating in other regions within the same country. Finally, we are comparing countries with varying levels of urbanization and rural contexts. As a result, piped water is more feasible to close the access gap in some countries than in others.

With these caveats in mind, our analysis of ten low- and middle-income countries suggests that piped water is substantially subsidized, as existing tariffs do not seem to fully recover the costs of service provision. Moreover, these consumption subsidies do not appear to efficiently address service gaps among the poor due to ineffective targeting.

Overall, we find that water consumption subsidies in all 10 countries are regressive and therefore do not adequately target the poor (the estimated Ω has a value under 1 in all cases, with an average value of 0.45 across all 10 countries). This is despite their high diversity of economic development, national income levels, proportion of rural populations, piped-water coverage, and the costs of producing and distributing piped water. We also determine that the severity of regressivity varies significantly (from 0.006 in Niger to 0.87 in Panama). On average, across the 10 low and middle-income countries examined, 56% of subsidies end up in the pockets of the richest 20% but only 6% of subsidies find their way to the poorest 20%.

Only a very small number of poor households benefit from subsidies, particularly within the African countries in our sample. This is because poor households are less likely to be located in areas serviced by utility providers (the variable *SA* in the analysis), and even where they are, they are less likely to be connected and consuming piped water (variable *C*) than the general population.

This suggests that access factors primarily drive this poor targeting performance (*SA* takes a value of 0.7 and *C* takes a value of 0.6 on average across all 10 countries). This problem is particularly pressing in the African countries (with an average *SA* of

0.47 and average *C* of 0.39 across the sample used) and Bangladesh (which has a *SA* of 0.75 but a *C* of 0.46). This is expected since these countries have large rural populations, aggravating the feasibility of extending the network to new service areas. However, connection rates are far from 100% even in urban areas in these countries (Table 2), implying that there is also scope to improve connection rates. Furthermore, in Ethiopia, Mali and Niger, available data shows that there is a significant proportion of households that are not connected to the network and that use a public tap as the main source of drinking water, both in urban and rural areas (Table A2 in the Appendix). This could indicate the potential feasibility of increasing connection rates for these households.

Aside from improving access for the poor, subsidy design could also be improved to better target the poor. The share of poor households that receive a subsidy conditional on being connected to the network relative to the equivalent share for the whole population (B) averages at 0.99 and the rate of subsidization conditional on receiving a subsidy for the poor relative to the equivalent rate for the whole population (*R*) averages at 1.02, across all 10 countries. This signals a need for improvement in subsidy design even given subpar network coverage and connection rates. This trend is observed in all countries.

It is worth noting that there is not an optimal value of omega; it is a policy choice that will vary across countries according to their particular fairness preferences and political equilibriums. If the objective is to use available and limited public funds to ensure poor households can access and consume piped water in an affordable and sustainable way, then an omega below 1 demonstrates that this objective is not being achieved.

To summarize, our results show that in most developing countries, improving the targeting of current water consumption subsidy schemes to the poorest households will primarily require improving their access to the service. This is because, by definition, unconnected households are excluded from the pool of subsidy beneficiaries. Therefore, network expansion into poorer neighborhoods, if technologically feasible, and policies that facilitate household connections should be pursued. Angel-Urdinola and Wodon (2012) provide evidence from Nicaragua that increased access rates among the poor over time improves the targeting performance of water consumption subsidies.

It is also important to note that the targeting performance of connection subsidies would also depend on the context, design of the subsidy, and the behavior of both utilities and households. For example, universal connection subsidies were simulated by Komives et al (2005) assuming all unconnected households were offered and accepted a subsidized connection. In countries where the proportion of unconnected households is higher among the poor than among the overall population, subsidies are likely to be pro-poor. Yet in practice, poor households may be located in areas more difficult to reach or face additional financial or technical barriers to connection, such as the inability to afford the fixtures required to connect to the network, preventing them from benefiting from connection subsidies (Komives et al, 2006).

In countries where water access is no longer a significant issue and connection rates are relatively high, such as El Salvador, Jamaica and Panama, simply modifying a subsidy's design could greatly improve its targeting of the poor. In some countries, quantity-based subsidies are used in combination with subsidies targeted using administrative selection. But in other countries, only administrative selection, like geographic targeting or mean-testing, is used. In general, administrative selection performs better than quantity-based subsidies in targeting the poor (Komives et al, 2006). Having said this, the error of exclusion can be quite high, since in an effort to target the poor accurately, a significant proportion of poor households are excluded.

Further detailed analysis of each context would be needed to design the most cost-effective set of policy instruments for improving the pro-poor performance of consumption subsidies, including those that improve access to safely managed water among the poor. The most desirable approach will vary across, and even within, countries. It will depend on state capacity to implement more refined and explicit mechanisms to target the poor, such as administrative selection, as well as whether the poor live in areas with an existing water network, whether they are able to undertake the necessary upgrades within the home for connection, and whether network expansion, if required, is feasible.

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Appendix

Household surveys

Table A1 below describes the household surveys and a breakdown of the samples by whether they are connected or not to the network and the information available to calculate water quantities consumed.

Construction of water connection variables at the household level

1. *Ethiopia:* Connected to piped water is defined as main source of drinking water in rainy season reported to be piped water into dwelling or into yard/plot (hh_s9q13 = 1 or 2), or and the same for the dry season (hh_s9q14 = 1 or 2). There is no information about using a neighbor's tap. Households can report using water from a piped water public tap/standpipe in each of the seasons (hh_s9q13==3 or hh_s9q14==3)
2. *Mali:* Connected to piped water is defined as L08_E = 1. Using a public tap is L08_E==4 and using a neighbor's tap is Lo08_E=2.
3. *Niger*: Connected to piped water is defined as MS06Q13 = 1. Households using public taps are those for which q6_18=14 and those using a neighbors' tap are q6_18=13.
4. *Nigeria*: Connected to piped water is defined as s11q33a = 1 or 2 (in dry season) or s11q33b = 1 or 2 (in wet season). No information on whether they use neighbors' tap or public taps available.
5. *Uganda:* Connected to piped water is defined as H9q7 = 10 (piped water into dwelling), or H9q7 = 11 (piped water to the yard).
6. *El Salvador:* Connected to network water services (piped water) is defined as r312 = 1, 2, 3, 4, 4.1, 6. (ANDA is the state-owned piped-water provider that directly serves around 30 percent of the households in the sample.). Households using neighbor's tap are those with r313==1 and those using public taps are those with r313==2
7. *Jamaica:* Connected to piped water is defined as i22 = 1 or 2. Public tap is i22=3. There is no information about neighbor's tap.
8. *Panama:* Connected to piped water is defined as v1j_ubicac= 1 (inside on-plot) or 2 (outside on-plot). Public tap is v1j_ubicac=4 and neighbor's tap is v1j_ubicac=3. There was no information on the enumeration area (EA) in 2015, but in 2014 there was information about access and EA (but no information on expenditure, so 2015 is used). Water access is equal to 1 for all households, so we assume access is equal to 1 for all households in 2015 as well.
9. *Bangladesh:* Connected to piped water (supply water) is defined as s6aq12 = 1, s6aq15 = 1, or s6aq16 = 1. The survey does not distinguish between type of piped water (on-plot, neighbor's tap, public tap).
10. *Vietnam:* Connected to piped water is defined as m6c10 = 1 (individual tap). Households using public taps are those with m6c10=2. There is no information about neighbor's tap use.

Table A1 Socio-economic household surveys

	Ethiopia	Mali	Niger	Nigeria	Uganda	El Salvador*	Jamaica	Panama*	Bangladesh	Vietnam
Survey name	Ethiopian Socio-Economic Survey	Enquête Modulaire et Permanente	National Survey on Household Living	General Household Survey (GHS) Panel Wave-3	The Uganda National Panel Survey	Encuesta de Hogares de Propósitos Múltiples	Jamaica Survey of Living Conditions	Encuesta de Hogares de Propósitos Múltiples	Household Income and Expenditure Survey (HIES)	Household Registration System Survey
Year	2015/16	2014	2014	2015/16	2013/14	2016	2012	2015	2016	2015
Total sample	4,954	5,462	3,617	4,560	3,117	20,609	6,579	11,502	46,034	5,000
Rural (%)	66%	56%	64%	68%	74%	46%	60%	44%	70%	42%
Poor (%)	27%	23%	22%	38%	32%	39%	32%	41%	40%	25%
Not connected	3,688	4,663	2,912	3,994	2,798	4,960	2,269	1,208	41,354	2,460
Not in serviced area	2,485	3,812	2,201	2,169	1,967	4,315	19	0	29,256	820
In serviced area	1,203	851	711	1,825	831	645	2,250	1,208	12,098	1,640
Connected	1,266	799	705	566	319	15,649	4,310	10,294	4,680	2,540
With (volumetric) Tariff data	525	799	705	201	113	6,649	4,310	10,294	1,156	1,611
… & positive water expenditure	417	753	646	51	102	6,312	2,952	10,262	42	1,586
… & no positive water expenditure	108	46	59	150	11	337	1,358	2,051	1,114	25
No Tariff data	741	n/a	n/a	365	206	9,000	n/a	0	3,524	918

Source: Authors' compilation. *Note:* These are all socio-economic surveys, which include information about income sources and expenditure on a range of goods and services but are not specific surveys to capture piped water used. Poor households are defined as belonging to deciles one to four of the expenditure per capita (or income per capita if marked with *) distribution, depending on the country. The figures are raw sample statistics, not weighted by sample weights.

Table A2 Households using piped water but not connected to the network

Country (Year of household survey)	Households using public taps (%)				Households using neighbor's tap (%)			
	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Total	Rural	Urban	Poor	Total	Rural	Urban	Poor
Ethiopia	30%	34%	18%	32%	.	.	.	.
Mali	23%	14%	42%	10%	4%	1%	10%	1%
Niger	20%	18%	29%	18%	2%	1%	7%	0%
Nigeria	.	.	.	.	.	.	.	.
Uganda	10%	5%	23%	5%	.	.	.	.
El Salvador	3%	3%	3%	4%	4%	6%	4%	6%
Jamaica	7%	11%	3%	12%	.	.	.	.
Panama	1%	0%	1%	1%	1%	1%	1%	1%
Bangladesh	.	.	.	.	.	.	.	.
Vietnam	6%	4%	7%	6%	.	.	.	.

Source: See sources to Table A1.

Tariff structure and imputation of quantities, unit prices, and subsidies

As explained in the section on Methodology and Data, the tariff data are taken from IBNET in most cases, and the year corresponds to the closest available to when the household survey was conducted. It is worth noting further specificities of each country when imputing quantities, unit prices, and subsidies:

1. *Ethiopia:* Each city or region has its own provider. There is only information on tariff structure for nine areas, so we compute the unit price paid by all households in areas we have information for and use this unit price for other households connected to water, and then combine this information with expenditures to impute quantities and calculate subsidies. Information from IBNET was used for the utilities listed in Table A3.

Table A3 Utilities and tariff structure used in Ethiopia

Utility	Year of tariff structure used
Addis Ababa Water and Sewerage Authority	2014
Ambo Water Supply	2013
Dire Dawa Water Supply and Sewerage Authority	2007
Debremarkos Water Supply and Sewerage Service Office	2013
Dessie Water Supply	2013
Gondar Water Supply and Sewerage Service Office	2013
Shashemene Water Supply and Sewerage Service Enterprise	2013
Mekelle Water Supply Service Office	2013
Wukro Water Supply Service Office	2013

Source: IBNET database.

2. *Mali:* There is only one water supplier, Société Malienne de Gestion de l'Eau Potable, in the country and we have information on the tariff structure from IBNET for the year 2013.

3. *Niger:* There is only one water supplier, Societe De Patrimoine Des Eaux Du Niger, in the country and we have information about the tariff structure from IBNET for the year 2009.
4. *Nigeria:* IBNET covers nine utility providers in the states of Ekiti, Enugu, Kaduna, Kano, Katsina, Niger, Oyo, Plateau, and the city of Lagos. Abuja has been sourced from Abubakar (2016). There are many other providers in each of the 37 regions covered by the household survey, but tariff structure data are not accessible. Hence, we impute the fixed rate as the average of the effective fixed rate charged in each of the states, we do have information for, using the few households for which self-reported water expenditure is positive (202 nairas per cubic meter). Around 75 percent of connected households report zero expenditure on water.

Table A4 Utilities and tariff structure used in Nigeria

Utility	Year of tariff structure used
Ekiti State Water Corporation	2018
Enugu State Water Corporation	2008
Kaduna State Water Board	2018
Kano State Water Board	2013
Katsina State Water Board	2015
Niger State Water Board	2018
Oyo State Water Corporation	2018
Plateau State Water Board	2012
Lagos Water Corporation	2017

Source: IBNET database.

5. *Uganda*: There is only one provider of piped water in the IBNET data, Uganda National Water & Sewerage Corporation, and there is no information to identify which households in the survey get piped water from this provider. Hence, we use the tariff structure of this provider to impute quantities and subsidies paid by all households connected to piped water. The tariff structure is from the year 2017.
6. *El Salvador*: There is one big public provider of piped water, Administración de Acueductos y Alcantarillados (ANDA), and many other local suppliers. However, we only have information on the tariff structure for ANDA clients for the year 2015, and hence we use this tariff structure for households connected to ANDA to get parameters *T, R,* and *Q* and to analyze the distributional performance of subsidies. The tariff structure is a volume-differentiated tariff (VDT) with extra charges for sewerage. In addition, most of the ANDA-connected households have a toilet connected to the sewerage services so we assume that all pay the extra charge and calculate quantities based on the complete tariff structure for water and sewerage services. Even though VDTs are known to be better at targeting subsidies to the poor, the current tariff structure has a big number of brackets that are difficult to rationalize from the perspective of best policy design.
7. *Jamaica*: Tariffs are IBTs with a fixed cost. However, around 70 percent of the water supply was free of charge (nonrevenue water) in 2013 according to the National Water Commission (NWC 2013: 57). Many of the households that

reported having access to piped water report zero expenditure, contributing to nonrevenue water.[24] In the household analysis for those households that are connected but report no expenditure on water, we impute the average water consumption of 16 m^3 and unit price of zero.[25] We use tariff structure data from IBNET for the National Water Commission for the year 2016.

8. *Panama:* Tariffs are IBTs with an initial fixed charge for consumption under 30 m^3. There are different providers, but all have the same tariff structure and levels and by law utility companies have to charge cost-reflective tariffs and avoid cross-subsidies, to promote rational and efficient water consumption and efficient supply and demand.[26] We use tariff structure data from IBNET for the Instituto de Acueductos y Alcantarillados Nacionales (IDAAN) for 2016.
9. *Bangladesh:* Most households report water expenditure equal to zero, even if connected to piped water. In addition, many of the utility providers charge a flat rate (16 out of the 23 with available data in IBNET). Hence it is difficult to calculate the quantity consumed and unit price. Of the seven districts with providers that charge a nonflat rate (Brahmanbaria, Chittagong, Dhaka, Jhalokati, Lakshmipur, Manikganj, and Sherpur), only households in Chittagong, Dhaka, and Manikganj report positive values of expenditure on water; the rest report zero expenditure. We calculate the quantity consumed and unit price for households that report positive expenditure in areas where there is a nonflat rate, so that quantity can be estimated. This is a very restrictive sample, but it is the only way to get an approximation of the quantities consumed and the price paid and hence of the Ω indicator, assuming all households that are connected consume the average quantity of those households with positive expenditure for which quantities can be estimated. In practice, we use the tariff structure for the following seven utilities that do not charge a flat rate from IBNET to calculate unit prices and quantities consumed.

Table A5 Utilities and tariff structure used in Bangladesh

Utility	Year of tariff structure used
CWASA, Chittagong	2015
DWASA, Dhaka and Naryanganj	2015
MaP, Manikganj	2015
Lakshmipur	2015
Jhalakathi Pourashava	2015
SHP, Sherpur	2015
Brahmanbaria Pourashava	2015

Source: IBNET database.

[24] The National Water Commission (NWC 2013: 152) proposes that one of the main reasons that households report being connected but make zero expenditure is due to illegal connections.

[25] According to NWC (2013), the average consumption per residential connection per month is around 16 m^3 (see figure 7.4 in NWC [2013], which reports 3,600 imperial gallons per residential connection per month, equivalent to 16 m^3).

[26] See Autoridad Nacional de Servicios Publicos: http://www.asep.gob.pa/index.php?option=com_content&view=article&id=139&Itemid=142 and http://www.asep.gob.pa/index.php?option=com_content&view=article&id=138&Itemid=120.

10. *Vietnam:* We have information about the tariff structure for only three utility providers serving some of the largest of the five provinces covered by the household survey. We use that information for households, plus impute unit prices and quantities for the other two areas using the median of the estimated price and quantities for those for which we have area-specific information. Vietnam has a large number of utility providers (around 180) scattered over the roughly 60 provinces in the national territory. Table A6 lists the information from IBNET that we use in practice in the analysis.

Table A6 Utilities and tariff structure in Vietnam

Utility	Year of tariff structure used
Hanoi Water Supply Co. Ltd, Ha Noi City	2015
Sai Gon Water Supply Corporation, Ho Chi Minh City	2013
Binh Duong Water Supply, Sewerage and Environment Co. Ltd, Thu Dau Mot City	2016

Source: IBNET database.