TAX EXEMPTIONS: A CATALYST FOR DEMAND AND SUPPLY OF PLASTIC SANITATION PRODUCTS

TECHNICAL SUPPLEMENT

SEPTEMBER 2021

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TABLES OF CONTENTS

1.0 INTRODUCTION

This document serves as a supplement to USAID WASHPaLS' report titled *Tax Exemptions: A Catalyst for Demand and Supply of Plastic Sanitation Products, Impact Assessment – Ethiopia*. It provides further details on select methodologies used for the assessment.

Please refer to the Impact Assessment document for questions on the rationale and scope of the methodologies explained in this document.

2.0 DST MODEL LOGIC

The Decision-Support Tool (DST) estimates the change in potential rural improved sanitation coverage and net government revenue for a new scenario (as defined by users), relative to a scenario with the fully loaded price (i.e., the price with all relevant taxes/tariffs applied) (see Figure 1).

Figure 1: Outputs of the DST

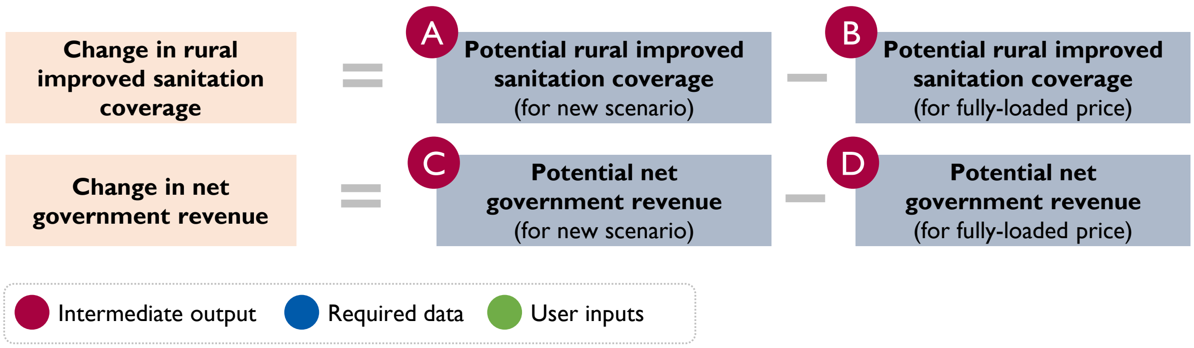


Table 1: Users inputs for the DST

SN	Data	Description
i	Value chain	Either an import value chain (with plastic pans imported in Ethiopia), which is in practice currently, or a domestic value chain (with plastic pans manufactured domestically), which the GoE wants to promote in the long-term.
ii	New tax/tariff rates	The new rates for customs duty, VAT, and surtax applied to plastic pans in Ethiopia
iii	Percentage of government subsidy	The percentage of price reduction which the government offers on the retail price of a plastic pan.

Our impact assessment has only analyzed the impact of tax/tariff reductions on the import value chain. However, the DST has the flexibility to allow future users to estimate the change in coverage and government revenue for different phases of our recommendation (refer to the Findings Report):

- Offering VAT reductions for domestically manufactured plastic pans (for Phase 2)
- Offering subsidies on domestically manufactured plastic pans (for Phase 3)

The DST also requires data on demographics, sanitation coverage, demand, and the sanitation value chain in Ethiopia (Table 2 provides a list). The subsequent sections explain the specific steps of the DST to calculate the intermediate outputs needed to derive the final outputs, using the user inputs and required data.

Table 2: Required data for the DST

SN	Data	Description	Source
1	Current rural improved sanitation coverage	The share of rural households that have either basic sanitation coverage (i.e., a private improved sanitation facility) or limited sanitation coverage (i.e., an improved sanitation facility shared with other households)	Joint Monitoring Programme (WHO/UNICEF, 2017)
2	Average number of households that share unimproved facilities	The average number of households that share an unimproved sanitation facility in rural Ethiopia	Ethiopia Demographic and Health Survey 2016 (CSA and ICF, 2016)
3	Demand curve of plastic pans	Percentage of rural households by household income segment that is willing to buy plastic pans at different price points	WASHPaLS analysis of Ethiopia Household Consumption-Expenditure Survey 2016 (CSA, 2016) Refer to *Derivation of synthetic demand* curves for detailed methodology
4	Number of rural households without improved sanitation facilities	Number of rural households by household income segment with unimproved toilets or no toilets (i.e., practicing open defecation)	Joint Monitoring Programme (WHO/UNICEF, 2017)
5	Costs and markups for value chain players	Costs and markups for each player in the value chain of plastic pans	T/WASH study (USAID, 2019)
6	Current tax/tariff rates	Tax/tariff rates currently applicable to plastic pans	T/WASH study (USAID, 2019)
7	Pass-through rate	The percentage of the tax/tariff reduction that value chain players pass to customers as a price reduction	Interviews with 9 value chain players

2.1 CALCULATION OF CHANGE IN RURAL IMPROVED SANITATION COVERAGE

The DST calculates the potential rural improved sanitation coverage for each scenario by estimating the potential demand for plastic pans and adding it to the current rural improved sanitation coverage (see Figure 2).

Figure 2: Estimation of potential rural improved sanitation coverage

Intermediate output	Required inputs
A Potential rural improved sanitation coverage for new scenario	E Potential demand for new scenario 1 Current rural improved sanitation coverage 2 Average number of households that share unimproved facilities
B Potential rural improved sanitation coverage for fully-loaded price	F Potential demand for fully-loaded price 1 Current rural improved sanitation coverage 2 Average number of households that share unimproved facilities

Intermediate output   Required data   User inputs

The potential demand is estimated only from rural households without improved sanitation facilities, i.e., households with unimproved or no toilets. We focus on these households as providing them with a plastic pan will increase the improved sanitation coverage.

For households that share their unimproved facilities, we multiply the potential demand from these households with the average number of households that share unimproved facilities, because a purchase from a single household will lead to an increase in improved coverage for all households that share the toilet.

2.1.1 ESTIMATION OF POTENTIAL DEMAND (FOR NEW SCENARIO AND FULLY LOADED PRICE)

The potential demand for plastic pans in each scenario is estimated by plotting the price on the demand curve. The demand curve provides the "percentage of rural households that are willing to buy" plastic pans at different price points for each household income segment - "bottom 40%", "middle 40%', and "top 20%" by per capita household expenditure.

This percentage is multiplied by the number of rural households without improved facilities in each household income segment. The sum of the products gives us the total potential rural households that will demand plastic pans for the new scenario and at the fully-loaded price (see Figure 3).

Figure 3: Estimation of potential demand

Intermediate output	Required inputs
E Potential demand for new scenario	G Price for new scenario 3 Demand curve of plastic pans 4 Number of rural households without improved sanitation facilities
F Potential demand for fully-loaded price	H Fully-loaded price 3 Demand curve of plastic pans 4 Number of rural households without improved sanitation facilities

Intermediate output Required data User inputs

2.1.2 ESTIMATION OF THE FULLY LOADED PRICE

The DST estimates the fully loaded price by applying the current tax/tariff rates to the import value chain (importer, wholesaler, retailer), and using data on the costs and markups for different value chain players.

Figure 4: Estimation of fully loaded price

Intermediate output	Required inputs
H Fully-loaded price	5 Costs and mark ups for value chain players 6 Current tax/tariff rates

Intermediate output Required data User inputs

2.1.3 ESTIMATION OF PRICE FOR THE NEW SCENARIO

The DST estimates the price for the new scenario by applying the new tax/tariff rates to the value chain chosen by users (import or domestic) and using the data on the costs, markups, and the pass-through rate.

Figure 5: Estimation of price for new scenario

Intermediate output	Required inputs
G Price for new scenario	5 Costs and mark ups for value chain players 7 Pass-through rate i Value chain ii New tax/tariff rates

Intermediate output Required data User inputs

2.2 CALCULATION OF CHANGE IN NET GOVERNMENT REVENUE

The DST estimates the net government revenue for the new scenario by subtracting the government subsidy per plastic pan from the tax/tariff revenue per plastic pan, and multiplying this difference with the total potential demand for plastic pans in the new scenario (estimation of which is described in the previous sections) (see Figure 6).

The DST estimates the net government revenue for the fully loaded price by multiplying the tax/tariff revenue per plastic pan with the total potential demand for plastic pans at the fully loaded price (estimation of which is described in the previous sections) (see Figure 6). Since the government is not currently providing subsidies, it is not included in the calculation.

Figure 6: Estimation of potential net government revenue

Intermediate output	Required inputs
C Potential net government revenue for new scenario	I Tax/tariff revenue per plastic pan for new scenario J Government subsidy per plastic pan for new scenario E Potential demand for new scenario
D Potential net government revenue for fully-loaded price	K Tax/tariff revenue per plastic pan for fully-loaded price F Potential demand for fully-loaded price

Intermediate output Required data User inputs

2.2.1 TAX/TARIFF PER PLASTIC PAN FOR FULLY LOADED PRICE AND NEW SCENARIO

For each price, the DST calculates the tax/ tariff per plastic pan by applying the relevant tax/ tariff rates to each stage of the value chain, and by using data on the cost, markups, and pass-through rate (if relevant) (see Figure 7).

Figure 7: Estimation of tax/tariff per plastic pan for new scenario and fully loaded price

Intermediate output	Required inputs
I Tax/tariff revenue per plastic pan for new scenario	5 Costs and mark ups for value chain players 7 Pass-through rate i Value chain ii New tax/tariff rates
K Tax/tariff revenue per plastic pan for fully-loaded price	5 Costs and mark ups for value chain players 6 Current tax/tariff rates

2.2.2 GOVERNMENT SUBSIDY PER PLASTIC PAN FOR NEW SCENARIO

The DST calculates the government subsidy per plastic pan for the new scenario by multiplying the percentage of government subsidy with the price of a plastic pan in the new scenario (estimation of which is described in the previous sections) (see Figure 8).

Figure 8: Estimation of government subsidy per plastic pan for new scenario

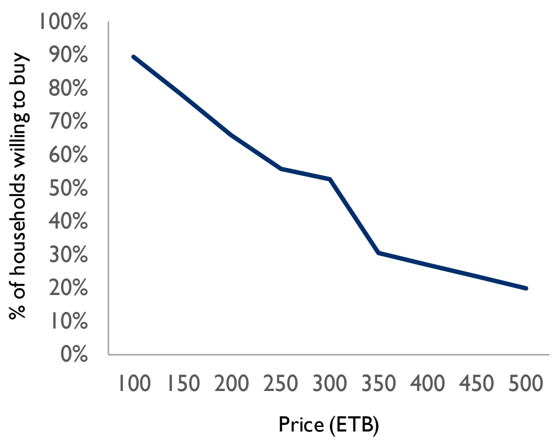
Intermediate output	Required inputs
J Government subsidy per plastic pan	iii Percentage of government subsidy G Price for new scenario

Intermediate output Required data User inputs

3.0 DERIVATION OF SYNTHETIC DEMAND CURVES

We require data on the willingness-to-pay (WTP) for plastic pans in Ethiopia to accurately estimate the change in demand for plastic pans due to tax/tariff reductions. WTP data indicates the share of households in our target market (i.e., rural households without improved sanitation) that would be willing to pay for plastic pans before and after lowering prices through tax/tariff reductions. Figure 9 shows a sample demand curve generated using WTP data. However, this data does not exist for Ethiopia, and travel restrictions prevent us from conducting a WTP study in Ethiopia.

Figure 9: Sample demand curve



WTP data for other plastic sanitation interface products is available for rural population samples in Kenya and we have access to detailed underlying data from this study (Peletz, 2019). We are unlikely to conduct the WTP study in Ethiopia until late-2020; therefore, we leveraged this data from Kenya to develop synthetic demand curves *contextualized* for the Ethiopian rural population without improved sanitation.

We used two different approaches to contextualize the WTP data from Kenya for the Ethiopian context, with the first approach being our primary demand curve. We used the second approach to compare the results and validate our primary approach.

The following sections include:

- A description of the WTP data from Kenya
- Details of our two approaches
- The limitations of each approach
- Approach to validate our primary approach
- Additional considerations

3.1 DESCRIPTION OF THE WTP DATA FROM KENYA

The WTP study from Kenya was conducted in 2017 by The Aquaya Institute, a WASHPaLS partner. The WTP data was collected using the Becker-Degroot-Marschak (BDM) auction method[1] (we also propose to use the BDM auction method in Ethiopia once travel restrictions are lifted). The Kenya WTP data provides the share of households in the target market that was willing to buy a plastic sanitation interface product at different price points. The target market was defined as households with unimproved sanitation facilities in the Busia and Nyeri districts in Kenya.

The WTP study from Kenya has certain other features which have implications for our synthetic demand curve. These are listed in Table 3.

Table 3: Features and implications of Kenya WTP study

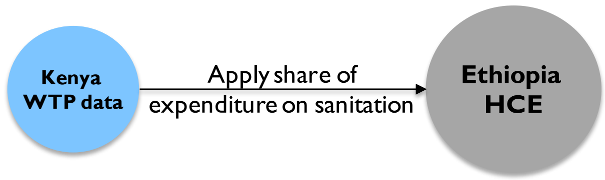
Feature of Kenya WTP study	Implications for Ethiopia synthetic demand curve
The WTP data is not for plastic pans, but a plastic latrine slab product	The plastic pan sold in Ethiopia costs lesser and is easier to operate than the plastic latrine slab in the Kenya study. We can assume that the demand curve generated using the WTP data from Kenya will be a conservative estimate of the demand curve for plastic pans in Ethiopia.
The sample included only households with unimproved sanitation facilities but excluded households that do not have toilets and practice open defecation	We applied the demand curve to both households with unimproved toilets and households without toilets. Both segments need to be considered as part of any policy to improve sanitation coverage. However, we adjusted our analysis to account for the differences between the two segments:: • We considered the additional cost of the installation which households without toilets need to incur • We created separate curves for different income segments, which accounts for the fact that households without toilets are typically poorer
The WTP data represents the bids on the product but does not include the installation costs	Installation costs vary significantly in the Ethiopian context. As such, we considered only consider the product price in the demand curve but conducted a separate analysis for installation costs.
The WTP data is in the local currency in the year of the study (2017)	We converted the WTP data (and any other data used in our methodology) to ETB 2020 levels using the World Bank's PPP conversion factors (World Bank, 2019) and consumer inflation rates (World Bank, 2019).

3.2 APPROACH 1 – APPLY SHARE OF EXPENDITURE ON SANITATION FROM KENYA TO ETHIOPIA

Approach 1 involved applying "sanitation expenditure thresholds" (i.e., the investment in a plastic sanitation interface product as a share of annual household expenditure) from the Kenya WTP data to the Ethiopia Household Consumption-Expenditure (HCE) survey 2015/16 (CSA, 2016) (see Figure 10).

[1] In a BDM auction, each individual makes a monetary bid for the product, "winning" it if their bid is above a randomly chosen price hidden inside an envelope. Individuals pay the price in the envelope, not their own bid, and both the winning bid and the price paid is recorded in the survey. Economists label the BDM auction as an incentive-compatible design since a bid affects only whether an individual wins, but not the actual price paid. As such, the best strategy for individuals is to report their willingness-to-pay truthfully.

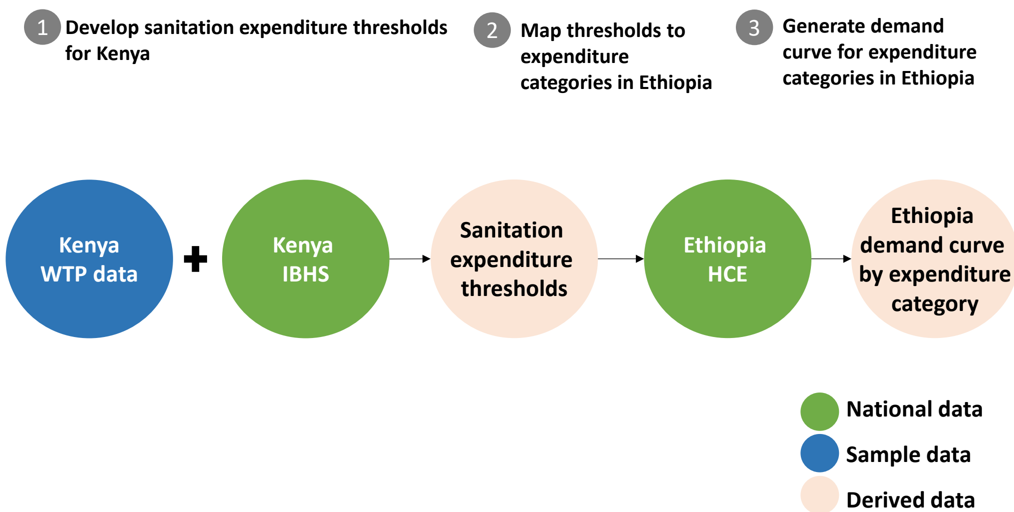
Figure 10: Overview of Approach 1



Approach 1 required a 3-step process (see Figure 11):

- Develop sanitation expenditure thresholds by expenditure category using the Kenya WTP data and the Kenya Integrated Household Budget Survey (IBHS) 2015-2016 (KNBS, 2016)
- Map the sanitation expenditure thresholds derived from the Kenya data to appropriate expenditure categories of the Ethiopia HCE survey (e.g., bottom 40%, middle 40%, and top 20% by annual per capita household expenditure)
- Generate demand curves for expenditure categories in the Ethiopia HCE survey using sanitation expenditure thresholds

Figure 11: Process for Approach 1



3.2.1 STEP 1 – DEVELOP SANITATION EXPENDITURE THRESHOLDS FOR KENYA

"Sanitation expenditure thresholds" represent the share of annual expenditure that households are willing to invest in purchasing a plastic sanitation interface product (like the plastic pan). As households with different income/expenditure levels are likely to spend different shares of their overall expenditure on sanitation, we developed separate sanitation thresholds for different expenditure categories[2]:

- Top 20% of *annual per capita household expenditure*
- Middle 20%-60% of *annual per capita household expenditure* (henceforth referred to as the "middle 40%")

[2] We used "per capita household expenditure" instead of "total household expenditure" to classify expenditure categories to account for the size of the household. Our main analysis uses expenditure as a proxy for income, as reliable income data for Ethiopia is not available.

- Bottom 40% of *annual per capita household expenditure*

The formula for the sanitation threshold is as follows:

$$Sanitation\ expenditure\ threshold\ for\ expenditure\ category =$$
$$\left(\frac{Average\ bid\ in\ expenditure\ category}{Average\ annual\ household\ expenditure\ in\ expenditure\ category}\right)$$

The Kenya WTP data captured wealth data but not expenditure (or expenditure category) data. To use the above formula, we made the following adjustments:

- We took average bids (numerator) from the Kenya WTP data but sourced the average annual household expenditure (denominator) from the Kenya Integrated Household Budget Survey (IHBS) 2015-2016. The average household expenditure was taken for rural households with unimproved sanitation in the Busia and Nyeri districts in Kenya since these households form the sample of the Kenya WTP data
- We assumed that the wealth categories in the Kenya WTP data are broadly equivalent to equivalent expenditure categories in the Kenya IHBS, as follows:
  - The average bid of wealth quintile 1 of the Kenya WTP data applies to the top 20% expenditure category of the Kenya IHBS
  - The average bid of wealth quintiles 2 and 3 applies to the middle 40% expenditure category of the Kenya IHBS
  - The average bid of wealth quintiles 4 and 5 applies to the bottom 40% expenditure category of the Kenya IHBS

  We believe that the above equivalence assumption between wealth and expenditure categories is reasonable based on the following literature:

- A study of Ethiopia, Bangladesh, Malawi, and Ecuador showed that 60-80 percent[3] of households in a given wealth quintile were within the same or adjacent expenditure quintile (Foreit & Shreiner, 2011)
- A study of Pakistan, Nepal, and Indonesia showed that approximately two-thirds of households in the bottom 40% by consumption expenditure are also in the bottom 40% when grouped by wealth index (Filmer & Pritchett, 1998)

Based on these adjustments, the final formula for our sanitation thresholds was:

$$Sanitation\ expenditure\ threshold\ for\ expenditure\ category =$$
$$\left(\frac{Average\ WTP\ bid\ amount\ in\ equivelant\ wealth\ category\ of\ Kenya\ WTP\ data}{Average\ annual\ household\ expenditure\ in\ expenditure\ category\ of\ Kenya\ IHBS}\right)$$

Output of Step 1: 3 sanitation expenditure thresholds for rural households with unimproved sanitation in Busia and Nyeri, one for each expenditure category:

[3] Ethiopia had the lowest equivalence of ~60 percent, whereas Bangladesh and Ecuador had the highest of ~80 percent.

Table 4: Output of Step 1 (Approach 1)

Expenditure category of rural households with unimproved sanitation in Busia and Nyeri	Sanitation threshold
Top 20%	0.18%
Middle 40%	0.25%
Bottom 40%	0.31%

The thresholds decreased from the bottom 40% to the top 20% because the numerator (i.e., average WTP bid) was similar across categories, but the denominator (i.e., annual household expenditure) increased by 1.8 times from the bottom 40% to the top 20%.

The thresholds also reflect the reality in many contexts that the poorest households have to spend a greater share of their income to get access to improved sanitation.

3.2.2 STEP 2 – MAP THRESHOLDS TO EXPENDITURE CATEGORIES IN ETHIOPIA

We mapped the thresholds from Kenya to expenditure categories in the Ethiopia Household Consumption-Expenditure (HCE) 2015/16 survey by comparing the *annual per capita household expenditures* for the three expenditure categories in both datasets.

As the average "annual per capita household expenditures" of each expenditure category in both datasets are similar (refer to Table 5), we applied thresholds developed for Kenya to the corresponding expenditure category in the Ethiopia HCE.

Table 5: Average annual per capita household (HH) expenditure

Expenditure category	Avg. annual per capita HH expenditure *(Ethiopia HCE) (ETB 2020)*	Avg. annual per capita HH expenditure *(Kenya IHBS) (ETB 2020)*
Top 20%	41,545	43,161
Middle 40%	18,362	18,911
Bottom 40%	9,595	8,888

Since the Ethiopia HCE survey does not have a breakdown by sanitation facility, the expenditure categories (and corresponding sanitation thresholds) were applied to all rural households (and not just those with unimproved sanitation, i.e., the sample from the Kenya WTP data).

The above assumes that the sanitation thresholds are a function of expenditure/income and not sanitation facility. We are comfortable with this assumption, as the threshold for a sanitation product (like the plastic pan) is unlikely to vary by type of sanitation facility. However, the installation costs required for the product will vary by sanitation facility, and we have conducted a separate analysis for this.

Output of Step 2 – Three sanitation expenditure thresholds, one for each expenditure category in rural Ethiopia:

Table 6: Output of Step 2 (Approach 1)

Expenditure category of all rural households in Ethiopia	Sanitation threshold
Top 20%	0.18%
Middle 40%	0.25%
Bottom 40%	0.31%

3.2.3 STEP 3 – GENERATE DEMAND CURVE FOR EXPENDITURE CATEGORIES IN ETHIOPIA

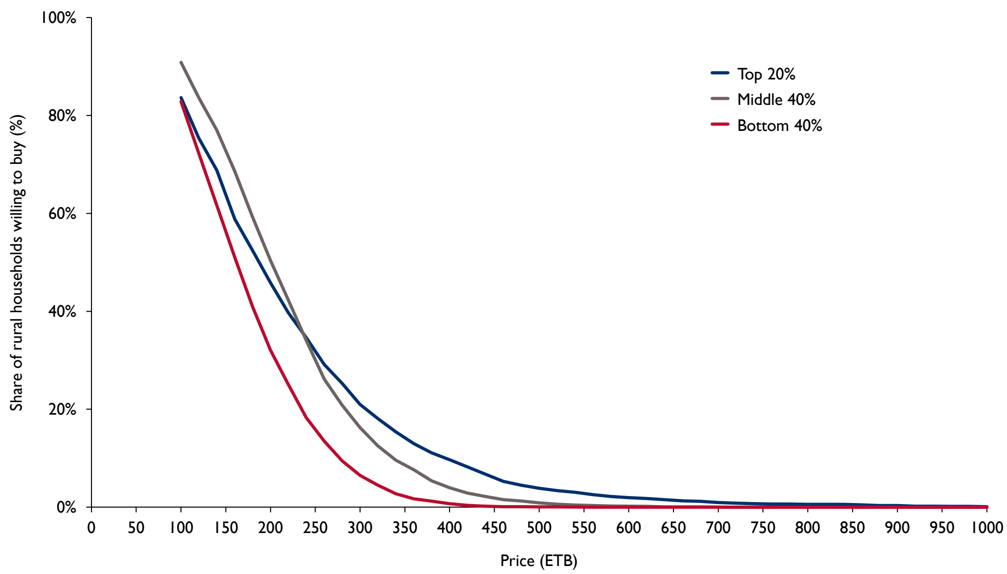
For each expenditure category in the Ethiopia HCE survey, we calculated the share of households willing to invest in plastic sanitation interface products at different price points using the sanitation expenditure thresholds from the previous step. Below is an example:

- Assume the price of the plastic sanitation interface product is ETB 100 and the expenditure threshold for the bottom 40% expenditure category is 0.31%
- Only households in the bottom 40% whose total annual household expenditure exceeds ETB 32,258 (price divided by the threshold) will buy at a price of ETB 100 (as this value is equal to 0.31% of their annual household expenditure)

Using this approach, we calculated the share of households in each expenditure category willing to buy at any price (ETB 100, ETB 110, and so on up to ETB 1000). This gave us a demand curve for each expenditure category.

Output of Step 3 – Demand curves for rural households in Ethiopia by expenditure category. The demand curves have "price" on the X-axis and the "share of households willing to buy" on the Y-axis.

Figure 12: Output of Step 3 (Approach 1)



We applied the above demand curves to both households with unimproved toilets and no toilets within an expenditure category, based on the assumption outlined in Step 2.

As the HCE data does not have a breakdown by sanitation facility, we sourced sanitation facility data by wealth category from the Ethiopia Demographic and Health Survey (CSA and ICF, 2016), and assumed that the distribution of sanitation facilities for a wealth category is the same for the corresponding expenditure category (based on the rationale given in Step 1).

3.2.4 LIMITATIONS OF APPROACH 1

Approach 1 is based on **two key assumptions**:

- The sanitation expenditure thresholds for an expenditure category (share of annual expenditure that households are willing to invest in a plastic sanitation interface product) in Ethiopia are similar to Kenya.

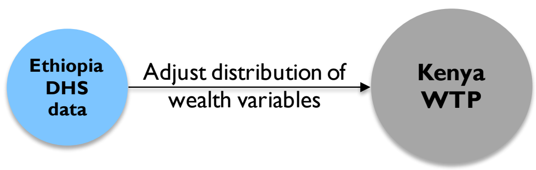
- The sanitation threshold and demand curve for all rural households within an expenditure category are the same, regardless of the sanitation facility.

If these assumptions are not completely valid, our demand curves will change. Both these assumptions can only be tested by conducting a WTP study in Ethiopia. However, we have validated the demand curves using additional approaches, which are outlined in the *Validating Approach 1* section.

3.3 APPROACH 2 – WEIGHT THE KENYA WTP DATA TO ETHIOPIA

Approach 2 involved weighting the Kenya WTP data to make it more representative of Ethiopia, by comparing the distribution of wealth variables in the Ethiopia Demographic and Health Survey (DHS) 2016 (CSA and ICF, 2016) and the Kenya WTP data (see Figure 13).

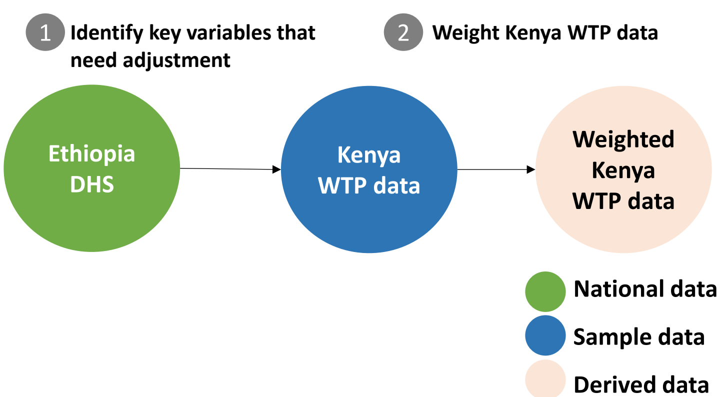
Figure 13: Overview of Approach 2



Approach 2 required a two-step process (see Figure 14):

- Identify key variables that need adjustment by comparing their distributions in the Kenya WTP data and the Ethiopia DHS
- Weight the Kenya WTP data, based on the distribution of the identified variables

Figure 14: Process for Approach 2



3.3.1 STEP 1 – IDENTIFY KEY VARIABLES THAT NEED ADJUSTMENT

We compared the distribution of wealth indicators in the Kenya WTP data and the Ethiopia DHS to identify variables that needed to be adjusted in the Kenya WTP data to make it more representative of rural households with unimproved sanitation in Ethiopia.

We considered rural households with unimproved sanitation in Ethiopia for comparison as the Kenya WTP data only sampled rural households with unimproved sanitation. Since we assume that the demand curve does not vary by sanitation facility (as described in Step 2 of Approach 1), we can still use the Approach 2 demand curve to compare it to the Approach 1 demand curve (which we have done in the *Validating Approach 1* section).

We considered wealth indicators as we assumed that wealth is typically correlated with households' willingness-to-pay for sanitation products. Within wealth variables, we looked at 11 variables that indicated possessions, mode of transport, and the types of materials used for house construction. Our rationale for choosing these variables was:

- These wealth indicator variables are typically comparable across contexts and indicate the household's ability to invest in improving their living standards
- Other wealth indicator variables such as water source and type of cooking fuel may not be comparable across contexts as they depend significantly on the local availability of facilities, which varies across contexts and not by wealth (e.g., a wealthy household in Kenya may still use surface water sources due to poor access to piped groundwater in their community)

Below is the list of the 11 wealth variables, common between the Ethiopia DHS and Kenya WTP data, which we compared:

Table 7: Distribution of wealth variables in Ethiopia DHS and Kenya WTP data

Wealth variable	Sub-category	Ethiopia DHS data (2016) (A)	Kenya WTP data (2017) (B)	Delta (B-A)
Has animal-drawn cart	No	98.54%	100.00%	1.46%
	Yes	1.46%	0.00%	-1.46%
Has radio	No	70.96%	69.16%	-1.80%
	Yes	29.04%	30.84%	1.80%
Has refrigerator	No	99.52%	100.00%	0.48%
	Yes	0.48%	0.00%	-0.48%
Has television	No	97.31%	99.69%	2.38%
	Yes	2.69%	0.31%	-2.38%
Has car/truck	No	99.88%	100.00%	0.12%
	Yes	0.12%	0.00%	-0.12%
Has bicycle	No	98.84%	91.59%	-7.25%
	Yes	1.16%	8.41%	7.25%
Has motorcycle/scooter	No	99.07%	99.69%	0.62%
	Yes	0.93%	0.31%	-0.62%
Owns land usable for agriculture	No	11.90%	6.23%	-5.67%
	Yes	88.10%	93.77%	5.67%
Owns livestock, herds or farm animals	No	12.17%	10.59%	-1.58%
	Yes	87.83%	89.41%	1.58%
Main roof material	Natural	41.26%	19.94%	-21.33%
	Finished	58.74%	80.06%	21.33%
Main floor material	Natural	94.96%	87.85%	-7.11%
	Finished	5.04%	12.15%	7.11%

Note:
Green indicates a difference of less than 5%
Yellow indicates a difference between 5-10%
Red indicates a difference greater than 10%

We chose to weigh the data based on 2 variables - "owns land usable for agriculture" and "main roof material" - due to the following reasons:

- "Main roof material" had the highest difference in distribution between the two datasets
- While "Has bicycle" and "main floor material" had a higher difference in distribution, we chose "owns land usable for agriculture" because:
  - We believed it was a better indicator of wealth than bicycle ownership
  - "Main roof material" was correlated with "main floor material" and adjusting for one adjusted the other
- We wanted to limit the weighting to only 2 variables to ensure that the effective sample size[4] did not reduce drastically

Output of Step 1: 2 wealth variables i.e., ownership of land and main roof material, that needed adjustment in the Kenya WTP data

3.3.2 STEP 2 – WEIGHT IDENTIFIED VARIABLES

We weighted the Kenya WTP data based on the distributions of the 2 identified variables in the Kenya WTP data and the Ethiopia DHS. The weights were based on the distribution of the 4 sub-categories of the 2 identified variables (refer to the last column of Table 8).

Table 8: Distribution of identified wealth variables in Ethiopia DHS and Kenya WTP data

Owns land usable for agriculture	Main roof material	Ethiopia DHS data (2016) (A)	Kenya WTP data (2017) (B)	Weight (A/B)
No	Natural	4.02%	1.25%	3.23
Yes	Natural	37.24%	18.69%	1.99
No	Finished	7.88%	4.98%	1.58
Yes	Finished	50.86%	75.08%	0.68

After weighing the data, we compared the distribution of the other 9 wealth variables to test if their distribution still broadly matched that of rural households with unimproved sanitation in the Ethiopia DHS.

Except for ownership of a bicycle, the distribution of all the variables was broadly similar. Further, the difference in the distribution of "main floor material" was also lowered. Given that the difference in the distribution for the ownership of a bicycle was less than 10%, we did not adjust the data further.

Table 9: Distribution of wealth variables in Ethiopia DHS and weighted Kenya WTP data

Wealth variable	Sub-category	Ethiopia DHS data (2016) (A)	Weighted Kenya WTP data (2017) (B)	Delta (B – A)
Has animal-drawn cart	No	98.54%	100.00%	1.46%
	Yes	1.46%	0.00%	-1.46%
Has radio	No	70.96%	71.58%	0.62%

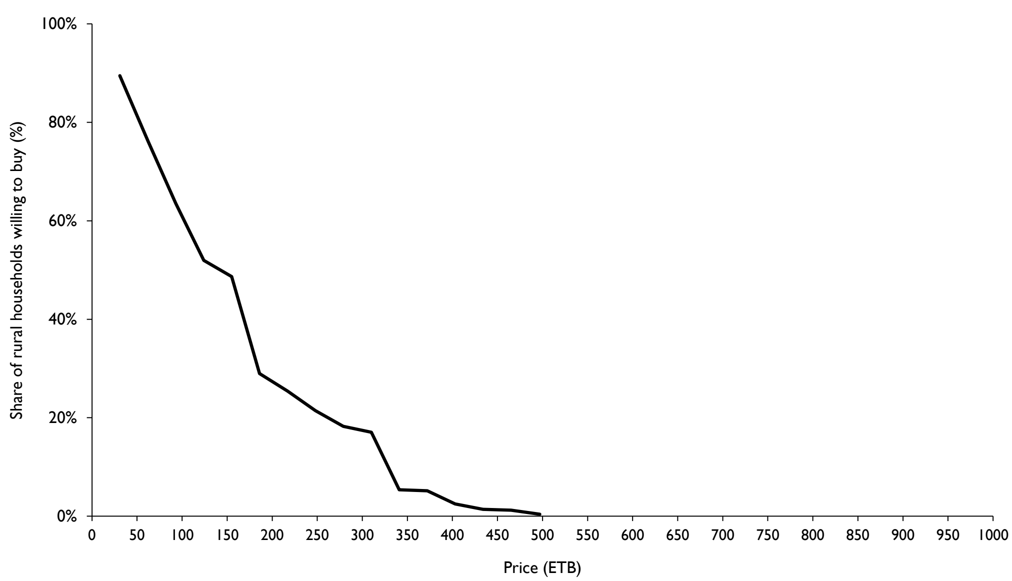
[4] The effective sample size typically reduces when a dataset is weighted. After weighting, certain observations in the sample will count for less than 1, effectively reducing the number of total observations in the sample.

Wealth variable	Sub-category	Ethiopia DHS data (2016) (A)	Weighted Kenya WTP data (2017) (B)	Delta (B – A)
	Yes	29.04%	28.42%	-0.62%
Has refrigerator	No	99.52%	100.00%	0.48%
	Yes	0.48%	0.00%	-0.48%
Has television	No	97.31%	99.79%	2.48%
	Yes	2.69%	0.21%	-2.48%
Has car/truck	No	99.88%	100.00%	0.12%
	Yes	0.12%	0.00%	-0.12%
Has bicycle	No	98.84%	89.92%	-8.91%
	Yes	1.16%	10.08%	8.91%
Has motorcycle/scooter	No	99.07%	99.51%	0.44%
	Yes	0.93%	0.49%	-0.44%
Owns livestock, herds or farm animals	No	12.17%	9.25%	-2.93%
	Yes	87.83%	90.75%	2.93%
Main floor material	Natural	94.96%	91.49%	-3.47%
	Finished	5.04%	8.51%	3.47%

Green indicates difference of less than 5%
Yellow indicates difference between 5-10%
Red indicates difference greater than 10%

Output for Step 2: Weighted Kenya WTP data and demand curve. The demand curve has "price" on the X-axis and the "share of households willing to buy" on the Y-axis.

Figure 15: Output of Step 2 (Approach 2)



3.3.3 LIMITATIONS OF APPROACH 2

- **We are weighting the data on variables that may not have a causal relationship with WTP in Ethiopia:** Approach 2 suggests weighting on wealth indicator variables. The causal relationship between these variables and WTP in Ethiopia is a hypothesis, and can only be tested after completing the WTP study in Ethiopia

- **We will not be able to breakdown the demand curve by expenditure/wealth category:** The distribution of all the wealth variables in the Kenya WTP data is not the same as the Ethiopia DHS, even after weighting. As such, the wealth index (and hence the wealth categories) generated from the Kenya WTP data cannot be applied to Ethiopia.

3.4 VALIDATING APPROACH 1

We have used the Approach 1 demand curve as our primary demand curve for the following reasons:

- **Limited sources of uncertainty:** Approach 1 assumes that the WTP for plastic pans is a function of household expenditure, which is likely true. The only sources of uncertainty are the sanitation expenditure thresholds, which also vary within a limited range - we assume it is more likely to vary between a narrow range of 0-10% than 0-50% as most households are unlikely to invest a significant share of their household income on sanitation. By contrast, Approach 2 assumes that the WTP for plastic pans is a function of several variables (e.g., multiple wealth-related variables), each of which is a source of uncertainty.

- **Ability to analyze by expenditure/wealth category:** Approach 1 offers the ability to analyze the impact of price reductions by expenditure category, which gives us a more nuanced understanding of the impact of any policy/intervention to reduce the prices of plastic sanitation products.

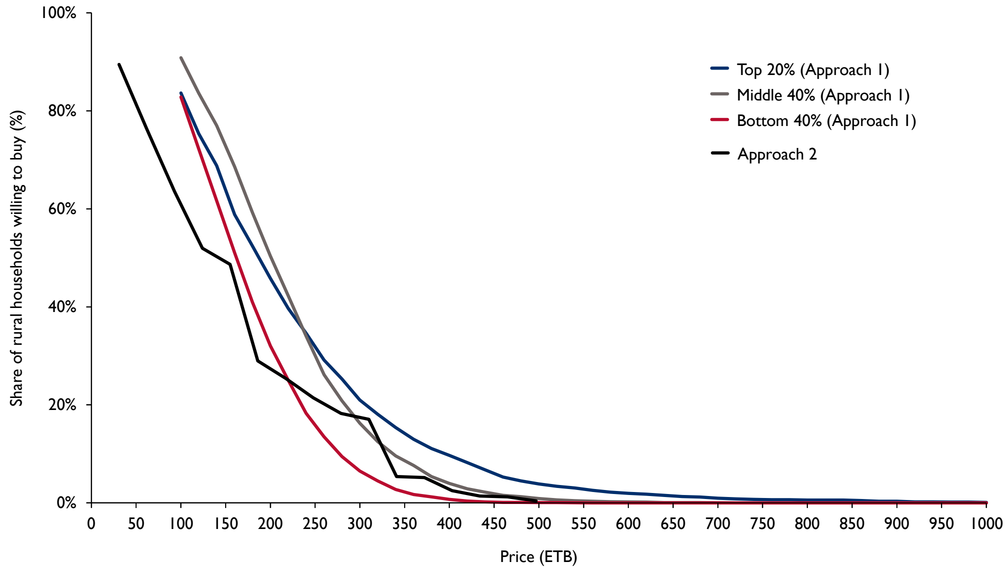
To validate Approach 1, we compared its results with Approach 2, and with price experiments run by T/WASH in Ethiopia.

3.4.1 COMPARISON OF APPROACH 1 TO APPROACH 2

Figure 16 compares the 3 demand curves for each expenditure category from Approach 1, and the demand curve from Approach 2. Since we do not have a breakdown of the Approach 2 demand curve by category, we can assume that it is an average of the category demand curves (since the underlying population for both curves is the same).

Based on a visual comparison, the demand curves are broadly similar, especially in that demand drops significantly beyond a price of ETB 400-600 (depending on the segment).

Figure 16: Comparison of Approach 1 and Approach 2 demand curves



3.4.2 COMPARISON TO PRICE EXPERIMENTS IN ETHIOPIA

T/WASH ran a price experiment on plastic slabs (a type of interface product) in Ethiopia, with the following results: [5]

- At a price of ETB 720, they sold 28 units to households in a 5-month period (October 2018-February 2019)
- After reducing prices to ETB 550, they sold 1,000 units to households in a 10-month period (March 2019-December 2019)

The jump in demand at a price of ETB 550 is consistent with the inflection points in our demand curves, which start rising between ETB 400-600, depending on the segment.

While various factors of the price experiment are not known (such as the level of marketing investments during the two periods), they do indicate that our demand curves may be reflective of actual demand for plastic sanitation products in Ethiopia.

3.5 ADDITIONAL CONSIDERATIONS

The tests highlighted in the previous section indicate that our demand curves can be a good proxy to conduct interim analysis in the absence of WTP data for Ethiopia.

However, we do acknowledge the limitations of both our approaches. We still plan to conduct the BDM auction study to gather WTP data for Ethiopia as and when travel restrictions are eased. This will help us refine our initial analysis based on the synthetic demand curve, and present a possibility of method comparison between the synthetic demand curves and the BDM auction demand curve.

[5] Based on notes shared by T/WASH

4.0 LIST OF VALUE CHAIN INTERVIEWS

We interviewed 9 value chain players to understand the current tax/tariff structure and process, the possible pass-through rate in the event of tax/tariff reductions, and (specifically for manufacturers) their interest in entering the market of plastic pans.

The table provides a summary of the players we interviewed. We have not mentioned specific names to preserve anonymity.

Type of value chain player	Products sold currently	Designation of interviewee
Manufacturer	Plastic products and packaging materials for beverages	Country CEO
	Ceramic products for wall and floor (e.g., hand-wash basins)	General Manager
	Plastic pipes and conduits	Sales & Marketing Manager
	Pipes and water tankers	General Manager
Importer	Plastic pans	Country Manager
Wholesaler	All sanitation products (including plastic sanitation products)	Owner
	All sanitation products (including plastic sanitation products)	Owner
Retailer	Construction materials (including plastic pans)	Owner
	Hardware materials (including plastic pans)	Owner

5.0 ADAPTATION OF ESI METHODOLOGY

We adapted an existing methodology—the Water and Sanitation Program's (WSP) Economics of Sanitation Initiative (ESI)—to estimate the economic value of the potential health benefits of a policy to reduce taxes/tariffs on plastic pans.

The ESI methodology provides an economic quantification of a country's losses from inadequate sanitation and potential benefits from improved sanitation. It is a standardized, peer-reviewed methodology that has been applied to more than 25 countries across South and East Asia, Africa, and Latin America.

The following sections provide:

- An overview of the ESI methodology
- An overview of our approach to adapt the ESI methodology for Ethiopia
- A list of the data, sources, and assumptions used for the ESI methodology

5.1 OVERVIEW OF THE ESI METHODOLOGY

The ESI methodology estimates several costs of poor sanitation, including:

- **Health-related costs** attributed to premature mortality, treatment of diseases, and productivity loss on account of illness and caregiving
- **Domestic-water related costs** such as treating and procuring water (e.g., cost of fuel to boil water, chlorine or filters to purify water) and the time spent in collecting or storing water
- **Access time costs** which quantify absence from school or work due to the time needed to access a toilet
- **Tourism costs** attributed to revenue losses from potential tourists avoiding travel to a country due to inadequate toilet facilities and risk of diarrhoea

We have only focused on **health-related costs** because the scope of our analysis is health-related benefits of improved sanitation.

The ESI methodology uses a two-step process to calculate the health benefits of improved sanitation:

- **Step 1:** Calculate health-related costs of inadequate or poor sanitation, which include three types of costs:
  - The cost of premature mortality
  - The healthcare costs for treating diseases
  - The cost of productivity losses due to illness

  Each of the three costs is estimated for two types of diseases:

  - Direct-impact diseases caused due to inadequate sanitation (e.g., diarrhoea, intestinal helminths, and trachoma)
  - Indirect-impact diseases caused by malnutrition (e.g., acute lower respiratory disease (ALRI), malaria and measles) due to diarrhea, which in turn is caused due to poor or inadequate sanitation

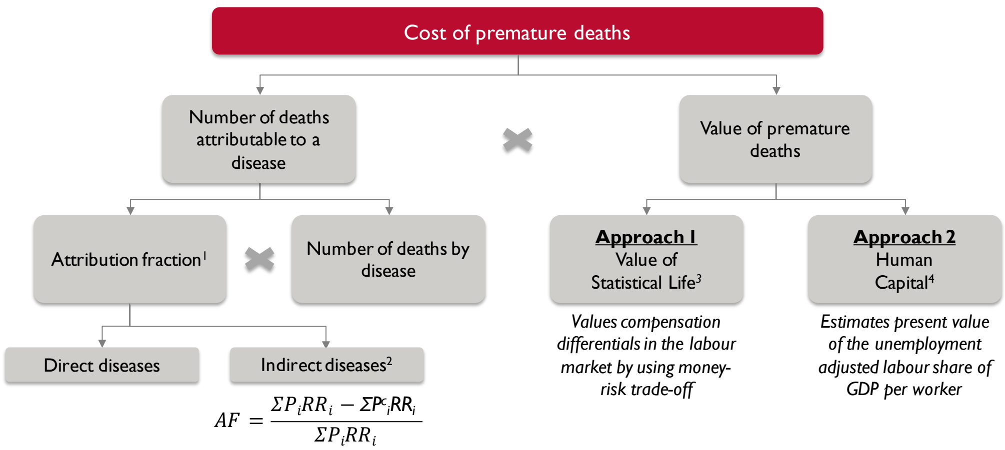
- **Step 2:** Estimate benefits as the proportion of health-related costs avertable due to improved access to sanitation

5.2 STEP 1: CALCULATE HEALTH-RELATED COSTS OF INADEQUATE OR POOR SANITATION

5.2.1 COST OF PREMATURE MORTALITY

This represents the value of productivity lost due to premature deaths caused by direct and indirect diseases attributed to inadequate sanitation. It is calculated by multiplying the number of deaths caused by diseases attributable to poor sanitation with the value of productive time lost due to each death (see Figure 17).

Figure 17: Calculation of cost of premature death



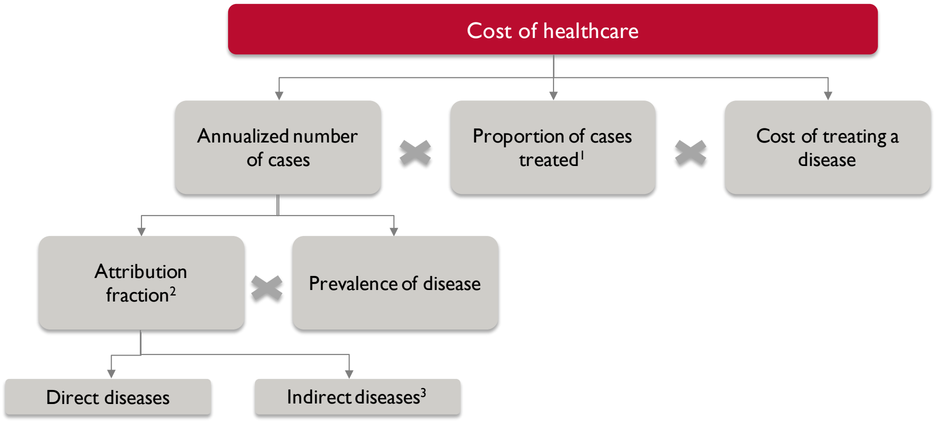
Notes:

1. *Attribution fraction is the proportion of the total number of deaths attributable to inadequate sanitation. This is taken as a benchmark percentage from a 2018 WHO publication for direct diseases and is calculated using a formula (see the next note) for indirect diseases.*
2. *P_i: Current underweight prevalence rate in different weight categories of the population (e.g., mildly underweight, moderately underweight)*
   RR_i: Relative risk of mortality due to a disease for the different weight categories
   P^c_i: Underweight prevalence rate for the counter-factual, i.e., the underweight prevalence rate one would expect in the weight category in the absence of diarrhea or other diseases.
3. *Value compensation differentials refer to the additional compensation that workers are willing to accept to work in more hazardous conditions that increase the chances of death, injury, or illness. It assumes that the compensation differentials in wages paid for different jobs partly reflect this compensation for bearing a higher risk to life and health.*
4. *We have used the Human Capital approach. It is estimated by calculating the present value of the labour share of GDP per worker (i.e., the GDP divided by the working-age employed population) using the annual growth rate of GDP per work, and the discount rate.*

5.2.2 COST OF HEALTHCARE

This represents the medical costs incurred to treat direct and indirect diseases attributed to inadequate sanitation. It is calculated by multiplying the number of annual cases of diseases attributable to inadequate sanitation with the medical cost of treating each case of the disease (see Figure 18).

Figure 18: Calculation of cost of healthcare



$$AF = \frac{\Sigma P_i RR_i - \Sigma P^c_i RR_i}{\Sigma P_i RR_i}$$

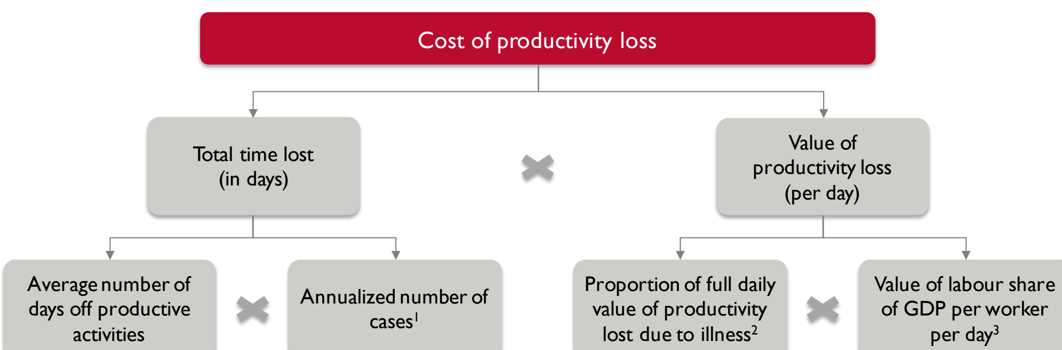
Notes:

1. *Refers to cases treated at a medical facility or by a healthcare provider*
2. *Attribution fraction is the proportion of the total number of disease cases attributable to inadequate sanitation. This is taken as a benchmark percentage from a 2018 WHO publication for direct diseases and is calculated using a formula (see the next note) for indirect diseases*
3. *P_i: Current underweight prevalence rate in different weight categories of the population (e.g., mildly underweight, moderately underweight)*
   RR_i: Relative risk of illness for the different weight categories
   P^c_i: Underweight prevalence rate for the counter-factual, i.e., the underweight prevalence rate one would expect in the weight category in the absence of diarrhea or other diseases.

5.2.3 COST OF PRODUCTIVITY LOSS

This represents the value of productive time lost due to illness for diseases attributed to inadequate sanitation. It is calculated by multiplying the total productive time lost due to diseases caused by inadequate sanitation with the value of productivity lost (see Figure 19).

Figure 19: Calculation of cost of productivity loss



Notes:

1. *Approach for calculating annualized number of cases is captured in Figure 18*
2. *Refers to the proportion of a productive day that is taken as lost due to illness*
3. *Value of a full day of productivity is measured using the labour share of GDP per worker i.e., the GDP divided by the working-age employed population. Annual rates are adjusted to a per day rate by assuming 235 working days a year.*

5.3 STEP 2: ESTIMATE PROPORTION OF HEALTH-RELATED COSTS AVERTABLE DUE TO IMPROVED ACCESS TO SANITATION

Health benefits are calculated as a proportion of health-related costs as the benefits or gains from improved sanitation (e.g., greater use of toilets) represent what can be saved by avoiding losses from health-related costs. The benefits will typically be smaller than the costs because not all adverse impacts of inadequate sanitation can be fully mitigated due to many factors such as the partial implementation of initiatives to improve sanitation, impacts due to multiple pathways, and geographical spillovers of sanitation-related diseases.

Based on a meta-analysis study (Fewtrell, et al., 2005), several ESI studies estimated a **32% reduction in health-related costs** as a result of improved access to sanitation. We have used the same proportion of 32% to convert health-related costs to health benefits.

5.4 ADAPTATION OF ESI METHODOLOGY FOR ETHIOPIA

To adapt the ESI methodology (described above) for Ethiopia, we generated a conservative estimate of health benefits. This minimized the risk of overestimating the impact of a policy or intervention, as this estimate is compared to the real monetary costs of implementing the policy.

We followed a 3-step process to adapt the ESI methodology for Ethiopia:

5.4.1 SELECTING DISEASES

We only included the health-related costs of diarhhoea in our analysis due to time and data limitations. This also gave us a conservative estimate of health-related costs of poor sanitation in Ethiopia, while ensuring that we still captured a significant portion of the total health-related costs. Diarrhoea accounts for a significant portion of total health-related costs in ESI studies for multiple countries[6] and is likely to account for a significant portion of total health-related costs in Ethiopia.

5.4.2 GATHERING DATA

We looked for Ethiopia-specific values for each component of the health-related costs for diarhhoea. If data was not available, we made assumptions based on ESI studies done in other countries or verified them with an ESI expert. These are further explained in the *Data, sources, and assumptions* section. We took conservative assumptions wherever required to minimize the risk of overestimating health-related costs of poor sanitation.

Our final estimate was for 2017 since most of the data was available for that year.

5.4.3 GENERATING THE ESTIMATE

To estimate health benefits, we inputted all the data and assumptions into a tool developed by the World Bank's Water and Sanitation Program and tailored by UNICEF.

The tool gave us the **average annual ETB value of health benefits (and costs) per household** that can be attributed to the use of improved sanitation facilities (such as the plastic pan). The tool estimated this value by:

- Calculating the per capita annual ETB value of health benefits (and health-related costs) for each age group
- Multiplying the per capita benefits (and costs) for each age group with the average members per household for each age group to arrive at the average health benefits (and costs) per household

[6] Diarrhoea accounts for 60-70 percent of the health-related costs in Cambodia, Philippines, India and Bangladesh.

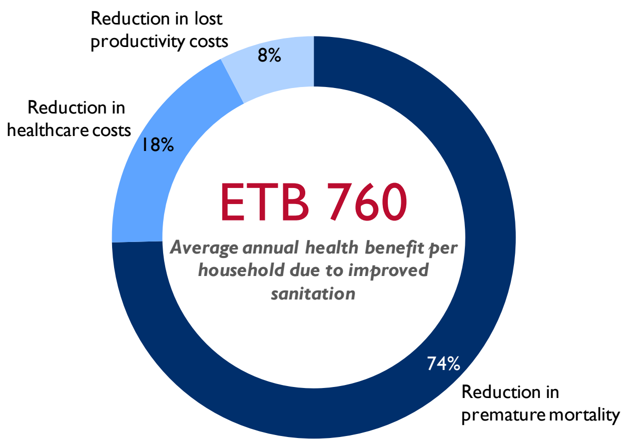
We multiplied this value of average annual health benefits per household with the total additional households that can afford plastic pans (after tax/tariff reductions) to estimate the potential health benefits of a policy to reduce taxes/tariffs.

5.4.4 RESULTS

Based on our analysis, **each household in Ethiopia incurs, on average, health-related costs of ETB 2,374 annually**, with premature mortality costs of ETB 1,771 (74 percent), healthcare costs of ETB 422 (18 percent), and productivity loss costs of ETB 181 (8 percent).

Each household in Ethiopia will accrue, on average, health benefits of ETB 760 annually if they get access to an improved toilet (see Figure 20).

Figure 20: Average annual health benefits per household due to improved sanitation



The next section provides more details on the specific data and assumptions used to generate these results.

5.5 DATA, SOURCES, AND ASSUMPTIONS

Inputs	Value	Source/Assumption	Comments
Cost of premature mortality			
Premature mortality rate	• 1.91 deaths per thousand per year for age group 0-4 years • 0.09 deaths per thousand per year for age group 5-14 years • 0.41 deaths per thousand per year for age group 15+ years	Diarhheal deaths (Global Health Data Exchange, 2017)	NA
Attribution factor for diarrhoea	43%	Attributable fraction of diarrhoea to inadequate sanitation (Global Health Observatory, 2016)	Value verified with an ESI expert
Unemployment-adjusted labour share of GDP per worker (annual)	ETB 37,602	GDP per person employed (World Bank, 2020)	Taken for the year 2017, and converted to ETB using PPP values (World Bank, 2019)
Average long-term annual growth rate of unit value of time	5.8%	Annual growth rate of output per worker (International Labour Organization, 2019)	Taken the average annual growth rate between 2010- 2020
Discount rate	7%	Based on National Bank of Ethiopia data (Trading Economics, 2020)	Taken as the 10-year interest rate in Ethiopia
Cost of healthcare			
Attribution factor for diarrhoea	43%	Attributable fraction of diarrhoea to inadequate sanitation (Global Health Observatory, 2016)	Value verified with an ESI expert
Number of cases of diarrhoea	• 2.5 cases per person per year for age group 0-4 years • 0.63 cases per person per year for age group 5-14 years • 0.63 cases per person per year for age group 15+ years	Ethiopia Demographic and Health Survey 2016 (CSA and ICF, 2016)	• Annual prevalence for diarrhoea is calculated by multiplying prevalence in a 2-week recall period from DHS (12%) with 52, and dividing by 2.5 (approach taken from the ESI India report) • Due to lack of data on the prevalence of diarrhoea above the age of 5 years, we assume that the prevalence in the population above 5 years is 25% of the prevalence in population below 5 years

Inputs	Value	Source/Assumption	Comments
			(approach taken from the ESI India report) • Both assumptions verified with an ESI expert
Percentage of cases seeking treatment in a health facility	• 42.9% for the age group 0-4 years • 32.2% for the age group 5+ years	Ethiopia Demographic and Health Survey 2016 (CSA and ICF, 2016)	DHS only has data for the age group 0-4 years. For the population above 5 years, we assume that the treatment rate for each facility is 75% of the treatment rate for the age group 0-4 years. Assumption verified with an ESI expert.
Percentage of cases requiring inpatient treatment	30% (of cases seeking treatment)	Assumption	Taken from ESI studies for other countries, and verified with an ESI expert
Percentage of cases seeking treatment by facility type	• 79% seek treatment in public health facilities • 21% seek treatment in private health facilities	Ethiopia Demographic and Health Survey 2016 (CSA and ICF, 2016)	DHS only has data for the age group 0-4 years. We assume the same ratio for the other age groups. We also assume the same ratio for both outpatient and inpatient cases.
Cost of health care per outpatient and inpatient episode by facility type	• ETB 173 for outpatient (public facility) • ETB 951 for outpatient (private facility) • ETB 956 for inpatient (public facility) • ETB 2,581 for inpatient (private facility)	Study of household expenditures on diarrhea treatment in Ethiopia (Tessema Memirie, et al., 2017)	• The study includes data only for the age group 0-5 years. We have assumed the same costs for all age groups. This assumption has been verified with an ESI expert • Outpatient costs for both public and private facilities have been taken as-is from the study after adjusting for inflation to 2017 price levels (the study collected data in 2013) • For inpatient costs in public health facilities, we have added the average cost of bed charges to the outpatient costs in public health facilities • For inpatient costs in private health facilities, we have multiplied the inpatient costs for public health facilities with 2.7 (this is same as the ratio of inpatient costs in public to

Inputs	Value	Source/Assumption	Comments
			private facilities for severe diarrhea cases)
Cost of productivity loss			
Attribution factor for diarrhoea	Same as above		
Number of cases of diarrhoea			
Unemployment-adjusted labour share of GDP per worker (annual)			
Days off productive activities	3 days	Assumption	Benchmark from ESI studies for other countries and verified with an ESI expert
Proportion of full daily value of productivity lost due to illness	• Working adults (15+ years): 30% • Non-working adults (15+ years): 15% • School-age children (5-14 years): 15% • Young children (0-4 years): 15%	Assumption	Benchmark from ESI studies for other countries and verified with an ESI expert
Conversion from health-related costs to health benefits			
The proportion of health-related costs avertable due to improved access to sanitation	32%	A study of the impact of WASH interventions on diarrhea (Fewtrell, et al., 2005)	Benchmark from ESI studies for other countries and verified with an ESI expert

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