# Behavioural responses to information on contaminated drinking water: randomized evidence from the Ecuadorian Amazon

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## Grantee Final Report

**Accepted by 3ie: March 2018**

## Note to readers

This impact evaluation has been submitted in partial fulfilment of the requirements of grant TW8.1021 awarded under the Transparency and Accountability Thematic Window.

The 3ie technical quality assurance team comprises Francis Rathinam, Marie Gaarder, Kanika Jha, an anonymous external impact evaluation design expert reviewer and an anonymous external sector expert reviewer.

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Suggested citation: Pellegrini, L, 2018. *Behavioural responses to information on contaminated drinking water: randomized evidence from the Ecuadorian Amazon, 3ie Grantee Final Report.* New Delhi: International Initiative for Impact Evaluation (3ie)

Research discussed in the publication is funded by UK aid through the Department for International Development (DFID) and the International Initiative for Impact Evaluation (3ie). 3ie quality assured the evaluation proposal, pre-analysis plan and the final impact evaluation report. The views expressed in the report are not necessarily those of DFID or 3ie.

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## Executive Summary

Access to safe water for human consumption is a global challenge and 'availability and sustainable management of water' is one of the objectives of the Sustainable Development Goals. The intervention evaluated in this study is a rapid and relatively inexpensive programme to increase transparency on water quality and engender behavioural change at the household level. The ultimate objective is to improve the quality of water consumed.

In Ecuador, in December 2016 a national survey was carried out –including a water testing campaign on the presence or absence of E. Coli– and it was estimated that 70.1% of the population has access to safe water. There is an urban/rural divide and while 79,1% of the urban population has access to safe water, this value decreases to 51.4% in rural areas (INEC 2017). The implications of this finding are that roughly one half of the rural population has no access to safe drinking water based on the results that include a single indicator of biological contamination (Edberg et al. 2000). In the 31 communities of the intervention area, in the Northern Ecuadorian Amazon, the results of the analyses carried out in the context of this intervention indicate that biological contamination is very common with more than 80% of the samples contaminated.

The idea underpinning this evaluation is to test a quick and inexpensive intervention that can improve water treatment, management and storage at the household level. The intervention falls within the broad categorization of 'Water, sanitation and hygiene' (WASH) projects and leverages on household behavioural change engendered by the provision of information on water quality and training on improved practices. The value of the intervention can be seen as temporary and complementary to more structural solutions to the challenges concerning the provision of safe water quality in rural Ecuador.

The main elements of the intervention are workshops that are participatory in nature and provide information on water quality from sources within the community. A follow-up activity, after 3 months, was the distribution of a report concerning water quality at the community level and of a short video to communicate the rationale and practicalities of improved water management practices.

While, the overall features of the intervention fit with mainstream WASH projects (cf Hulland et al. 2015), the special qualities of the intervention being evaluated are transparency and return of information: the workshops of water treatment, handling and storage were preceded by the collection and testing of water samples and included the return of information on the analyses' results. That is, while information on water quality and the effects on human health of consuming contaminated water are common practice in WASH interventions (e.g. Kelly and Barker 2016), the intervention provided information on water quality from several sources at the level of the specific community. Moreover, another feature of the intervention is the use of a 'guided participation' process that concluded each workshop, leading to (morally) binding commitments of the intervention team and the beneficiaries.

The study area is the Northern Ecuadorian Amazon, focusing on 60 communities fulfilling a set of criteria: they have at least 20 households, the distance with the border with Colombia is larger than 5km, and no information on water quality is available to the local population. A total of 90 pre-selected localities were included as clusters, primary sampling units, and 60 were randomly selected—31 treatment and 29 control. In the context of the evaluation, two rounds of household surveys were carried out: before and after the intervention in both control and treatment groups.

The key evaluation questions are whether behavioural change took place and if it is possible to identify meaningful and statistically significant differences in the way water is treated and handled comparing the treatment and the control group. Specifically, the analysis is based on the results of the household survey and examines whether households treat drinking water at all; if it is treated, whether it is boiled or chlorinated. All households were asked whether members wash their hands before handling water. In case the households have a rainwater harvesting tank, they are asked whether maintenance and cleaning of the system took place in the last three months. Further questions focused on whether households changed the way they manage water in the last twelve months; in the cases where there was a change whether this was related to the practice of boiling or chlorinating water.

Overall, the results to the most basic questions concerning this impact evaluation suggest that the intervention had little impact on behaviour. That is, little improvements are detected in terms of treating or managing water in the treatment group if compared to the control group. The fact that the selection into treatment and control groups was randomized and the two groups appear balanced on observable characteristics provide confidence in this result.

When it comes to the specific strategies that could be promoted by local and national policy-makers, this impact evaluation focused on a very specific intervention that can be succinctly described as rapid and inexpensive, adapted to local context, but ineffective to really solve the problem.

# 1. Introduction

Access to safe water for human consumption is a global challenge and 'availability and sustainable management of water' is one of the objectives of the Sustainable Development Goals. Specifically, objective 6.1 is: "By 2030, achieve universal and equitable access to safe and affordable drinking water for all" (United Nations 2015).[1] The intervention evaluated in this study is a rapid and relatively inexpensive programme to increase transparency on water quality and engender behavioural change at the household level. The ultimate objective is to improve the quality of water consumed.

In Ecuador, in December 2016 a national survey was carried out –including a water testing campaign on the presence or absence of E. Coli– and it was estimated that 70.1% of the population has access to safe water. There is an urban/rural divide and while 79,1% of the urban population has access to safe water, this value decreases to 51.4% in rural areas (INEC 2017). The implications of this finding are that roughly one half of the rural population has no access to safe drinking water based on the results that include the single best indicator of biological contamination (Edberg et al. 2000). On the one hand, a more comprehensive battery of tests of various forms of contamination would further reduce the estimated share of the population having access to safe water. On the other hand, the trend data indicate that over the past decade there has been a substantial improvement in terms of access to water and rural households' connections through public networks increased from 29.9% in 2007 to 57.5% in 2016 (INEC 2017).

The idea underpinning this evaluation is to test a quick and inexpensive intervention that can improve water treatment, management and storage at the household level. The intervention falls within the broad categorization of 'Water, sanitation and hygiene' (WASH) projects and leverages on household behavioural change engendered by the provision of information on water quality and training on improved practices. Clearly, behavioural change based on information provided at the community and household level cannot substitute for infrastructure construction,

[1] See: https://sustainabledevelopment.un.org/sdg6, accessed 19/12/2017.

upgrading and maintenance. The value of the intervention can be seen as temporary and complementary to more structural solutions to the challenges concerning the provision of safe water quality in rural Ecuador.

Globally evidence has been collected on the impact of short term WASH interventions (Yates, Allen, and Joseph 2017) as well as long-term (Hulland et al. 2015; De Buck et al. 2017). Our evaluation falls in the former category according to the definition adopted by Hulland et al. (2015): 3 months had passed from the end of the intervention when the follow-up household survey took place.

Wash interventions have been categorised as 'hardware' (i.e. providing actual equipment) or 'software' (i.e. based on promotional approaches) (De Buck et al. 2017:1). The intervention being evaluated falls in the software category and focuses primarily on induced behavioural change concerning water used for drinking purposes. It focuses on the adoption of water treatment techniques and improved practice in terms of water handling and storage. While, the overall features of the intervention fit with mainstream WASH projects (cf Hulland et al. 2015), the special qualities of the intervention being evaluated are transparency and return of information: the workshops of water treatment, handling and storage were preceded by the collection and testing of water samples and included the return of information on the analyses' results. That is, while information on water quality and the effects on human health of consuming contaminated water are common practice in WASH interventions (e.g. Kelly and Barker 2016), the intervention provided information on water quality from several sources at the level of the specific community. Moreover, another feature of the intervention is the use of a 'guided participation' process that concluded each workshop, leading to (morally) binding commitments of the intervention team and the beneficiaries (cf. Wang, 1990). On the side of the beneficiaries, the commitments always included the treatment of water and improved handling and storage practices. On the side of the implementing agency, the commitment included provisions to visit the communities again and provide extra information in print.

The study area is the Northern Ecuadorian Amazon and, as originally planned, the intervention was on oil-related contamination fitting in the 'Transparency and Accountability in Extractive industries' theme. Two assumptions underpinned the intervention: that the analyses would find oil-related contamination and that there would be heterogeneous levels of contamination in the water sources. Both assumptions were violated (see Section 2.1 for further details and for information on how to interpret the findings) and the focus of the intervention switched to biological contamination. As a result, the focus of the impact evaluation is also on biological contamination.

The report proceeds as follows: the next section introduces the intervention, the associated theory of change, and research hypotheses. Next context and timeline are presented, followed by the presentation of the evaluation and the intervention. Section 7 introduces the analysis and results of the evaluation, Section 8 contains the discussion. The section on specific findings for policy and practice concludes.

# 2. Intervention, theory of change and research hypotheses

## *2.1 Intervention*

The intervention's objective is to induce behavioral change through the disclosure of information about the contamination of drinking water sources, and this disclosure could work as a transparency mechanism having its own effects on behavior at the individual and household levels (Figueroa and Kincaid 2010). The main hypothesis being tested is that information can potentially influence the choice of treating drinking water.

### ***2.1.1 Initial approach***

The initial objective of the intervention was to focus on oil-related contamination based on the assumption that households can access water from different sources and that these sources have diverse water quality in terms of oil-related contamination. An implicit assumption was that it is possible to detect oil-related contamination. The analyses concerning the quality of water for human consumption carried out in June and November 2016 in the intervention area indicate otherwise and produced very little in terms of detection of Polycyclic Aromatic Hydrocarbons (PAH) and metals. It should be pointed out that to assess conclusively water quality it is necessary to perform continuous monitoring on an extensive list of parameters and the overall assessment of water quality in the area is beyond the scope of the intervention. It is also worth noting that the intervention covers only one of the channels through which exposure to oil contamination can affect human health: water for human consumption. That is, obvious contamination channels such as inhaling, dermatological contact, and through food are not examined here (e.g. Orta-Martínez, et al. 2018).

Furthermore, the analyses provide information on water quality only in two points in time, as a consequence they cannot provide information on human exposure to oil-related contaminants through water consumption in the past, nor of the risk of future exposure. Given the nature of the contaminants associated with the oil industry, that are mutagenic and cancerogenic, acute exposure in the past is sufficient to increase health risks –even beyond the generation being exposed. These health risks cannot be captured with the methodology used in this study and the findings cannot be considered as an assessment of the oil industry's impacts on water quality in the Orellana and Sucumbíos provinces. The results of the study, and of the water analyses in particular, cannot be used as an indication of the impact of the oil industry operations on human health in the study areas, such assessment should be carried out through a comprehensive epidemiological study. In fact, existing epidemiological studies find that oil operations have resulted in increased morbidity and mortality rates (e.g. see San Sebastián and Hurtig 2005).

The results of the analyses carried out in the context of this intervention indicate that biological contamination is very common with more than 80% of the samples being contaminated. The spread of biological contamination is somewhat in excess of the initial expectations since it affects also samples from sources that in principle should be free from this type of contamination. In particular, rainwater harvesting systems with filters that were introduced specifically to overcome water quality problems are also found to be the source of contaminated samples. One possible explanation is that maintenance practices of rainwater harvesting systems are less than ideal: the recommendation from the providers is to empty and clean the tanks weekly, while interviews in the field indicated that it is not uncommon to clean the tanks once every six months, or longer. Furthermore, the way the tanks are cleaned might not be thorough enough to eliminate E. Coli. As a consequence, the likelihood of contamination is substantial even for systems that, if operated correctly, are expected to provide uncontaminated water. Another possible explanation is that the samples are taken from the containers that households normally use to carry (and sometimes store) the water. It is possible that these containers are (also) a source of contamination. The sample collection procedure has the advantage that it mimics the way water is collected and provides information on the quality of water actually consumed, but does not allow for the identification of the precise stage of contamination –that is, we cannot be sure whether contamination is present at the source, or in the container, or introduced unwittingly by the person handling the water.

### *2.1.2 WASH intervention*

Given the findings on PAH, metals, and biological contamination the intervention switched its focus to 'Water, sanitation and hygiene' (WASH) and the information and behavioural change is focused on biological contamination. The main elements of the intervention are workshops that are participatory in nature and provide information on water quality from sources within the community. A follow-up activity, after 3 months, was the production and distribution of a report at the community level concerning water quality and the distribution of a short documentary shot on purpose in the area to communicate the rationale and practicalities of improved water management practices. Taken together, the intervention borrows from community-based approaches (community involvement and engagement), social marketing approaches (reports and documentaries), sanitation and hygiene messaging (presentations during the workshops) and approaches addressing psychosocial factors (participation and commitments) (De Buck et al. 2017; Wang 1990).

The intervention focuses on 'software' measures based on the assumption that there are no binding 'hardware' constraints (De Buck et al. 2017: 1; Hulland et al. 2015: 3). That is, the equipment and materials necessary for treating water and storing it appropriately are available to the households. Boiling is definitely an option for most households: approximately 96% of the sample uses gas as cooking fuel and Gas canisters are heavily subsidized. The cost of a canister of 15KG of gas in the region is between $2.5 and $3 USD, and they are widely available.[2] Chloride is currently available in small towns and markets, a 1 litre bottle of concentrate costs around $1.50 USD. Smaller size options are sold from $0.50 USD upwards and are available in small grocery store and markets throughout the region. The cleaning of rainwater collection systems would require little material costs, but is physically demanding and time-consuming.

*Workshops*

[2] The subsidized price is reflected in the average share of household consumption that is spend on gas in Ecuador: 0.35%. Source: INEC Índice de Precios al Consumidor, 2014. Available at: http://www.ecuadorencifras.gob.ec/indice-de-precios-al-consumidor/

The workshops took place in 31 communities during the second half of April 2017. They provided the information on water quality, contextual information and recommendations regarding improved water management practices.

The development of an effective communication strategy to deliver the results to the communities was an integral component of the intervention. The aim was to communicate the results to the communities not only to inform them of the quality of the drinking water sources but also to promote the adoption of practices –at the community, household, and individual level- that could help them improve the quality of the water consumed. The intervention strategy aims at inducing behavioural change at different levels by providing an understanding of the sources of biological contamination in the sampled sources, while simultaneously inducing the adoption of enhanced water, sanitation and hygiene practices.

The project team visited the 31 communities performing a socialization workshop in each of them. All the families in each community were invited to the workshops by the community leaders. The workshops were organized after working hours in most cases. Not all the families were able to attend due to personal circumstances or other impediments. Printed material –a poster and a brochure– with the information discussed during the workshop was given to the participants and extra material was left to the community representative for the families that could not attend. Thus, the intervention had a two-pronged approach: face to face interaction at the community meeting and provision of printed material.

Specific roles to conduct the workshops included a facilitator, a co-facilitator, a child caregiver and one person in charge of logistical support. The facilitator was the one guiding the workshop discussion while the co-facilitator was in charge of providing specific inputs and documenting the workshop. The support of a person in charge of childcare was key to ensure the attendance and attention of the mothers during the workshop. Women are often the ones providing childcare and also the ones responsible to treat drinking water in the household. The children had materials, e.g. art supplies, that they used to produce messages related to the content of the workshops: the importance of hand-washing and how to prevent fecal contamination.

The workshop duration was around 2.5 hours. During the pilot longer formats were attempted (3 to 4 hours) but the decision was to give shorter workshops to improve participation in terms of attendance and attention. During the pilot, women, in particular, seemed reluctant to subtract so much time from household activities. The time format, together with having a children caregiver, seemed to have worked adequately and 56% of the participants in the workshops were women.

Community leaders were also key participants in the workshops and contributed to organize the event and invite community members. The community president usually spoke at the beginning and end of the workshop, synthesizing the community reactions to the information presented by the technical team. The presidents also supported the intervention by delivering printed materials with the workshop information to the families that could not attend. The formal results of the water analysis, the workshop report, and the short video were delivered to the president of each community in a follow-up visit, for them to share with the rest of the families during their monthly community meetings. The technical team gave a detailed explanation about each of the documents to the community leaders.

Some of the workshop content and explanations were of a technical nature, especially the parts concerning the information on water analyses. To assure that the explanation was understood by all participants, the workshop was structured flexibly allowing the facilitator to adapt the explanations to the needs of the audience. Furthermore, the presentation was supported by printed materials and clear illustrations.

Figure 1 workshop in the community 2 De Septiembre, 2-May-2017

Source: Research team

The workshops were designed as a dialogue: the team presented the general results of the study and the specific results for the locality and reflected on topics related to:

1) How water sources get contaminated
2) Why oil pollution was not found in drinking water
3) Why biological contamination was present in the community-specific water sources
4) What are the health risks associated with biological contamination
5) What measures can the community, households, and individuals take to protect themselves from biological contamination

Based on the comments of community members, the intervention was well-received and the following points are particularly important to emphasize

- There was general satisfaction with the manner in which the intervention was carried out and its results returned since neither public nor private entities that have collected samples of water, soil, etc., have returned the results of their analyses and studies. In addition, the fact that the testing was performed by academic institutions gave greater credibility to the results, if compared to information provided by oil companies, or state authorities.
- Some participants would have expected a higher level of oil-related pollution in drinking water. This is understandable since the communities of the study are located within the area of influence of oil activity in Orellana Sucumbíos. The caveats of the approach used, mentioned above in this section, were explained, especially the fact that the results cannot be interpreted as evidence that there is no oil contamination in the area.
- Some communities reported that the issue of biological contamination in drinking water has not been addressed as a problem in the community by any actor, and they were surprised by the results. The widespread presence of fecal contamination in drinking water sources generated discussions about the causes and possible actions that the community, households, and individuals can take.

- At community level, the lack of adequate infrastructure for the disposal of human excreta, lack of protection to community water sources (i.e. fencing that limits access to livestock), and lack of adequate water sources (i.e. piped treated water) were identified as persistent problems that explain the presence of fecal contamination in drinking water.
- At the household level, the lack of maintenance and cleaning of the various water collection systems, and the lack of application of treatment measures (i.e. boiling water or chlorinating water) were identified as challenges. With respect to chlorine, a general lack of knowledge about its correct use to treat drinking water was identified.
- Some community members expressed reluctance to boil water since it was perceived that doing so altered its taste negatively.
- At the individual level, weak hygiene measures, especially hand washing, were identified as common problems.
- The report with the laboratory results delivered to each representative of the communities was received as a useful information tool that, in several cases, will be used by the community to ask for the necessary infrastructure to improve drinking water quality with state authorities.

As previously mentioned, the objective of the intervention is to induce behavioural change through the disclosure of information about the contamination of drinking water sources. In this sense, extensive research proves that the knowledge of the negative effects of a particular action does not automatically lead individuals or communities to change their behavior (Figueroa and Kincaid 2010). A careful understanding of the nature of what motivates people and the social and economic pressures that act upon them is required in order to better promote a certain behavioural change (Kelly and Barker 2016). To address these challenges, the workshops were designed based on participatory methods by engaging community members in a process of collective self-reflection, to facilitate understanding and ownership of solutions (Baum, MacDougall, and Smith 2006; SENAGUA 2017). After presenting the results of the drinking water tests, the facilitator engaged with the participants in a reflection to understand the determinants of the test findings, discuss, and suggest which measures could be taken to address biological contamination. To reinforce the chances of the adoption of such actions, the facilitators invited the participants to commit to the implementation of the identified practices (see also ONU-HABITAT and Fundación Project WET 2011). The facilitators asked a commitment from the community members (see Table 1: The most frequent commitments made at each level), but also committed themselves to a follow-up visit to distribute the new material.

During the follow-up visit the workshop report was delivered and a short film with the workshop messages to each community. The workshop report included the commitments made by the participants to implement measures to improve water quality. The short film was recorded during the information workshops emphasised the role of community members in improving water quality, and concluded with a drone image of the community and pictures from the workshops. The film was personalized for each community to make it more appealing to its members. The follow-up visits to deliver the Workshop Report and the short film to the 31 treatment communities took place during the last week of July and the first week of August 2017. The research team delivered a printed copy of the report and 3 copies of the short film to the community representative. The formats of the short film were 2 DVD copies and 1 MP4 copy. The video was played to the community representatives and the team invited them to share it with the community members. In most cases, the representatives committed to playing the video and read out the report during the next community meeting.[3]

[3] One example of the video is available here: https://www.youtube.com/watch?v=epPbm-HpafI (¿Cómo mantener el agua saludable? - Instituto de Geografía USFQ).

Table 1: The most frequent commitments made at each level

| At Community Level |
|---|
| • Organize working days to do the maintenance of the rainwater harvesting systems with filters. If the community does not have a trained community technician, the community representatives will contact FDA or UDAPT and request a training to the households. |
| • Contact the local governments and other actors to request latrines facilities, appropriate drinking water systems, and protection of current water sources. |
| • Contact the local governments and other actors to provide training in the construction of latrines, measures to protect water sources, use and management of water systems, and water quality in general. |
| • Contact the local governments and other actors and request them to deliver the information from previous water studies, and to perform new studies on water quality in the community. |
| • Get a formal training on how to use chlorine as a measure of treatment for drinking water before applying it. |
| • Contact FDA or UDAPT to evaluate the possibility of installing new filtered tank systems. |
| |
| **At Household Level** |
| • Boil the drinking water before consuming it |
| • Use chlorine to treat drinking water only after receiving a technical training |
| • Keep a clean bathroom/latrine, kitchen, and house in general |
| • Keep clean and protected the various water collection systems |
| • Wash and cover food and containers where water is stored |
| • Take the children regularly to be checked at the health centre |
| |
| **At Individual Level** |
| • Wash hands often, especially before eating and after going to the bathroom. |
| • Take a bottle with treated water to drink while working in the field. |
| • Educate children about practices to prevent fecal contamination. |
| • Go to the doctor in case of illness, and deworm periodically. |

## *2.2 Theory of change*

The theory of change in this evaluation is the result of a retroductive process. In fact, a genuine theory of change would be one that is thought-out *before* the intervention, while the one presented here is elaborated *ex-post*. The problem is that, as discussed in Section 2.1.1, crucial assumptions underpinning the intervention as originally planned have been violated –i.e. the results of the analyses were pretty homogenous across the various sources and detected very little in terms of PAH and metals. Once it became apparent that the intervention as originally planned would be of limited use, it was decided to adjust it and focus on biological contamination. The changes took place within severe constraints on what was feasible because of resources, and time, limitations. Also, as a consequence, the intervention itself has been designed without a fully-articulated theory of change.

Access to clear, reliable and, most importantly, actionable knowledge is key to better environmental and health outcomes. The intervention is based on the premise that access to water quality data, information on the effects of polluted water on human health and social pressure, among other factors, would lead to behavioural changes. Therefore, the hypothesis is that information on drinking water quality, coupled by information on the health risks associated with consumption of contaminated water will inform and shape individual preferences, cognition and behaviour leading to the choice of treating water.

The outputs of the intervention are the analyses of water quality and the communication of the results including the related information on the implications for human health of the implications of exposure to biological contamination and of ways to improve water quality. The expected outcomes are that, on the basis of the information provided, individuals will adopt strategies to improve water quality. The intervention focused in particular on boiling water, chlorination and cleaning of rainwater harvesting tanks. The ultimate impacts is reduced exposure to biological contamination and, as a consequence, improved health status of the general population and in particular of infants. The theory of change is summarized in Table 2.

In terms of impact timeline, the preparation of the intervention consists in the collection of water samples, the analysis and the preparation of the workshops. In our case, this phase lasted approximately 10 months. With hindsight, this phase could be substantially shortened since the results on biological contamination are available within a few days from the collection of the sample, while the analyses of Polycyclic Aromatic Hydrocarbons (PAH) and metals took several months. Since the latter produced in large majority negative results, they became uninfluential for the intervention and could be skipped if the intervention is replicated. The actual roll-out of the intervention took three months: beginning with the workshop providing information and concluding with the provision of video and printed materials in the follow-up visit after three months. The outcomes of interest for the impact evaluation, related with behavioural change, were then explored with a household survey after three months from the completion of the intervention.

Table 2: Theory of Change

| | |
|---|---|
| ***Outputs*** | |
| **Analyses of water quality** | Water samples of the different sources of drinking water of 31 communities are analysed |
| **Provision of results** | The results of the water quality analyses are provided in a socio-culturally adapted and participatory manner through workshops conducted in each community]. |
| **Provision of information** | Test results alone cannot be sufficient as they need to be interpreted within a broader context. Communities are provided with the necessary contextual and scientific information, to understand the health impacts of exposure to contaminated water and potential courses of action to improve water quality –mainly: boiling or chlorinate water and clean rainwater harvesting systems. |
| ***Outcomes*** | |
| **Behavioural change** | We expect the intervention to increase the number of households treating water to reduce or eliminate biological contamination. |
| ***Impacts –Medium to Long-term*** | |
| **Reduced exposure to biological contamination** | Improvement of the general health status of the population |

## *2.3 Research hypothesis*

The research hypothesis is that there is a sizeable and statistically significant difference in the water treatment and management behaviour of the control and treatment groups.

The main research hypothesis is that the treatment group –households belonging to communities where the intervention took place– are adjusting their behaviour to reduce exposure to contaminated water. Specifically, the hypothesis is that there is an increase in the number of households that: boil water, use chlorine, and/or clean the rainwater harvesting systems regularly. These changes are captured by questions in the questionnaire that was administered 3 months after the completion of the intervention. The answers to these questions provide the main data for the impact evaluation: the share of respondents that boil, chlorinate, and/or clean the rainwater harvesting system.

## 3. Context

The intervention was originally planned to take place at the same time in the Ecuadorian and Peruvian Amazon through implementing agencies that are grassroots organizations representing indigenous people and/or individuals and communities that are affected by oil extraction. The greatest challenge faced by the impact evaluation is that the intervention itself became redundant (at least in the originally planned format) in the project area in Peru when it appeared that the Peruvian state has unexpectedly decided with immediate effect to provide centralized water treatment facilities to most communities in the study area. The promise to construct infrastructure to provide safe water for human consumption to communities affected by oil contamination in the Northern Peruvian Amazon dates back (at least) to 1993, but actual construction started over summer 2015 (Orta Martínez, et al. 2018). As a consequence, the decision was taken to move the whole impact evaluation to Ecuador, where the number of communities and households being monitored was doubled compared to what was originally envisioned (60 communities, rather than 30 and 1,200 households rather than 600). Clearly, the move was rather complex. On the one hand, the Peruvian implementing agencies still had the desire to see an impact evaluation (of some sorts) of the new water treatment facilities and the departure of the project created some disappointment and required careful and diplomatic communication. On the other hand, the logistics and practicalities associated with this major shift created several hurdles: the re-allocation of responsibilities of staff in the field and supervisory responsibilities, reallocation of budgets (to be discussed with partners and authorized by 3IE), extra discussions with Ecuadorian implementing agencies, etc. Overall, the move of the whole impact evaluation to Ecuador created an unexpected additional workload, but was successful.

The implementing agencies are the Amazon Defence Front (FDA) and the Union of People Affected by Texaco (UDAPT) that work in the provinces of Orellana and Sucumbíos in the Ecuadorian Amazon. These implementing agencies are long-time partners of the impact evaluators and agreed to implement the intervention in a manner that is compatible with a rigorous impact evaluation. The implementation of the project suffered from some delays related to the larger scale of the impact evaluation to be carried out in Ecuador as well as for some practical implementation issues.

While the implementing agencies' activities are mostly focused on the socio-environmental impacts of oil extraction, they recognize biological contamination as a health issue that demands structural solutions from the local and national authorities. Both agencies are committed to supporting local communities claiming their rights to safe water.

## 4. Timeline

The preparation phase of the intervention was about ten months, while the intervention roll-out is 3 months. The first stage of the intervention are the workshops returning, contextualizing and explaining the results of the water quality analyses. The workshops are the pillar of the intervention and included components explicitly aiming at the promotion of behavioural change. The second critical element of the intervention was the follow-up visit to deliver printed and video material on water quality. The timeline of the intervention and of the impact evaluation is presented in Table 3.

Table 3: Intervention and impact evaluation milestones:

| | |
|---|---|
| Intervention Pilot | March/April 2017 |
| Intervention | April/May 2017 |
| Intervention Follow up | July/August 2017 |
| Household Survey | October/November 2017 |
| Final report to 3IE | March 2018 |

## 5. Evaluation: Design, methods and implementation

### *5.1 Pre-selection criteria*

While the implementing agencies did not have a ready-made list of all the local organizations and the local population that work with them, they provided the relevant information to the research team in order to construct the frame.

The *Frente de Defensa de la Amazonía* (FDA) had developed membership agreements with a variety of organizations including farmers', artisans', women's and other types of grassroots organizations, which situated it as a coordinating agency rather than a grassroots movement. When asked for a list of all the members, FDA delivered a provisional list since a revision of the internal procedures of membership was underway. However, there were no specific geographical locations attributed to most organizations and the varied nature of the members made it difficult to accurately draw a map of the localities that FDA had an influence on.

Similar issues were found in the case of the other implementing agency, *Union de Afectados y Afectadas por las Actividades Petroleras de Texaco* (UDAPT). Following an opposite approach, UDAPT focused their efforts at the settlement level given the purpose of their work and did not work exclusively with grassroots organizations. Since UDAPT is an organization representing the populations affected by the negative impacts of oil extraction activities of Chevron-Texaco, it is within their objectives to reach the most affected localities, support their struggle for environmental justice and collaborate to improve living conditions. The list of communities collaborating/member of UDAPT was more extensive if compared to FDA.

In order to avoid disturbing the randomized nature of the impact evaluation, a set of criteria was pre-defined allowed to minimize political influences over the choice of study localities. During April 2015 a reconnaissance mission was carried in Orellana and Sucumbíos. The purpose of this mission was to go through the lists handed by both implementing agencies to verify the relationship to the listed locality (in the case of UDAPT) and to identify the actual area of influence of grassroots organizations (in the case of FDA). The list of visited localities reached over 130 settlements mostly situated in the rural areas of both provinces. The main purpose of this quick survey of localities was to identify potential study locations, therefore a rapid questionnaire allowed to collect data at the locality level regarding total population and number of households/families, the main sources of water in the settlement, and the general issues concerning water (pollution, limited access, lack of treatment, etc.).

In order to include only communities that would benefit from the project implementation and would lend themselves for an impact evaluation, a set of criteria was defined, in line with the hypotheses of the study, to identify the primary sampling units. Those communities that fulfilled the criteria were included in the list of clusters used to select randomly the clusters in the sample. The first criterion is demographic: all localities with less than 20 households were excluded from the population of interest since we were planning to carry out 20 household surveys per locality. The information used for this criterion was reported by local community leaders during the first visit and 7% of visited localities were excluded.

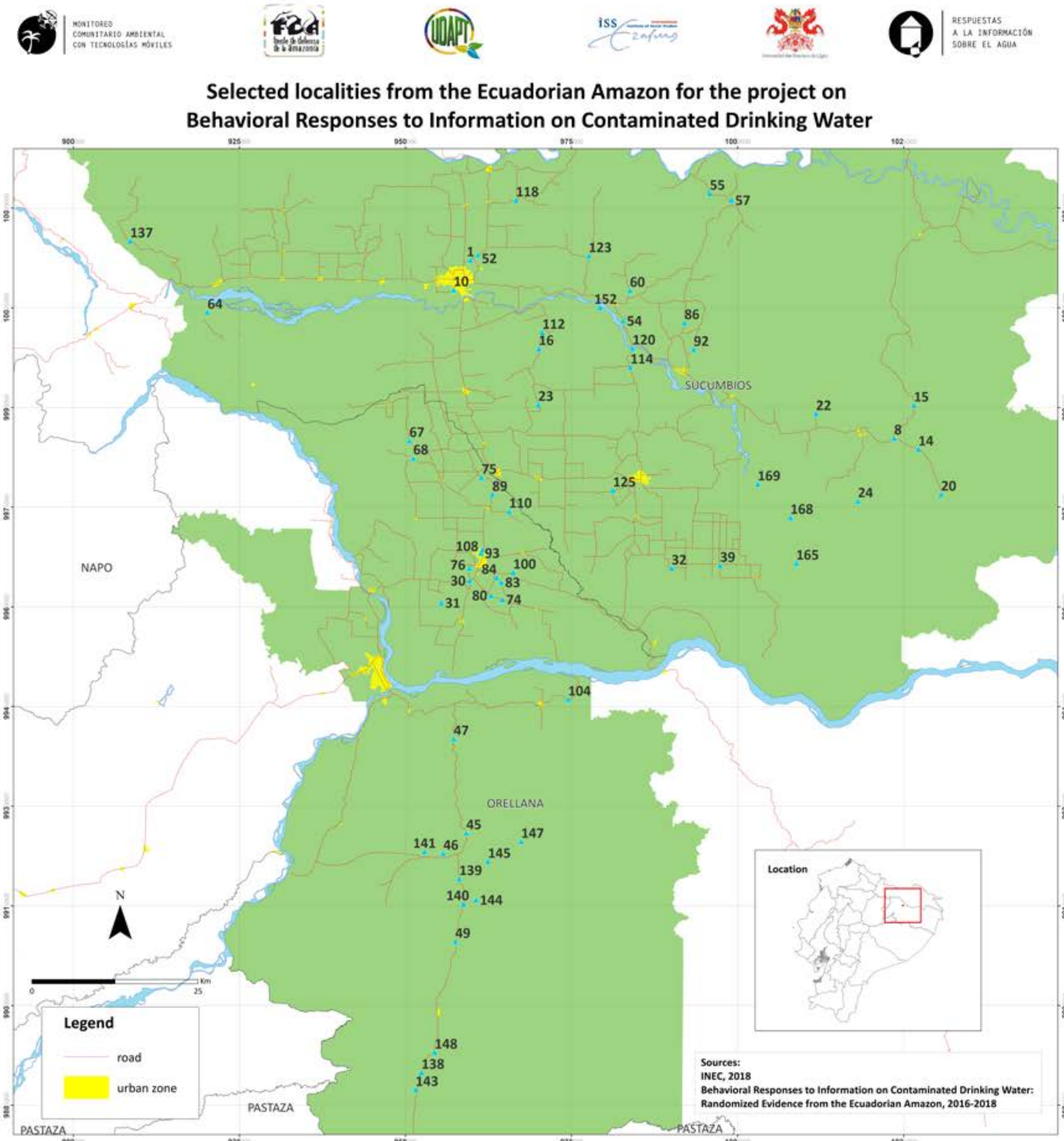
An additional criterion was set for security reasons. All settlements located within 5km from the northern border of Ecuador with Colombia were excluded since these are areas that are often used as a buffer zone in conflicts among Colombian military, guerrilla and paramilitaries. Also, in these areas criminality, including but not limited to narcotrafficking, is rife. This criterion resulted in the exclusion of 2% of visited localities.

The final criterion was the exclusion of localities where water analyses had already been carried out and results returned to local population. The responses varied among the visited localities. While in most cases local residents had not received any information about the quality of water, some localities had received partial information from local and national governmental institutions, international and local organizations, schools and research facilities, etc. Overall 33% of visited localities had received some sort of information about the quality of water, therefore the expected behavioural change was less likely to take place in these localities.

In short, the main criteria set for pre-selecting localities were: a population of at least 20 families/households, a location outside 5km of the Colombian border, and nonexistent information about water quality. A total of 90 pre-selected localities were included as clusters and 60 were randomly selected (31 treatment and 29 control).[4] The geographical distribution of the communities is presented in Figure 2 and is rather typical of the area: communities are distributed along the roads and the rivers.

[4] The original plan was to have 30 treatment and 30 control clusters, however there was a practical mistake and eventually one extra community was treated.

Figure 2: Study area: Orellana and Sucumbíos Provinces, Ecuador.




## Localities

- 1- Barrio Santa Marianita- FDA Y UDAPT
- 8- Aguas Negras- FDA
- 10- Barrio Naranjal- FDA Y UDAPT
- 14- Las Palmas- FDA
- 15- Marian 4- FDA
- 16- Marianita de Jesus El triunfo- FDA Y UDAPT
- 20- Rey de los Andes- FDA
- 22- Unión Bolivarense- FDA
- 23- Virgen de Baños- FDA
- 24- Virgen del Rosario- FDA
- 30- La Parker- FDA Y UDAPT
- 31- Los angeles- FDA Y UDAPT
- 32- Los Olivos- FDA
- 39- San Vicente- FDA
- 45- Dayuma central- FDA Y UDAPT
- 46- El Puma- FDA Y UDAPT
- 47- km 26- FDA Y UDAPT
- 49- Rumipamba- UDAPT
- 52- Santa Marianita- FDA Y UDAPT
- 54- 12 de Octubre- UDAPT
- 55- 13 de Marzo- FDA
- 57- Chone 1- FDA
- 60- Echeandía- UDAPT
- 64- San Andres- FDA
- 67- 2 de Septiembre- FDA
- 68- 25 de Diciembre- FDA
- 74- La Loma del Tigre- UDAPT
- 75- La Ponderosa- FDA
- 76- Las Palmeras- UDAPT
- 80- Pimampiro- UDAPT
- 83- San Agustin (kichwa)- UDAPT
- 84- San Antonio- UDAPT
- 86- San Vicente- FDA
- 89- Sultana del Oriente- UDAPT
- 92- Virgen del Rosario- FDA
- 93- 25 de diciembre- FDA
- 100- La Florida- UDAPT
- 104- Pamigua- UDAPT
- 108- Santa Rosa- UDAPT
- 110- Unión Chimboracence- FDA Y UDAPT
- 112- Asociación Flor de Mayo- UDAPT
- 114- Cooperativa 28 de marzo- UDAPT
- 118- Patria Nueva- FDA Y UDAPT
- 120- Unión Paz y Progreso- FDA Y UDAPT
- 123- Tres Palmas- UDAPT
- 125- 16 de abril- UDAPT
- 137- Recinto Bermejo- UDAPT
- 138- San Francisco de Cononaco- UDAPT
- 139- Tiputini- UDAPT
- 140- Sarentsa- UDAPT
- 141- El Esfuerzo- UDAPT
- 143- Shiripuno- UDAPT
- 144- La Nueva Joya- UDAPT
- 145- Conga- UDAPT
- 147- Auca Este- UDAPT
- 148- La Andina- FDA Y UDAPT
- 152- Comuna Kofan Dureno- UDAPT
- 165- Comunidad Bellavista (Siekopai)- UDAPT
- 168- Sototsiaya (Siona)- UDAPT
- 169- Abokëwira (Siona)- UDAPT

## *5.2 Survey*

The Household Survey (HS) was conceived as the main instrument for collecting quantitative data at the household level. The geographic areas where the survey was carried out are two provinces in the northern Ecuadorian Amazon: Sucumbíos and Orellana. The first survey was designed and implemented in March – June 2016 and the second in October – November 2017.

The survey was structured following existing models of household surveys, in particular the Demographic and Health Surveys designed by the United States Agency for International Development.[5] This survey allows the gathering of data covering a diversity of topics ranging from demographic composition, dwelling characteristics, and socioeconomic structure of the household.

Additional information has been collected on water use practices (harvesting, transport, storage) and water sources, the perception of impacts of oil activities, and social participation. These topics were introduced as sections within the household survey using other templates of demographic surveys. Other questionnaires used for designing the HS included the 7th National Census of Population and 6th National Census of Dwellings and the National Survey of Employment and Unemployment (2016) by the National Institute of Statistics and Census of Ecuador.[6]

The first survey was piloted in Tarapoa, Orellana, during the first days of June 2016. The town of Tarapoa was chosen for piloting the survey since it was in the list of clusters but it was not selected for the study. A total of 15 surveys were administered among household heads by 4 researchers and feedback was discussed after the experience of the team in the field. With minor changes, the survey was ready for the baseline. The Household Survey was used for data collection during mid-June 2016 by a team of 9 enumerators and a supervisor.

The second household survey, carried out in the second half of October 2017, followed the same organizing principles and targeted the same communities and households. The second survey was piloted in two communities, Sol Naciente and San Antonio, Sucumbíos during the 15th and

[5] DHS: http://dhsprogram.com/, accessed on 20/12/2017

[6] http://www.ecuadorencifras.gob.ec, accessed on 20/12/2017.

16th of October 2017. These communities were selected for piloting since they are part of the list of clusters but were not selected for the study. Furthermore, the information workshop format was also piloted in these two communities, therefore the families did have some background information on the topics to be evaluated with the survey. During the first day, a total of 20 surveys were administered among household heads of Sol Naciente by the 12 enumerators responsible for the survey. 5 researchers accompanied the visits, and feedback was discussed after the experience of the team in the field. The survey format was adjusted based on the feedback and then piloted again in San Antonio. A total of 12 surveys were administered among household heads by the 12 enumerators accompanied by the research team. The survey format was further adjusted and the survey was ready to be used for the evaluation. The data collection period was from October 17th to November 2nd, 2017 with a team of 11 enumerators and 1 supervisor. Given the changing focus of the intervention from oil-related to biological contamination and the WASH nature of the intervention, the second questionnaire contains more details regarding practices that can determine biological contamination of water.

The first household survey was administered in a traditional paper format and data entered and cleaned in the following weeks. In the second survey, the software Survey123 for ArcGIS was used to collect data through tablets and smartphones. The latter method for data collection allows for on-the-spot consistency checks and immediate transfer of the data to a central database. These obvious advantages have to be weighed against the fact that more advanced technology created some frustrations of a new type: flat batteries, overload of the wifi in the hostel where the enumerators were hosted (and as a consequence issues with the regular transmission of the data) and in general some tension due to the fact that the enumerators had limited experience with this technology.

### *5.3 Household selection*

Data gathering in each locality started with the presentation of the project objectives and an interview with local leaders who had previously been informed and agreed to participate in the study (all selected clusters accepted the intervention and the impact evaluation). The research team visiting each locality was usually composed of two enumerators, one researcher and a driver; in order to make progress over time and use resources efficiently, three research teams were deployed simultaneously in three localities.

The interview with the leader was carried out in order to identify the main water sources and the distribution of households in each village. The local leader then directed the enumerators to identify the dwellings and households that belonged to the community: the leader would signal the extremes of the locality so that each enumerator would start with the household at one extreme and then move on to the centre of the locality. The survey was then administered to 20 households per community; however, in some cases the population present at the moment the survey was carried out was smaller than 20 households. In order to complete the required sample size (1200 surveys) households in neighbouring communities were also surveyed as long as the new community was not already part of the survey and the households shared the same sources of water of the neighbouring community. After half a day of surveying, the team would gather to identify the water sources in each community that would be sampled as part of the study. This identification was based on household responses, in particular the section about water sources, consumption and practices, to ensure that the households included in the survey shared the three sources. After checking that the cited water sources were confirmed by both leaders and households, the researcher would randomly select sources to draw the water samples. In treatment localities, three water samples were drawn from three different water sources (when three different sources were available).

Within each locality 20 households had to be surveyed. However, in 17 localities out of the entire list of 60 localities, there was an insufficient number of household. In these 17 localities it was decided to survey the neighbouring localities that 1) used the same or similar water sources, and 2) were not already included in the entire list of 60 study localities. However, in 8 localities it was not possible to arrive at the proposed number of 20 households since there were no neighbouring communities sharing the same source of water. The minimum number of households surveyed in these localities is 16 (this was the case for 6 localities).

During the second data collection campaign, households surveyed in the first campaign were the target for a follow-up interview. With the help of field maps and name lists the enumerators were instructed to find the households and administer the survey, if possible, with the same member of the household. However, in every locality there were households that could not be found and new households were interviewed to replace them. Moreover, in the localities with less than 20 interviews in the first survey, an attempt was made to interview additional households in order to reach the level of 20 households per community. By the end of the second campaign, only 3 study localities had less than 20 interviews and 2 study localities counted 21 interviews. The total sample is composed of 1191 households, 971 are households already in the 2016 sample. Appendix A provides information about attrition.

The questionnaire was answered by the households that agreed to participate in the study. Households that for any reason refused to participate were skipped and the next available household was asked to participate in the survey. The rate of non-responsiveness is approximately 1% of all households.

## 6. Programme or policy: Design, methods and implementation

The design and implementation of the intervention was carried out in close collaboration between the team of researchers and the implementing agencies. On the one hand, the project and the evaluations have leveraged, from their inception, on the long-standing partnerships and collaborations between researchers and community organizations involved in the project. On the other hand, the collaboration was essential to ensure that the principles of rigorous impact evaluation would be respected.

In order to meet the objectives of scientific rigour of the impact evaluation and equity among the communities, the approach has been a randomized phase-in. That is, both control and treatment groups are going to be treated in the end, but the order of treatment is random. Thus, during the duration of the impact evaluation 31 randomly selected communities have been treated, in January/February 2018 the remaining 29 communities are going to receive information regarding their water quality that has been tested in the meantime. Water testing to detect coliforms and E. coli has been carried out taking three samples from three sources per treatment community and the results suggest widespread biological contamination.

## 7. Impact analysis and results of the key evaluation questions

The key evaluation questions are whether behavioural change took place and if it is possible to identify meaningful and statistically significant differences in the way water is treated and handled. Specifically, the analysis is based on the results of the household survey and examines whether households treat drinking water at all; if it is treated, whether it is boiled or chlorinated. Furthermore, all household were asked whether members wash their hands before handling water. In case the households have a rainwater harvesting tank, they are asked whether maintenance and cleaning of the system took place in the last three months. Further questions focused on whether households changed the way they manage water in the last twelve months; in the cases where there was a change whether this was related to the practice of boiling or chlorinating water. Table 4 presents hypotheses, outcome description and measurement.

Table 4: hypotheses, outcome description and measurement

| *Hypotheses* | *Outcome description* | *Measurement* |
|---|---|---|
| *Households belonging to treatment communities start to treat drinking water* | For the household, it is common practice to treat water | The share of households that respond positively to the question: "Do you do anything to make drinking water safer?" |
| *Households belonging to treatment communities start boiling drinking water* | For the household, it is common practice to boil water | The share of households that treat water and responded "boil water" to the question: "What treatment do you do?" |
| *Households belonging to treatment communities start chlorinating drinking water* | For the household, it is common practice to chlorinate water | The share of households that treat water and responded "chlorinate" to the question: "What treatment do you do?" |
| *Households belonging to treatment communities start washing hands before handling drinking water* | For the household, it is common practice to wash hands before handling drinking water | The share of households that respond positively to the question: "Do you wash your hands before manipulating drinking water?" |

| | | |
|---|---|---|
| *Households belonging to treatment communities start doing maintenance the rainwater harvesting system* | The rainwater harvesting systems are maintained at least every three months | The share of the households that have a rainwater harvesting system and responded positively to the questions: “Have you ever done maintenance to the system?” and “Have you done any maintenance in the last 3 months?” |
| *Households belonging to treatment communities start changing their behavior with respect to the management of drinking water* | Households change behavior | The share of households that respond positively to the question: “In the last year, have practices and behaviors changed over water?” |
| *Households belonging to treatment communities that change their behavior with respect to the management of drinking water and start boiling or chlorinating* | Households change behavior and start to boil or chlorinate drinking water | The share of households that respond positively to the question: “In the last year, have practices and behaviors changed over water?” and in the follow-up question on “How they changed behavior” answered that they started boiling or chlorinating drinking water. |

Note: all information is based on self-reported behaviour collected through the survey instruments.

The first question is whether drinking water is treated by the household and in the survey reads: ‘Do you do something to improve the quality of drinking water?’ The results of this crucial question are presented in Table 5. While the treatment group is more likely to treat water, the difference appears to be a modest 4.5% and is statistically insignificant. Limited to the households that answered that they do some form of treatment, the following question is what kind of treatment they apply. The two most interesting categories are the practice of boiling water and/or use of chloride since these were always included as practical recommendations in the workshops and were included in the commitments. The results are presented in Table 6.

Table 5: Share of the households that reported treating drinking water

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Any treatment* | 0.366 | 0.411 | 0.390 | 0.314 |
| *N* | 571 | 620 | 1191 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

Table 6: Share of the households that reported each treatment

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Boil* | 0.856 | 0.894 | 0.877 | 0.311 |
| *Chlorinate* | 0.091 | 0.071 | 0.080 | 0.481 |
| *N* | 209 | 255 | 464 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

The question regarding the change of behaviours that follows concerns the practice of hand washing before handling water and is complementary to treating water. The results are available in Table 7 and the difference is insignificant.

Table 7: Share of the households that reported hand washing before handling water

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Handwashing* | 0.799 | 0.784 | 0.791 | 0.689 |
| *N* | 571 | 620 | 1191 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

Other questions concerned sub-samples and, in particular, the ones who had a rainwater harvesting system with filter were asked about its maintenance. While these systems should guarantee safe water, our analyses suggest that they are not free from contamination (see Section 2.1 above). After consulting the organizations that install and deliver the systems and visiting households using them, it turned out that while the advice is to provide maintenance (i.e. thorough cleaning) of the systems on a weekly basis, in practice many households clean them much more irregularly. The workshops had a component on the importance of regular maintenance of the systems: the practice of emptying them entirely and cleaning them on a regular basis. The questionnaire had two questions on these systems: the first asked whether maintenance was ever performed since installation and the second whether maintenance was performed in the last three months. The results are reported in Table 8

Table 8: Share of the households that reported maintaining the rainwater harvesting system

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Yes, ever* | 0.779 | 0.833 | 0.803 | 0.587 |
| *Yes, in the last 3 months* | 0.649 | 0.567 | 0.613 | 0.421 |
| *N* | 77 | 60 | 137 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

The questionnaire also contained questions explicitly pertaining behavioural change. The first question inquired whether in the last 12 months any change took place in the way water is treated within the household (Table 9). If the answer was positive, a follow-up question would ask about the change (Table 10). These are the only results that appear to produce a difference that is statistically significant. In terms of the size of this difference, the treatment group has experienced more behavioural change (19% vs. 8%) and more than half of the behavioural change is associated with the practice of boiling water. Overall, this change seems rather modest in magnitude since the difference in terms of introducing the practice of boiling water between treatment and control group is 3%.[7]

Table 9: Share of the households that reported a change in the way water is managed in the last 12 months

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Change* | 0.079 | 0.194 | 0.139 | 0.000 |
| *N* | 571 | 620 | 1191 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

[7] We also controlled whether there is a social desirability effect in the answer to this question by comparing the results with those on water treatment (Table 5) and it appears that they are coherent. That is, the respondents who claimed to have changed behaviour and started to boil water did in fact state that they boil water when asked without reference to 'behavioural change'. It is worth noting that the two questions were placed in different parts of the survey.

Table 10: Share of the households that reported each type of change

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Boil* | 0.333 | 0.592 | 0.521 | 0.006 |
| *Chlorinate* | 0.111 | 0.050 | 0.067 | 0.270 |
| *N* | 45 | 120 | 165 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

These results were also confirmed in a treatment on the treated analysis, where we considered as control group households belonging to control communities that had not been exposed to training events in the last year and compared them to households from treatment communities that did actually attend the workshop. That is, the differences presented in Table 5 to Table 8 are equally modest in magnitude and statistically insignificant. The results from Table 9 to Table 10 are also confirmed and the difference in behavioural changes is modest in magnitude, but statistically significant when it comes to change in general and boiling water in particular.

The two rounds of surveys provide data for a panel that includes information on water treatment and specifically boiling and chlorination at two points in time. Thus, we run a linear regression with a simple model containing only the treated dummy (T, equal to 1 if the community is treatment and the survey is post-intervention), the time dummy (t) and (absorbed) dummies for each community ($\Lambda$). The model is:

$$Y_{ijt} = \alpha + \beta_1 T_{jt} + \gamma \Lambda_j + \delta t + Z'_{ijt}\beta_2 + \epsilon_{ijt}$$

Where the subscripts $i$, $j$, and $t$ represent household, community, and time, respectively. The same regression was then run with covariates ($Z$): the household head age, the household head gender and the household size (cf. Hulland et al. 2015). The results are presented in Table 11. They appear inconclusive. Similar models have been run with specific practices –boiling and chlorination– as dependent variables, but treatment is similarly insignificant.

Table 11: Share of the households that report treating water

| | *Treat water* | *Treat water* |
|---|---|---|
| *Treated* | 0.0056 | 0.0053 |
| | (0.271) | (0.303) |
| *2017 year* | -0.0007 | -0.0026 |
| | (0.830) | (0.648) |
| *Household head age* | | 0.0007 |
| | | (0.462) |
| *Household head gender* | | 0.0579 |
| | | (0.182) |
| *Household size* | | 0.0015 |
| | | (0.789) |
| *constant* | 0.428*** | 0.322*** |
| | (0.000) | (0.000) |
| *N* | 2296 | 2296 |

Source: Own database, household survey 20016 and 2017. Linear regression, absorbing community dummy, p-values in parentheses, * p<0.05, ** p<0.01, *** p<0.001.

Overall, the results to the most basic questions concerning this impact evaluation suggest that the intervention had little impact on behaviour. That is, little improvements are detected in terms of treating or managing water in the treatment group if compared to the control group. The fact that the selection into treatment and control groups was randomized and the two groups appear balanced on observable characteristics (Blondeel, Cisneros-Gallegos, and Pellegrini 2016; See also Appendix H and Appendix L) provide confidence in this *prima facie* result.

## 8. Discussion

### *8.1 Summary of findings*

The results of this impact evaluation are mostly negative since we do not find substantial and significant behavioural difference in the way water is treated by the treatment group if compared to the control group. Only when focusing on behavioural change with respect to water management, it turns out that there is a difference and that the treatment group is more likely to have started boiling water in the last 12 months. This difference is statistically significant but rather modest in absolute terms.

Facing this negative result, we find two main ways to interpret it. The first is that the intervention was not sufficiently intense/long: the duration and intensity of the exposure to information could easily be expanded through more workshops (to ensure broader participation and reiterate commitments), the follow-up visit could have included a community meeting or even visits to the households. The second way is that this specific intervention simply did not work. It must be noted that 37% of the control households do treat water already, thus room for improvement is limited to the remaining households and some of them might face objective problems with water treatment. Moreover, during the workshops and qualitative interviews with some community members, it appeared that some individuals were already aware of the need to treat water and of correct management practices, but other constraints were mentioned as barriers to behavioral change. For example, some individuals mentioned disliking the taste of boiled water, while others mentioned the need to wait for the water to cool down as a reason to avoid boiling the water.

Overall, the challenge in interpreting the negative result is that the intervention is very focused and took place in a very limited amount of time. The format of the workshops, their duration, the fact that the follow-up visits were only focused on delivering video and print material are all specific characteristics of the intervention that might have limited its effectiveness.

In terms of costs, the intervention required approximately 25,000 USD for implementation in 31 communities. Details of the cost calculations are provided in Appendix J.

## *8.2 Limits of the impact evaluation*

This impact evaluation suffers from potential biases and is based on reported behaviour. In particular, the social desirability bias and the Hawthorne effect (or observer effect) could bias to some degree the answers provided. The social desirability bias and the Hawthorne effect would specifically lead respondents of the survey to state that they treat water even if they do not. It should be noted that, in principle, both effects would bias the results of both control and treatment groups. However, if the bias affects especially the treatment group, for example because the respondents are more aware of the 'correct answer/behaviour' once they have been exposed to the intervention, the bias would be in favour of the impacts being evaluated, so it would be *against* our findings. One way to deal with these biases, if a similar evaluation is carried out in the future, would be to introduce also random spot checks and observation to validate reported behaviour.

At the same time, some degree of contamination of the control group seems to have taken place and in the total population 22% of households said to have participated some sorts of events regarding water quality during the last year. While 35% of households in the treatment group reported having attended, in the control group 8% of households responded that way. That is, a share of the households in the control group were exposed to interventions closely associated with the treatment, resulting in some degree of control group contamination. This is the main limitation with respect to the internal validity of the study.

## *8.3 Generalizability*

When it comes to the external validity of the findings, it is worth reminding that while the problem of biological contamination of water sources is common to the rural population in Ecuador, the intervention is very specific and several factors in its set up might affect its effectiveness. As such, we would expect that the results hold for the population of Ecuador in the Amazonian provinces, but at the same time we are cognizant that changes to the specific format of the intervention might also change its effectiveness in terms of behavioural change.

## 9. Specific findings for policy and practice

The results of this impact evaluation indicate that in the study area the problem of biological contamination is pressing –more than 80% of the samples of drinking water were found to be contaminated. As a consequence, most households are exposed to contaminated water and the issue of water quality should be given due attention.

When it comes to the specific strategies that could be promoted by local and national policy-makers, this impact evaluation focused on a very specific intervention that can be succinctly described as rapid and inexpensive, adapted to local context, but ineffective to really solve the problem. This intervention was never understood to replace infrastructural improvement and had the much more limited aim of mitigating persistent shortcomings of water quality through behavioural changes. It turns out that, by and large, even that aim is beyond the possibilities of the intervention. Thus, the intervention was able to only influence the behaviour of a fraction of the population.

Given the history of the intervention, that originally focused on oil-related contamination and later changed to biological contamination, the intervention itself was profoundly modified and adjusted along the way within severe constraints. These constraints referred to the time available to develop and implement the intervention (one year) as well as the resources available to cover the costs of the intervention (approximately 25,000 USD).

The intervention was designed from the outset with the knowledge that the provision of ‘scientific facts’ alone is not sufficient to induce choices that result in improved health and safety outcomes. This is true both in both developing and developed country contexts and cut across a variety of practices ranging including healthy eating habits, the decision to smoke and to wear seatbelts. For instance, (potential) smokers are not simply convinced to quit (or not to start) when they are told about its negative effects. Yet there is evidence that different approaches to information provision can make meaningful differences in behavior (Kahneman, 2011). The intervention agencies developed a tailor-made approach that aimed at maximizing the degree of behavioral change. This impact evaluation shows that the intervention nevertheless failed to make a major impact. The negative result only shows the need to better understand the drivers of behavioral decisions. On the one hand, a more extensive and intensive intervention addressing more households, with more workshops (or other events), and developed over a longer time frame, might be markedly more effective. On the other hand, the change of behavior at the household level could be a poor (temporary) substitute of improved water provision and substantial investment in physical infrastructure is needed.

With respect to the original objective of the intervention to focus on oil-related contamination, the analyses produced very little in terms of detection of Polycyclic Aromatic Hydrocarbons (PAH) and metals. Our conclusion is that only continuous monitoring on an extensive list of parameters, as opposed to the two sets of analyses produced in this intervention, would provide a complete and reliable assessment of the impacts of the oil industry on water used for human consumption. While this kind of monitoring was outside the scope and possibilities of the present intervention, the quantification and characterization of oil-related pollutants in water sources remain a research area with important open questions in the Northern Ecuadorian Amazon.

## Appendix A

### Field Notes

Information workshops to return water results

Information workshops were carried out in the 31 treatment communities to return the results of the water tests and discuss practices to improve drinking water quality, during the second half of April 2017. This workshop was considered the keystone of the intervention. During the planning and implementation of the workshops, some relevant insights were gained which can provide useful inputs on how to return scientific information to communities.

What is an adequate timing for the information workshop?

Time is a crucial factor to consider when planning and implementing information workshops with the communities. The field researchers in charge of the workshops were divided in three teams looking to visit three communities per day. Each team was responsible to contact the leaders of each community to establish a day, time and place to carry out the workshop, and to prepare a workshop schedule. In addition, written invitations were prepared and delivered to the leaders to invite the community members. It is also important to provide the leaders with sufficient information on the workshop topic to engage them and increase the efforts made to invite more people.

In most communities, people are only available to attend workshops during the afternoon. This consideration had to be taken into account at the planning stage and the workshops got scheduled in the afternoon during working days and in the morning on the weekends. During weekdays the fatigue of the participants was evident, and the workshop had to be adapted to the energy level of the audience. On the weekends, the level of attendance to the workshop was greater and the energy level of the participants was also enhanced. The workshop was piloted and adjusted so that the total duration of the workshop could not exceed two hours. During the pilot, the workshop lasted more than three hours to cover in detail information on water results and engaging activities like community mapping. However, the audience started to leave after the first hour. Since the main objective of the workshop is to deliver the information on water quality and water practices to most of the families from the community, the workshop had to be adjusted to a shorter format by reducing some activities.

Which materials can support the information workshop?

Materials are good support tools to ensure a better retention of the information that is shared in the workshop, and also to inform the families that could not attend the workshop. However, for materials to be useful they have to be adequately elaborated considering the cultural context of the audience. Three different products were prepared i) a brochure, ii) a poster, and iii) a video. The brochure had detailed information about the objectives of the study, the methodology of analysis for oil and biological contamination in drinking water, the results and their interpretation, and the practices to improve water quality at the individual and household level. The poster summarized this last part on practices to improve water quality given that this was the main aspect that needed to be remembered and put in practice by the families. Since the information provided in the brochure was quite technical, the design and illustrations were used to attract the attention and clearly convey ideas. The team worked closely with the designers' team before and after piloting the material to ensure a balance between information and design. The final result was a booklet of about twenty pages with text and illustrations, and an A1 poster to deliver to all families. In each community a printed poster on canvas was also delivered to be displayed in a place of public access, like the school, health center, meeting place, church, etc. This poster would also serve to replicate the message of prevention and elimination of biological contamination in water for families who have not attended the workshop. As a recommendation to improve the materials it could be useful to include pictures of the same locations of the study, for example of water sampling and water systems, in this way, the content of the material may appear less abstract to the families.Some brochures and posters were left to the local leaders in order for them to distribute it to the residents who did not attend the workshop. This is to ensure greater access to information for all members of the community.

The video was prepared during the workshops to be delivered at a later stage as a refresher of the information provided during the workshops. The video was recorded with the participation of community members explaining in their own words what is fecal contamination, the effects of exposure and measures to avoid it. The last part of the video got personalized for each community by showing a drone video of the community and pictures from the information workshop. Three copies of the video were delivered to each community leader on July-August 2017 so they could share it with the families and present it during community meetings.

What is a good presentation format that engage participants?

Each team consisted of a facilitator, a co-facilitator, a person to take care of the children and a driver/logistic support. The facilitator was the one in charge of guiding the workshop, while the role of the co-facilitator was to provide support in the technical explanations, and to document the memories of the workshop.

The support of a person to take care of the children was necessary to ensure the assistance and attention of mothers during the workshop, crucial since they are the main agents when it comes to water quality in the household. The people who looked after the children had teaching material also related to the content of the workshop: drawing sheets to paint with messages about the importance of washing hands and avoiding fecal contamination. In addition, games and play activities were organized to keep the children entertained. This was recognized as a good strategy by mothers in several communities.

Although the content of the workshop regarding water testing results was technical, the explanation had to be understood by all participants. The design of the presentation allowed the facilitators to adapt the explanations to the needs of the audience: the presentation was supported with printed canvas with the main ideas and clear illustrations, so the facilitator could use them at convenience. The use of canvas was chosen to avoid inconveniences related to the lack of electricity in some community meeting spaces. In addition, to facilitate understanding, the presentation of the results of the study was based on graphic representations of pollutant concentrations in water: a glass of water with a layer of pollutants in the bottom and a red line as a limit was illustrated, in this way, when the contamination exceeded the red limit, then there was an excess of contaminants in the water for human consumption. This allowed for a better explanation of the existence of contaminants in the water below or above the permissible limits. to explain the channels of oil and fecal contamination in the water, the illustrations were based on the observation of certain practices and the discussion on whether this were good or bad for water quality.

The workshop concluded with the definition of "commitments" or future actions that people will commit to take at the individual, household, and community level, some commitments were also allocated to the implementing agencies. The definition of commitments in a participatory way allowed participants to get directly involved in the solution of the problem of fecal contamination in the drinking water and increase the degree of responsibility to take actions. The team committed to return the memories of the workshop, to take an additional water sample testing to validate results, and to follow up on the agreed commitments through the households' survey at the end of the intervention.

# Appendix B

## Pre Analysis Plan, Behavioral Responses to Information on Contaminated Drinking Water: Randomized Evidence from the Ecuadorian Amazon

**Sample:**

The first six months will be used as an inception period were data on geographical and socio-economic variables will be used to match a random set of communities into treatment and control groups. Months 7 to 11 will be used for primary data collection (socio-economic survey, with focus on water sources and analysis of water samples). Months 12 to 13 will be used to provide information to community members on water quality. Months 19 to 23 will be used to collect a second round of data (socio-economic survey and analysis of water samples). The following 2 months info on water quality (from the second round of analysis) will be reported back to the communities. The data will allow the testing of the assumption that water quality is stable over time and comparing water sourcing in the treatment and control groups. When it comes to the subgroups targeted by the intervention, the implementing agencies are grassroots organizations acting on behalf of the beneficiaries of the intervention.

The unit of observation in the study is the household and in the first 3 months socioeconomic and environmental information will be collected leading to the randomized selection and matching of treatment and control communities. The intervention will be in two stages separated by a 12 months period with 30 communities (15 in each country) treated at the onset of the project and an additional 30 used as control. The control communities will be treated after one year during the follow-up surveys when the initially treated communities will also have their water rechecked. The unit of the randomization is the community (cluster) to which the households belong.

For the sampling of eligible communities we rely on the 2007 population census for Peru and the 2010 population census for Ecuador. We select small communities between 100 and 1000 inhabitants that are located in the Amazon and exposed to oil exploitation activities. We make a list of all eligible communities and randomly select 30 communities in the Northern Peruvian

Amazon and 30 in the Northern Ecuadorian Amazon. Thus the sample is equally split across the two countries. To increase power and balance at baseline, we will use multivariate, pair-wise matching. Our strategy minimizes the Mahalanobis distance in observables characteristics at baseline between pairs (for discussions see McKenzie and Bruhn 2009; King et al 2007). Within each matched pair of communities, one will be randomly picked for treatment and the other as initial control. If for some reason, a pair will drop out of the analysis, the remaining sample will still be balanced across pairs. Matching variables include community size (census data), remoteness and access to natural water sources (GIS information). To avoid spill-over effects from treatment into control communities we have to ensure that the communities are located far enough from each other not to use the same water sources. Therefore, we might have to randomly replace communities that are too close to each other

–from a randomly drawn reserve list of communities. Among those 60 communities we select 15 for treatment in each country. In the communities, we make a list of all households living there at the moment of the baseline survey. We develop that list of actual settlements with the help of the community elders and representatives. We will also include dispersed settlements that are part of the community in that household listing. From the household list we randomly select 20 households per community for the survey. We will assure that equal probability of being surveyed is given to all households no matter whether they live in the center of the community or at its periphery. Thus we apply a clustered sampling method with communities being our clusters and a random sample of 20 households per cluster being selected for interview. This sampling is most appropriate in the context of our study as the information and transparency intervention about water quality is implemented at the community level with households being the ultimate beneficiaries. Replacement sample: If we do not find the members of a household after repeated visits we replace the household by another randomly chosen household from the same community. For this purpose we will have a reserve list of households. This allows us to ensure that we survey exactly 20 households per community.

Instead of equally sampling 20 households per community we could sample the number of households per community relative to the size of the community. We prefer an equal number of households per community to keep the sampling design easy for implementation on the ground.

In order to adjust for unequal community sizes we can make use of the population size as probability weights in our empirical analysis. At the household level we interview the household head or his/her spouse. In addition, we employ a detailed household roster where we collect key information about every member of the household. The detailed household roster will allow us to study water-related responses to our intervention for different age-groups.

**Data sources:**

The data collection will include both output and outcome variables. In terms of outputs, the variables of interest include the actual return to communities of the information on water quality collected through the data analyses. Data on output will be collected through the monitoring system of the intervention and are a necessary (but not sufficient) condition to observe and measure outcomes and impacts. In terms of outcomes, the project will collect and analyze information on choices made by households to source water, monetary and non-monetary costs associated with access to water and health status related to acute forms of intoxication from water. In terms of actual impacts, we have a set of variables related to changes in water sourcing practices towards sources that are 'cleaner' as well as the arising costs and their distribution. We will also explore whether health impacts can be detected, even though given the relatively short time frame (one year) of the analysis we will be able to analyze only health indicators associated with acute but not chronic exposure to polluted water sources. While we will try to access clinical information through the health posts, it is unclear whether in all the villages we will be able to gain access to this information and the analysis might be limited to the information provided by the households rather than clinical data. Covariates that are going to be included and controlled for in the analysis include geographical data on spatial distribution of communities, of oil extraction activities and oil infrastructure –GIS– as well as socioeconomic information at the household level.

**Estimation Technique:**

Our Identification strategy is based on the randomized introduction of the intervention that allows us to construct a counterfactual by examining the households in the not-yet-treated communities as control groups. In the econometric analysis we will employ an OLS framework with covariates to identify the impacts of the intervention in an intent-to-treat fashion. The treatment of all groups at the end of the programme is necessary on ethical and political grounds since it ensures that all participants will eventually benefit from the treatment, making it more acceptable for all groups to join the project and its evaluation. The distribution of groups will be balanced across the two countries. Our expectation is that biases related to externalities, spillovers, and contamination issues are limited. In particular we chose the community as unit of randomization to be able to ensure that treated and control communities are sufficiently distant from each other: given the difficulties and expense related to (mostly fluvial) transportation in the area, regular visits to treatment communities to gain access to clean water are simply not an option for the control groups.

Up to 80 percent of the water sources in Amazonian areas with oil extraction and oil infrastructure are contaminated with heavy metals and Polycyclic Aromatic Hydrocarbons (OEFA 2013). We conservatively expect that 75% of the households in our sample rely on contaminated water for their daily hygiene, cooking and drinking. As a consequence of the water testing in the treatment communities and the accompanying information campaigns, we expect at least a 15% decrease in the use of water from contaminated sources. As households might rely on a diverse mix of water sources we expect quite some variation across communities and impose a sigma of 0.5. This results in a standardized absolute effect size of 0.3. In order to capture this effect with a feasible sample size that can be credibly attained and followed up on in the difficult to access rainforests, we propose a two-level randomized-block design with the first level, i.e. level of intervention, being the community and the second level being constituted by the households. We follow Hedges and Rhoads (2010) and calculate the operational effect size by making use of the standardized effect size, an intra-class correlation coefficient (rho) of 0.6 and the proportion of between-cluster variability that is attributable to heterogeneity of treatment effects (omega), which we set at 0.5. Rho covers the extent to which the households within a cluster are more alike than those in different clusters. By setting it at 0.6 we expect to properly allow for similarities between neighboring households. Concerning omega, we expect that effects are likely to be fairly consistent across communities as all the communities are made up of indigenous people, the ecological zone is the same and in terms of the socio-economic profile the communities are expected to be equally poor. What will bring in some heterogeneity is the opportunity households have to move from one water source to another. Therefore, we expect some degree of heterogeneity here. If treatment effects were perfectly consistent across communities, omega would be 0. We consider a value of 0.5 plausible for our set-up. In order to attain power of 0.8, this implies that we need to include 60 communities in our study. We equally split the sample into treatment and control communities resulting in 30 treatment communities. These sample size calculations are based on our most conservative expectation for changes in water sources. We expect the information component of our intervention to have a larger effect than the actual behavioral impact we will be able to measure. We expect awareness about water quality and its impact on health to increase and social mobilization to take place to lobby for better water. Moreover, we will collect further demographic and socio-economic variables at the community and the household level, which can also be included in the analysis to further increases the power of our study. Put differently, with the additional covariates we should be able to even detect smaller effects or split the sample to search for heterogeneous effects across countries.

**Qualitative analysis:**

The qualitative analysis will cover questions that relate to the quantitative ones, but cannot be answered with quantitative methods. These questions, for example, refer to events of low frequency or with considerable time lag that would not fit in our quantitative evaluation. Moreover, the quantitative analysis will have to be embedded in an in-depth contextual study that will allow for a sound interpretation of the econometric results. The research team includes social scientists that specialize in qualitative methods and will contribute to the production of case studies and a political economy analysis of the dynamics surrounding the implementation of the project and its impacts. A feature of particular importance for this part of the study is the comparative analysis that can be carried out by assessing differences and similarities in the two countries.

# Appendix C

## Power Calculations

### Two-Level Randomized-Block Design

Calculations are based on Chapter 8 by Hedges and Rhoads (2010)

| | | |
|---|---|---|
| $\delta$: standardized effect size | 0.08 | 0.3 |
| $\mu 1$: mean in treatment area | 0.41 | 0.52 |
| $\mu 2$: mean in control side | 0.37 | 0.37 |
| Difference in means= | 0.04 | 0.15 |
| $\sigma$: sigma | 0.5 | 0.5 |
| n: # households within clusters | 20 | 20 |
| $\omega$: degree to which treatment effects vary across clusters* | 0.5 | 0.5 |
| $\omega$= 0: treatment effects are perfectly consistent across clusters | | |
| $\rho$: intraclass correlation | 0.6 | 0.6 |
| Operational effect size = (effect size) x (design effect) | 0.10 | 0.38 |
| Operational sample size = # of clusters (m) | 60 | 60 |
| Power | ≈0.12 | ≈0.814 |

The resulting power is taken from Table 2 of Hedges and Rhoads (2010) based on the operational effect size and the operational sample size

Possibility to include covariates to further increase power

* Effects are likely to be fairly consistent across communities (indigenous people, same opportunity to move from one water source to the another, same ecological zone), so that a value of $\omega$= 0.5 is plausible

# Appendix D

## Results

**Table 12: Share of the households that reported treating drinking water**

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Any treatment* | 0.366 | 0.411 | 0.390 | 0.314 |
| *N* | 571 | 620 | 1191 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

**Table 13: Share of the households that reported each treatment**

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Boil* | 0.856 | 0.894 | 0.877 | 0.311 |
| *Chlorinate* | 0.091 | 0.071 | 0.080 | 0.481 |
| *N* | 209 | 255 | 464 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

**Table 14: Share of the households that reported hand washing before handling water**

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Handwashing* | 0.799 | 0.784 | 0.791 | 0.689 |
| *N* | 571 | 620 | 1191 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

**Table 15: Share of the households that reported maintaining the rainwater harvesting system**

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Yes, ever* | 0.779 | 0.833 | 0.803 | 0.587 |
| *Yes, in the last 3 months* | 0.649 | 0.567 | 0.613 | 0.421 |
| *N* | 77 | 60 | 137 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

**Table 16: Share of the households that reported a change in the way water is managed in the last 12 months**

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Change* | 0.079 | 0.194 | 0.139 | 0.000 |
| *N* | 571 | 620 | 1191 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

**Table 17: Share of the households that reported each type of change**

| | *Control* | *Treatment* | *Overall* | *p-value* |
|---|---|---|---|---|
| *Boil* | 0.333 | 0.592 | 0.521 | 0.006 |
| *Chlorinate* | 0.111 | 0.050 | 0.067 | 0.270 |
| *N* | 45 | 120 | 165 | |

Source: Own database, household survey 2017. Standard errors clustered per community.

**Table 18: Share of the households that report treating water**

| | *Treat water* | *Treat water* |
|---|---|---|
| *Treated* | 0.0056 | 0.0053 |
| | (0.271) | (0.303) |
| *2017 year* | -0.0007 | -0.0026 |
| | (0.830) | (0.648) |
| *Household head age* | | 0.0007 |
| | | (0.462) |
| *Household head gender* | | 0.0579 |
| | | (0.182) |
| *Household size* | | 0.0015 |
| | | (0.789) |
| *constant* | 0.428*** | 0.322*** |
| | (0.000) | (0.000) |
| *N* | 2296 | 2296 |

Source: Own database, household survey 20016 and 2017. Linear regression, absorbing community dummy, p-values in parentheses, * p<0.05, ** p<0.01, *** p<0.001.

## Online appendixes:

**Appendix E: Monitoring Plan**
This appendix is only available online and can be accessed from
http://www.3ieimpact.org/media/filer_public/2018/03/28/tw8r21021-appendix-e.pdf

**Appendix F: Cost data of the programme**
This appendix is only available online and can be accessed from
http://www.3ieimpact.org/media/filer_public/2018/03/28/tw8r21021-appendix-f.pdf

**Appendix H: Population in treatment and control groups**
This appendix is only available online and can be accessed from
http://www.3ieimpact.org/media/filer_public/2018/04/06/tw8r21021-appendix-h.xlsx

**Appendix L: C Comparison of treatment and control groups in the baseline**
This appendix is only available online and can be accessed from
http://www.3ieimpact.org/media/filer_public/2018/03/29/tw8r21021-appendix-l.pdf

# Appendix G

## Do files

*Treatment and control comparison, household survey 2017*

```
*orth_out treat water (any treatment)
orth_out P12 using test.xls  , by(cot) pcompare count overall vcount vce(cluster i3) replace

* orth_out handwashing before handling water
orth_out P42 using test.xls  , by(cot) pcompare count overall vcount vce(cluster i3)  vappend

*drop if does not treat water
drop if P12==0
* orth_out treat water (boiling, chlorinate)
orth_out p2her p2clo using test.xls  , by(cot) pcompare count overall vcount vce(cluster i3)
vappend
```

*Panel Analysis*

```
* areg Treat water (any treatment)
areg PP12 treated i.year, absorb (locality_id) cluster(locality_id)
eststo
areg PP12 treated i.year hhh_age hhh_g hh_size , absorb (locality_id) cluster(locality_id)
eststo
```

```
esttab using panelresults1.csv, p star(* 0.10 ** 0.05 *** 0.01) replace

* areg Treat water (Boiling)
areg P2HER2 treated i.year, absorb (locality_id) cluster(locality_id)
areg P2HER2 treated i.year hhh_age hhh_g hh_size , absorb (locality_id) cluster(locality_id)

* areg Treat Water (Chlorinate)
areg P2CLO2 treated i.year, absorb (locality_id) cluster(locality_id)
areg P2CLO2 treated i.year hhh_age hhh_g hh_size , absorb (locality_id) cluster(locality_id)

eststo clear
```

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