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Research Collaboration

Household Water Treatment and Safe Storage (HWTS) in Colombia: Stakeholders & Trends

In partnership with

CAWST
Centre for Affordable Water and Sanitation Technology

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EXECUTIVE SUMMARY

In May 2019, organizations working on Household Water Treatment and Safe Storage (HWTS) carried out the first National Learning and Experience Exchange for implementers in Colombia. Subsequently, one of the priorities established was documenting specific information about HWTS implementation. In response, the Centre for Affordable Water and Sanitation Technology (CAWST) designed a database to map out organizations' HWTS implementations and interventions across the country. Through a collaboration between CAWST and Engineering for Change, this research shows the current interventions in Colombia as well as the main stakeholders and trends based on the information gathered in this first HWTS database in Colombia .

The data highlight the efforts made towards improving HWTS implementation in Colombia, comprising at least 32 organizations, mainly non-government organizations (NGOs), Rotary clubs and the private sector. Dynamics amongst stakeholders showed alliances between private businesses with humanitarian institutions to produce and implement technologies respectively. Ceramic pot and candle ceramic were the most implemented types of filters.

The total impact of implementations from 2005-2019, comprises an estimate of over 660,000 beneficiaries. The departments of Cundinamarca, Guajira and Córdoba had the highest number of implementations. The most common type of implementation was by direct sales, which occurred in urban areas (centered in capital cities of the different reported departments). However, implementations in rural areas were mostly to offer assistance to community development. HWTS technologies were also implemented for humanitarian assistance or emergency aid and addressed either climate (drought or flooding) or sociopolitical displacement, migration and settlement of people. Information on who will cover the cost of spare parts and replacement of the implemented filters is unclear, even though most of the technologies were subsidized by the implementers. Finally, data on the quality of the water source, the presence of chemical contamination as well as the efficiency, monitoring and current state of HWTS technologies once implemented were mainly unavailable.

Based on this analysis, we present various conclusions and recommendations for HWTS interventions in Colombia. The results show only filtration technologies were implemented, with each organization implementing a single solution. To improve both adoption and suitability of technologies, a multi barrier approach is recommended once the context has been sufficiently analyzed and feasible technology has been selected. Due to the great uncertainty of water quality both at the collection source, at the end of filtration and after storage and use, long term monitoring strategies should be implemented. Lastly, documenting and publicly disclosing implementation information will strengthen the current database and allow further analyses.

TABLE OF CONTENTS

1 Introduction

Although Colombia is one of the richest countries in the world in terms of water availability [1], access to safe drinking water is still a major challenge for nearly 20% of the population, who represent the most vulnerable communities in rural and dispersed areas without access to safely managed water services [2]. In the past years, there have been important advances in Colombian water and sanitation public policies that recognize the need for improved approaches to address the specific needs of these populations (CONPES 3810 (2014), Decree 1898 (2016) and resolution 0844 (2018) [3]). Legislation now recognizes the possibility of using appropriate alternative water and sanitation solutions for the dispersed rural context, rather than conventional water treatment plants. In addition, with the establishment of the Sustainable Development Goals (SDGs) in 2015, not only is access to water services a focus, water quality and safe management has become critically important. This is why Household Water Treatment and Safe Storage (HWTS) solutions become relevant to guarantee water quality at the consumption point, especially for rural communities in Colombia.

CAWST defines HWTS as "any approach used to safely treat and store water at the household level or at the point of consumption (PoC)"; often referred to as "alternative solutions" as well. HWTS technologies and treatment techniques aim to ensure safe or improved quality water availability at the household level, point of use, or community level while generating user empowerment and improving the feasibility of local maintenance, longevity, and sustainability. These strategies often use the multi-barrier approach (MBA), that replicate the model used by centralized water treatment system that includes several steps for treatment. In the MBA , multiple stages offer various forms of "barriers" against waterborne pathogens, involving mechanisms, which include water resource protection, sedimentation, filtration, disinfection and safe storage.

In Colombia, there have been notable HWTS-related efforts led by various stakeholders including local and international NGOs, foundations, Colombian national governmental institutes, cooperation and multilateral agencies, UN agencies, universities, and groups from the private sector. However, the status of these interventions, including measures of successes and/or failures, has been hard to determine due to the lack of documentation, systematization, comparison and dissemination of knowledge and learnings of these experiences. Therefore, identifying national interventions in water integral management such as water security plans and HWTS, is a fundamental necessity in order to portray the current state of the country. Consolidating such interventions could help articulate the status of sector in order to build effective, sustainable and replicable models that can lead to better practices when adopting HWTS alternatives. For this reason, this research focuses on analyzing the current stakeholders and their impact, as well as trends of HWTS implementations and interventions in Colombia; generating evidence from field experiences will support stakeholders in identifying opportunities for improvement.

2 Background

Previous efforts made to address the state of HWTS in Colombia are uncertain. In May of 2018, the First Latin America Regional Workshop "Advancing the water safety Agenda"[4], was carried out in Bogotá, Colombia bringing inter-sectoral stakeholders together to learn about the state of the efforts towards SDG 6.1 in countries within Latin America. This workshop was organized by the Colombian government (Ministry of Housing and Ministry of Health), Pan American Health Organization (PAHO), UNICEF and CAWST.

In May 2019, a group of organizations working with HWTS (including CAWST) organized the First National Learning Exchange for HWTS Implementers in Bogotá, Colombia with the aim to improve the longevity and sustainability of HWTS interventions [5]. The event hosted roughly 39 different stakeholders, who shared and reflected upon the lessons learned, achievements, difficulties in the field, and the challenges that HWTS still face in Colombia. The need to create a National HWTS Network resulted from the event and participants agreed that gathering more specific information about HWTS was a priority, resulting in the design of a database to map out HWTS implementations and interventions across the country. The aim of the database is to register the number and type of technology interventions, identify the implementing organization(s) and stakeholders, and report on the locations of projects, all in a dynamic platform that allows for future interventions to be included. The following analysis relies on the first information gathered for this database, voluntarily provided by some of the HWTS implementers in Colombia.

3 Methods

3.1 Data collection

CAWST & E4C collected implementation data from HWTS related organizations after the First National Learning exchange for HWTS implementers in Bogotá, Colombia. Target informants included attendants of this event: ranging from governmental officials, technology producers, distributors, Rotary club members, local and international foundations, NGO representatives, academia, and UN officials. In total, 72 participants representing 39 different organizations and institutions attended the event. During the workshop, attendees agreed to participate in a database aimed to collect and synthesize records of HWTS implementations in the county. For a period of two and a half months, workshop participants were given online access to a standardized database created by CAWST, to input their data. Data from these organizations and institutions were also collected via phone and email interviews with representatives, and included into this database. In total, 32 organizations who implement HWTS in Colombia, participated by inputting their HWTS implementation data in this database.

The protocol was designed to elicit a broad range of qualitative and quantitative information, related to HWTS interventions, from each organization. This included information about the type of organization, type, brand and number of HWTS technology implemented, beneficiaries, locality and year, as well as information about the water source and quality, type of communities or scenarios served, post-implementation monitoring, the state and efficiency of technologies implemented, and their sustainability related to cost and local market availability.

3.2 Inclusion criteria

This study only included enumerated HWTS implementation programs in Colombia, therefore, HWTS implementations by organizations which operated in other countries or which lacked sufficient numeration reporting were excluded from the sample.

3.3 Data constraints

The number of registered data on HWTS implementation, presented here, is an estimate of HWTS implementations in the country. It might have some level of data duplication due to the cooperative interventions' dynamic between different organizations.

The number of beneficiaries is also an estimate. This is the number of people who benefited from the implementation of each particular HWTS technology. Some entries explicitly indicated benefited individuals but for those entries that did not have this information, this value was calculated with an estimate of 6 members per family (average household) and as a minimum value for the case of schools, community centers and mixed scenario of implementation (household, schools and/or community centers).

4 Results

4.1 Implementations

Thirty-two (32) organizations (Figure 1) provided information for the CAWST database: eight Rotary clubs, seven NGOs, five foundations, five departmental government institutes, three private filter manufacturing and distribution businesses, two national governmental institutes, one local governmental institute, and one UN program.[1] See Appendix 1 for specific names by stakeholder type.

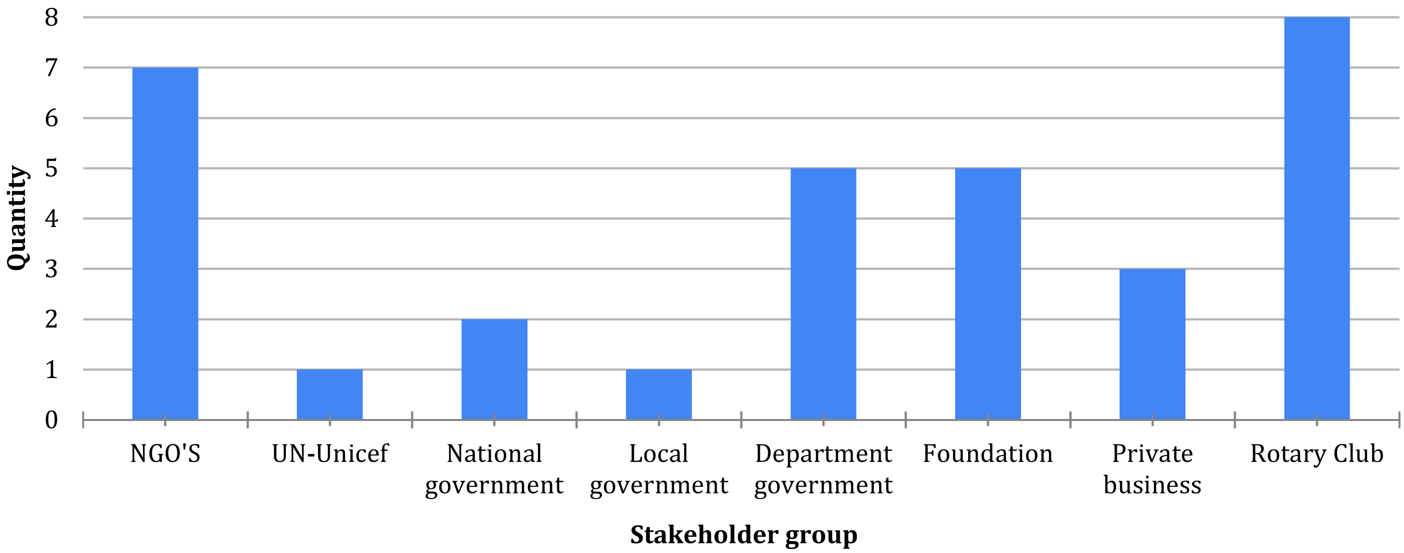

Figure 1. Types of stakeholders that implement HWTS technologies

In total, implementers deployed an estimated 133,930 HWTS technologies in Colombia during the period 2005 to June 2019. These include five types of water filter groups (Figure 2). The most common type of filters implemented were ceramic candle filters with 77,698 units (58%), followed by 48,872 ceramic pot filters (36.5%), 6,287 biosand filters (4.7%), 1066 membrane filters (0.8%) and 7 sand and candle filters (<0.1%). Amongst the different types of membrane filters implemented were Lifesaver Jerrycan, Lifestraw community, Paul, Sawyer, and Skybox Filters. Ceramic candle filters included Stefanni, Stefany Flex and colempaques filters. Ceramic pot filters included the Ekofil, Agualogic, Asopafin and UTP filters.

Organizations implement HWTS in a mix of rural, dispersed-rural, urban, and peri-urban locations. And, most (61.6%) implement projects in multiple sites (a mix of rural and urban locations). Roughly 20% of technologies were reported to be implemented only in rural areas and 15% in dispersed-rural areas, however since over 60% of respondents claimed to implement projected in "mixed" regions, these implementation numbers in rural areas are likely higher. Similarly, technologies only implemented in urban and peri-urban areas account for 2.8% of implementation, but likewise are also probably higher.

The final location of HWTS technologies implemented in Colombia have been in households, schools and community centers. "Mixed locations" account for 62.1% of implementations (corresponding to 83,194 implemented units), and include a combination of households and schools or households and community centers in which the information available did not specify how much for each. 37.6% (50,305 units) of implementations' locations are households, 0.2% were schools, and 0.1% were implemented in other final locations including host populations and locations where there have been displaced people and migrant populations.

1 This classification is for the organizations and institutions that have reported HWTS implementations and distributions, however there are various implementation models amongst these actors.

4.2 Beneficiaries

The number of beneficiaries from these interventions, organized by filter type, is displayed in Figure 3. Of the 604,529 documented beneficiaries, candle filters have benefited an estimated 314,856 individuals (47.4%); ceramic pot filters have reached an estimated 298,992 individuals (45%); biosand filters 37,039 (5.6%); and membrane filters 13,063 (<1%).

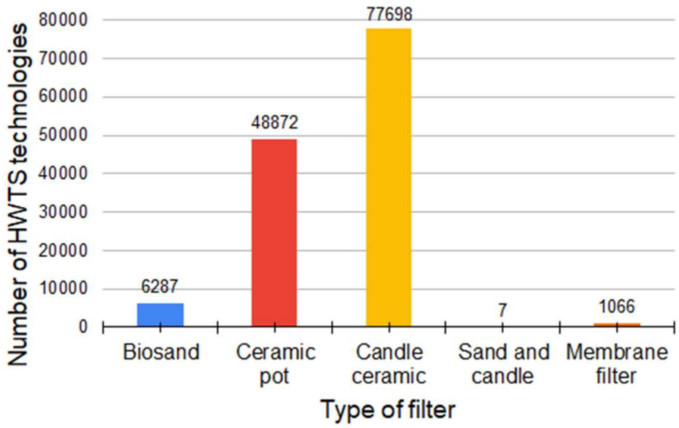

Figure 2. Type of HWTS technologies

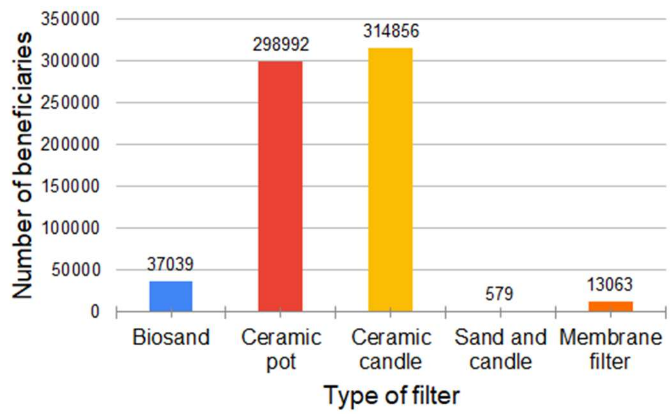

Figure 3. Beneficiaries by type of HWTS technologies

Twenty-seven of the thirty-two departments (political and administrative divisions) of Colombia reported having HWTS technology implementation (Figure 4, left). Departments with the highest implementations were Cundinamarca (64,832 units; 48.5%, in red), Córdoba (13,231 units; 9.9%, in orange), Guajira (9,016 units; 6.7%, in orange), Antioquia (6,128 units; 4.6%, in yellow), Arauca (5,963 units; 4.5%, in yellow), Nariño (5,313 units; 4%), and Valle del Cauca (5,146 units; 3.9%). There were no interventions reported in five departments: Atlántico, Cesar, Guainía, Huila, San Andrés and Providencia.

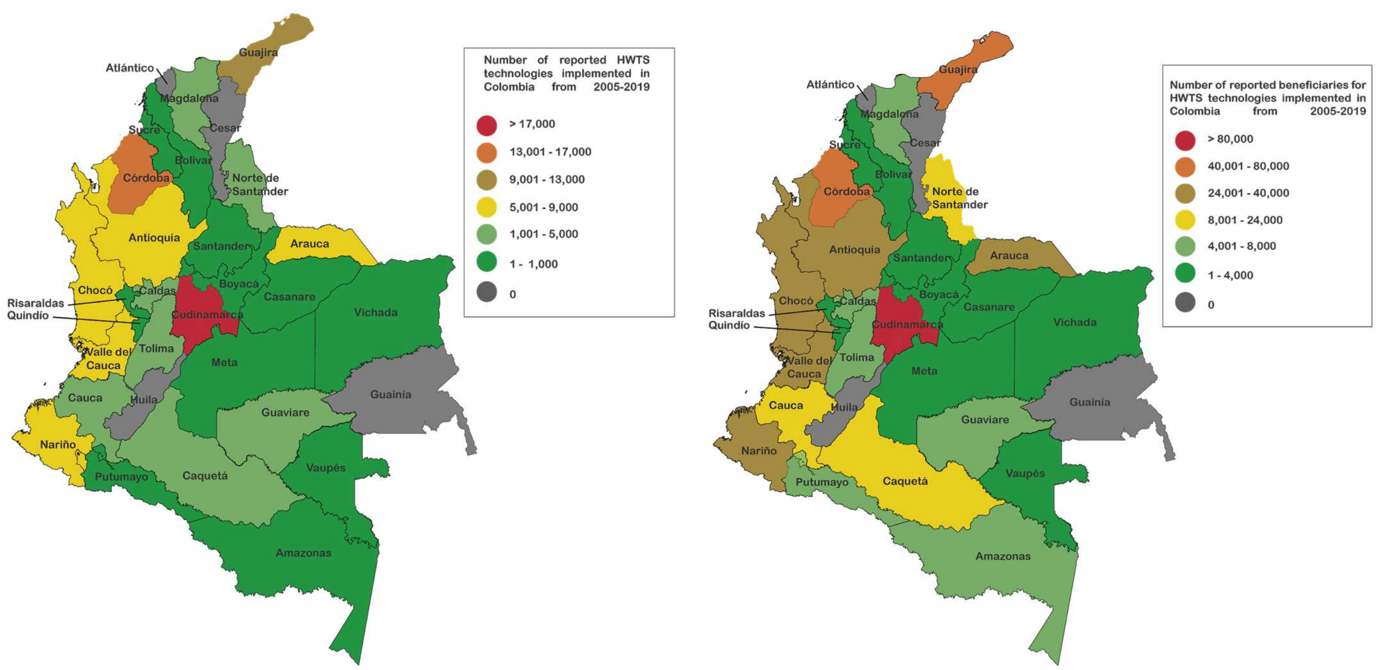

Figure 4. Number of reported HWTS technologies (left) and HWTS beneficiaries (right) of implementations in each department in Colombia from 2005 to June 2019.

Overall, interventions reached more than 114 different municipalities across the country. The municipality with the highest distributions corresponded to the district of Bogotá D.C. in the department of Cundinamarca (in red in the maps of figure 4), with 62,700 filters distributed by a private company through direct sales. Interventions from 2005 to June 2019 benefited 604,529 people. Figure 4 (right) shows the number of reported beneficiaries of HWTS technologies implemented per department. The departments with the highest number of benefited individuals correspond to those with the highest number of filters implemented. Cundinamarca had the higher amount of beneficiaries with 262,771 people, followed by the department of Córdoba with 77,554 beneficiaries, Guajira with 64,039 people, Chocó with 35,101, Antioquia with 30,855, Valle del Cauca with 30,617 and Nariño with 30,597 served individuals.

4.3 Water quality

As shown in Figure 5, in 91% of the cases there is no information about the quality of the water source. Only 9% report having information, which would include having some kind of physicochemical and/or microbiological testing. More than half of the water sources (69.8%) reported microbial contamination and for the rest this information is unknown (30.2% of data unavailable). Concerning the presence of chemical contamination, 0.8% of the implementations report chemical contamination of the water source, involving petroleum, mercury, heavy metals, chlorine in excess, fluorides and organic load. Nonetheless, for the majority (89.6%), no information of chemical contaminations is available and only 9.7% of water sources are free of this type of contamination.

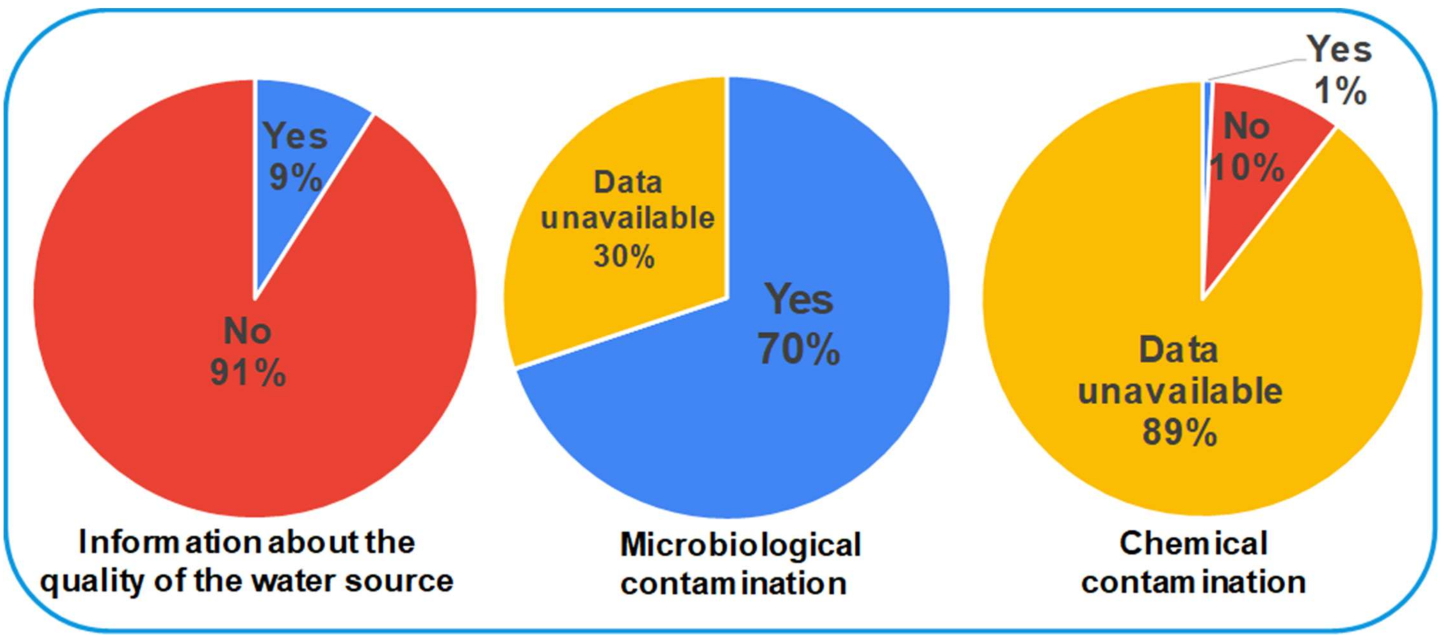

Figure 5. Quality of the water source where HWTS are implemented. Available information about the quality of the water source (left), known presence of microbiological contamination (middle) and known presence of chemical contamination in the water source (right).

4.4 User provision model

Most of HWTS technology interventions in Colombia have been by direct sales (59.1%) and to assist community development (34.7%); 5.7% of implementations have been carried out to provide humanitarian and/or emergency aid (5.7%), while the least number of implementations reported have been through investigation programs (0.5%). Direct sales have reached an estimate of 262178 people, assistance to community development, humanitarian and/or emergency aid and investigation programs have benefited an estimated 282402, 55437, and 4512 individuals respectively during 2005-2019 in Colombia.

Within direct sale distributions it has been found that 92.2% have been sent to urban areas, specifically to the capital cities of departments, including Bogotá, Medellín, Cali, Cúcuta and Ibagué (with the exception for Barranquilla, the fourth largest city of Colombia for which there were no reports) (Bottom, Figure 6.) The remaining 7.8% of this type of interventions have gone to municipalities outside the main city within those departments which tend to be rural areas. Meanwhile, the majority of implementations done to assist community development occurred in rural and dispersed-rural communities (89.5%) and only 2.5% were located in urban or peri urban scenarios. An additional 8% of these interventions represent an unspecified mixture of the previous.

As for HWTS technologies that have been implemented in Colombia to provide humanitarian and/or emergency aid (5.7%), shown in figure 6. Figure 7 shows that a great amount of technologies implemented to deliver aid have been delivered to attend droughts (2994 units, 39.1%). 824 technologies have been implemented to respond to migratory flows, 800 for flooding and 800 for subnormal neighborhoods correspond to 31.8% of all humanitarian and/or emergency aid implementations. In this case, migratory flows include regular migrations and Venezuelan emergency migrations. However, in 29.1% of the HWTS technologies implemented, there is uncertainty regarding the reason for the humanitarian and/or emergency aid delivered (not shown in figure 7).

A total of 7654 technologies deployed to provide humanitarian and/or emergency aid have benefited an estimated total of 55,437 people. While technologies implemented to deliver aid in drought scenarios have been the most distributed and have benefited 11,976 individuals, technologies implemented to respond to migratory flows have benefited the most amount of people (21,200 people). Technologies delivered to respond to flooding or subnormal neighborhoods have helped 3200 and 3500 people, respectively.

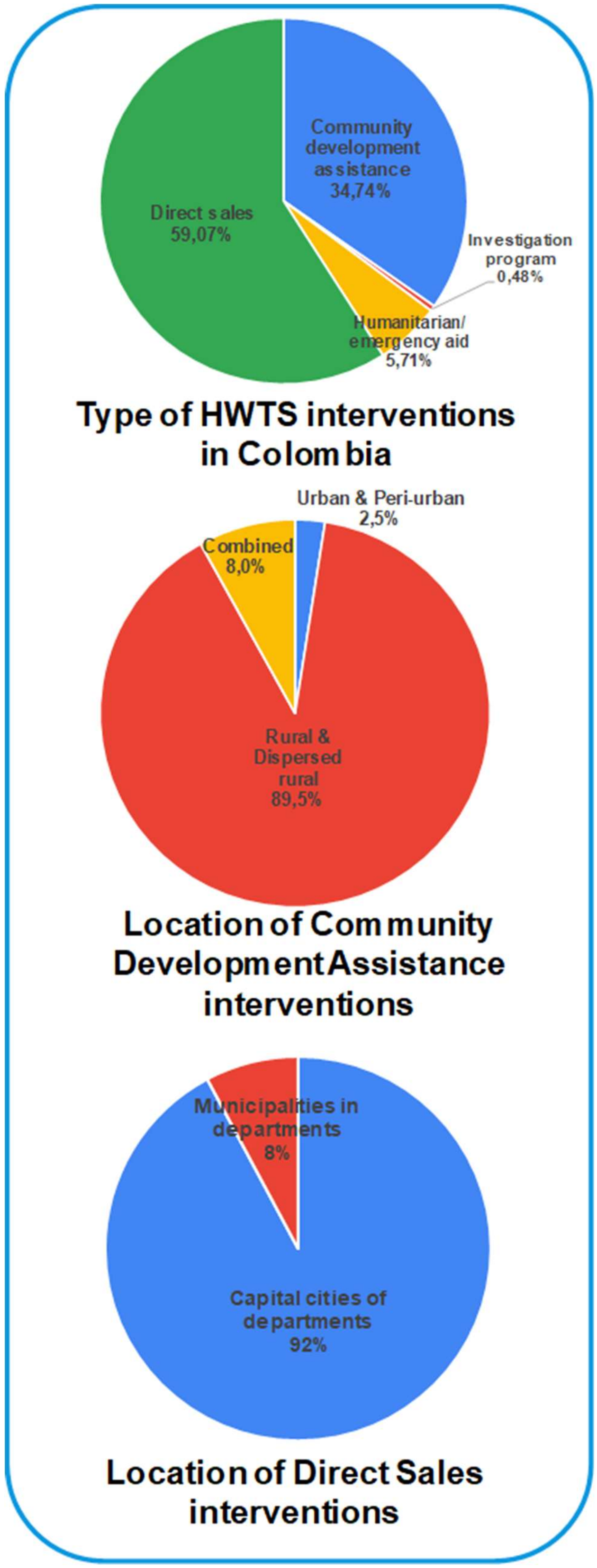

Figure 6. Type of HWTS interventions in Colombia

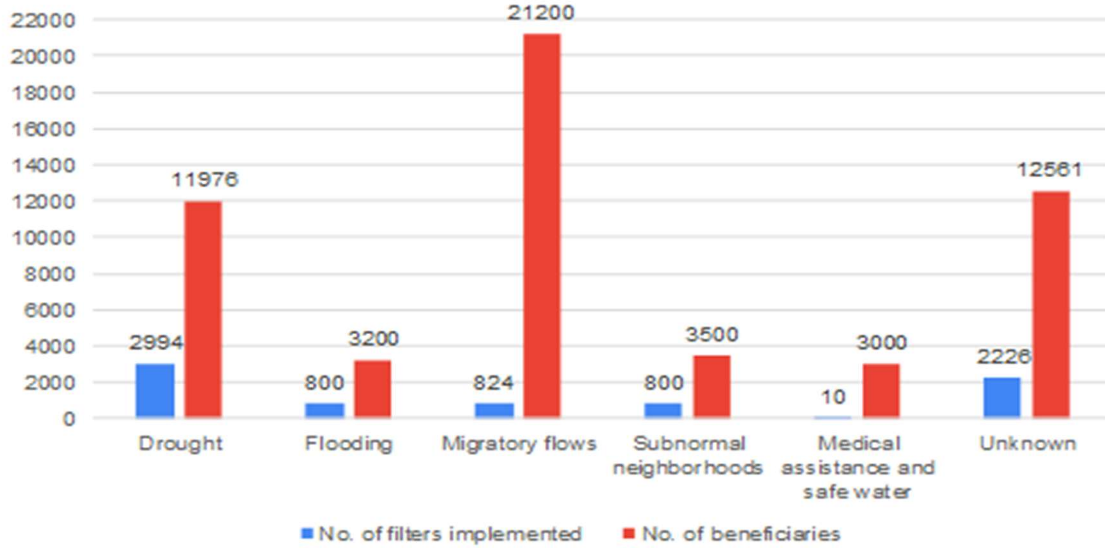

Figure 7. Types of humanitarian/emergency aid scenarios that HWTS implementations responded to.

Table 1 shows how the cost of the HWTS technologies implemented is covered and spare parts availability /local market, respectively. As of June 2019, data regarding the current status of HWTS interventions (91.7% unavailable) and water treatment efficiency (94.5% unavailable,) are highly unavailable. Only 4.8% of the implemented technologies were mostly in use, 2.3% worked and the rest were between 25 - 75% in use. Concerning the efficiency of the filters, only in 5.6% of the cases the information is available. Table 1 also shows few monitoring visits after implementation of HWTS technologies. Interestingly, organizations claimed to implement an additional 2226 units of HWTS technologies in response to humanitarian and/or emergency situations and that have benefited 12,561 people, however, these organizations did not claim that specific implementation information in the survey.

Table 1. Responses by HWTS implementing organizations regarding monitoring and long-term HWTS use.

	Yes	No	Unavailable data
Are spare parts available locally?	90.1%	7.0%	2.1%
Do you have information about the current performance of your HWTS implementations?	5.6%	94.5%	0%
Have the HWTS technologies been monitored after implementation?	14.2%	0%	85.8%
Are >50% of all implemented HWTS technologies still in use?	7.7%	1.4%	90.9%

4.5 Partnerships

When it comes to alternatives that provide safe water to the Colombian population, there are many different stakeholders making efforts through the implementation of different types of technologies. However, from this first close-up of the state of implementations, it is evident that institutions and organizations involved do not work independently but usually in cooperation with others. Although Rotary clubs, NGOs and foundations are the most numerous type of stakeholder involved, the private sector seems to be driving HWTS implementation. The private sector manufactures and provides filters and governmental institutions (local, departmental and National) provide funding or the logistics, and both of these stakeholders are usually paired with NGOs to achieve HWTS implementations. However, not all private filter-supplying companies or distributors provided information on the alliances done with other organizations so more information in required to make this statement completely.

In total, implementers deployed 133,930 HWTS technologies across Colombia (from 2005-2019), 119,400 registered units have been distributed by the private sector as direct sales. These involve products such as ceramic candle and ceramic pots. However, to what NGOs or foundations these have been sold to, or if they have been sold to other organizations, is unknown and in the case of being sold to direct users, their final destination and type of community served is mostly unspecified (market as mixed). Usually due to internal politics of these companies, the information is not publicly available. This unfortunately means that for 89.15% of filters registered in this database, there is still more information lacking to determine where all these filters are going.

NGO's, rotary clubs and other foundations implemented biosand filters, which are not a commercial brand. This means they constructed them on site, most through an alliance with CAPD, the Canadian Association for Participatory Development.

Data show stakeholders involved in HWTS implementations across Colombia, mostly implement just one type of filter, and that depending on the filter being implemented it is very likely to know who is behind it. Private companies also sell one specific brand and type of filter each. Overall, very few organizations have registered implementing more than one type of filter, such as Fundación Entropika and Water Aid Colombia and local governmental institutions.

5 Discussion

5.1 Implementations

Differences in the number of implementations for each product technology category might be due to implementation dynamics/logistics or "barriers" according to each type of filter. Ceramic candle and pot filters might be the most implemented because of their ready-to-use local availability. While building biosand filters, although possibly cheaper, require a large steel mold and the assistance of the community for construction, thus requiring training and more time for the logistics of implementation in comparison to ceramic candles and pots. Although membrane filters are likely to perform to the highest standard, they represented fewer than 1% of all implemented HWTS. Low implementation is likely due to a variety of factors, including the fact that all membrane filters were imported from outside Colombia, suggesting a higher pricing, and other potential barriers to adoption such as cultural acceptance, design complexities, maintenance procedures and disposal that do not make this the most popular filter implemented, even though they likely perform to the highest standard.

Implementation of filters is concentrated in the departments of Cundinamarca, Córdoba and Guajira. In Cundinamarca, the majority (98.25%) were a direct sale delivered to the city of Bogotá, the capital, for mixed final destinations, which is a non-specific combination of households, schools and/or community centers. In such cases, it is unclear who final users are. Additionally, having a high number of HWTS in the city is an unexpected finding since these users have continuous access to safe water through conventional water treatment plants and distribution systems. This shows a high demand of filters by users in the capital that might imply an interest in improving water quality of the city water service. Another possibility might be that implementers purchased the filters there and deployed them in other places of the country. However, this is not certain and requires more inquiry. Outside of Bogotá, the remaining technologies implemented in this department have been in rural areas in farmer's households with the purpose of assisting community development.

La Guajira is the department with the lowest water coverage amongst rural areas in the country (4% of its rural population have access to potable water according to the National Agricultural and livestock census) [6].

Although 90% of its urban areas have potable water coverage, average continuity of this service is only 9 hours/day according to the National Health Institute (INS) 2015 - Ministry of Housing [6]. This might explain the high number of technologies implemented in this department as well as the high number of stakeholders involved in the area (9 organizations). 58.17% of implementations have been to assist community development for "campesinos" (farmers) and indigenous people in rural areas, whereas the remaining 41.83% has been humanitarian and emergency assistance, mostly due to drought and mixed migratory flow. Municipalities with the most implementations have been Maicao, Riohacha, Fonseca and Albania. Since deserted landscapes characterize Guajira department, which borders Venezuela, geography could also contribute to water availability and conditions.

The third department with the highest implementation of HWTS systems is Córdoba. Here, most registered implementations have been done by rotary clubs in the municipalities of Montería, Chima, San Pelayo, Canalete to assist community development for mostly rural farmers. Only 3% have been direct sales and sold to non-specified populations.

The reason behind the lack of HWST solutions reports in the departments of Atlántico, Cesar, Guinía, Huila and San Andres and Providencia, is unknown. It is possible that there are very few or none NGO's or Foundations in these departments or perhaps lack of participation in HWTS events. The government of the Atlántico department states there is 98% drinking water coverage and 81% sewage coverage through conventional means and projects being underway [7]. This might explain why HWTS solutions might not be required. However, there is no distinction between urban and rural populations and more information is needed to make an assessment. Recent news about the department of Cesar reported 84% drinking water coverage in urban areas and 25% in rural areas and a 65% coverage of residual water treatment systems [8]. In Huila, the execution of major infrastructure projects in potable water and basic sanitations have been underway to serve more than 305,000 people [9]. In Guinía, one of the least populated department of the country, made up mostly of indigenous reserves, there are also large infrastructure works for housing and water at Inírida [10], the department's capital and some municipalities [11]. San Andrés and Providencia, on the other hand is an archipelago with a history of drinking water shortage [12], desalination plants aim to address the shortage [13]. In all of these departments, despite current infrastructure, rural areas still need safe water. HWTS solutions can contribute to this goal where conventional systems might not be effective. One other reason why these departments may not have had so many interventions from NGOs and development agencies (even government and private sector) might be due to their remoteness which leads to higher costs for implementation. However, there is a need of deeper investigation to determine the actual state of HWTS in these five departments.

Figures 9 and 10 show that the areas and final locations where HWTS technologies have been implemented/distributed have a high number of mixed scenarios. This is unspecified information that makes interpretation challenging and shows a need for stakeholders to register more defined data for a better understanding of the state of implementations and decision making. Nevertheless, implementation in rural and dispersed-rural areas and in households are prominent showing that HWTS are addressing these types of community as alternative solutions to conventional water treatment system; this is further stressed by the fact that 89.5% of implementations for assistance to development are carried out in rural and dispersed-rural areas (Figure 11).

Given that HWTS technologies have been destined and recognized by the government as alternatives to traditional centralized water treatments especially for rural and dispersed rural settings, where these do not necessarily apply, it has been unexpected to find that the majority of implementations have not been in these contexts. Why 92.2% of direct sales distributions (Figure 11) (which constitute 72,037 - more than half of total national implemented technologies) have been directed to capital cities of departments, where there is a higher access to potable water (81%) in comparison to rural areas (40%) is unknown. This might suggest that HWTS technologies might not only be serving the 19% of the population in urban scenarios that do not have access to safe water but the generalized lack of treatment of contaminants in urban centralized plants. Because this is where the majority of the Colombia population resides, numbers are consequently higher.

Moreover, data show that in Colombia, humanitarian assistances or emergency aid addresses either climatic or a seasonal phenomenon such as drought, flooding, or socio-political situations related to population displacement, migration and settlement (Figure 12). This is due to the geographical and social context of Colombia and indicates that HWTS have been a means of responding to these scenarios and that there is still a clear need for the country to prepare for these expected and unexpected events.

5.2 HWTS technologies

A significant finding from this study is that most implementers focus on filtration systems and do not follow the different steps of the multi-barrier approach. Filtering water without prior sedimentation, shortens the lifespan of filters may be shortened in areas where water is turbid. In addition, failing to disinfect water after filtration may leave a small percentage of pathogens in the water, increasing the risk for recontamination. Therefore, it is worth noting these technologies are solving the microbiological and chemical contamination in water. These contaminants pose a great risk to the growing public health problem, not only for HWTS served communities but also for the rest of the country. Even though HWTS are part of the solution, there is a need for additional efforts since centralized plants do not treat all of these pollutants effectively either.

5.3 Water quality

In this sense, it is clear that according to figure 7, these systems eliminate a generalized situation of microbial contamination. Although the information on the water quality of the water sources is mostly unknown (91%) (Figure 6) probably due to the lack of accessible and low cost testing solutions for physicochemical and microbiological water characteristics, it seems initially contradictory that for 69.8% of the cases it is known that there is presence of microbial contamination. This can however be explained by various facts: in Colombia only 42% of national residual waters are treated (according to the Ministry of Housing monitoring system 2017 [6]), in rural areas domestic wastewaters are usually dumped directly into rivers and furthermore, residual water treatment plants only perform primary treatment before returning municipal waters to rivers. In addition, microbial contamination of drinking water sources is probably also known indirectly because of its rapid effect on the health of inhabitants through cases of gastrointestinal problems. This could explain a generalized knowledge of the presence of high organic loads in waters sources. Determining chemical contamination is, on the other hand, much more expensive and inaccessible for communities through laboratory tests and indirect health symptoms indicating this type of contamination might be diverse and take longer to express making it difficult to distinguish.

5.4 User provision model

Results showed the majority (59.30%) of filters have been donated or subsidized (30.09%) in some way. The type of stakeholders involved in the study, mainly NGO's, rotary clubs, UN and other humanitarian aid institutions are a contributing factor to this statistic. This is however an important fact in order to consider a competitive market for HWTs systems.

5.5 Monitoring

Although most implementers are aware of the lab tested efficiency of the technologies, the current state of the technology is mostly unknown, which suggests poor monitoring after implementation. This also suggests over confidence in the technology, since the efficiency is bound to maintenance and proper operation conditions; meeting said conditions is hard to know without proper monitoring.

6 Conclusions

Information gathered for the database demonstrates the efforts towards improving HWTS implementation in Colombia; comprising at least 32 organizations, mainly NGO's, Rotary clubs and the private sector. Dynamics amongst stakeholders showed alliances between private businesses with humanitarian institutions to produce and implement technologies respectively. The most implemented types of filters were Ceramic pot and candle ceramic. The total impact, from implementations from 2005-2019, comprises an estimate of over 660,000 beneficiaries. Three departments showed a high number of implementations: Cundinamarca, Guajira and Córdoba. Direct sales were the prevailing form of distribution, mostly addressed to urban areas (centered in capital cities of the different reported departments) and implementations in rural areas were mostly to offer assistance to community development. Humanitarian assistances or emergency aid targeted either climate (drought or flooding) and socio political displacement, migration and settlement of people. Although most of the technologies were subsidized, information on who will cover the cost of spare parts and replacements is unclear. Finally, data on the quality of the water source, the presence of chemical contamination as well as the efficiency, monitoring and current state of HWTS technologies once implemented was mainly unavailable.

Based on the results, HWTS implementations and interventions in Colombia trends include:

1. Organizations reported only filters in terms of type of HWTS solutions.
2. Most organizations implement one single technology.
3. Most of the implementations focus on certain departments, possibly where there is a larger population, implementer interest and/or ease of access.
4. Organizations implemented HWTS technologies in all types of contexts (rural, peri-urban etc.) and in different environments (homes, schools, community centers).
5. The private sector directs a large part of its business towards urban centers, while organizations providing assistance to community development are present in rural and dispersed areas.
6. Implementers subsidize heavily most of technologies to the user. This makes it difficult for there to be real and sustainable direct sales of products and services to the final user (also considering replacements and spare parts).
7. There is a huge gap regarding information on the quality of water sources; there is suspicion (since information is insufficient to back this claim) of microbiological contamination but not of chemical contamination.
8. There is little information on the state and efficiency in the field of technologies once implemented.
9. Private companies reported direct sales to other implementers (such as NGO's), how they reach final users is unknown.
10. Lack of information constraints the scope of the analysis and conclusions; the dynamic database should evolve over time and further prove or disprove this trends (which will depend on market, climate, social and political factors).

6.1 Recommendations

Based on the results and conclusions, stakeholders can improve HWTS implementations and interventions in Colombia by:

1. Apply the multiple barrier method to achieve higher water quality. Incorporate other HWTS steps besides filtration; reinforce them or start implementing them on the field.
2. Analyze which is the most appropriate technology based on the needs of the local community, avoiding implementation of a single HWTS technology.
3. Analyze vulnerable populations lacking safe drinking water and prioritize those areas for intervention.
4. Change paradigms: HWTS technologies are not limited to rural areas but seem to be meeting the general needs of the Colombian territory both in urban as well as in rural areas.
5. Improve business model by analyzing where the market niche is and conduct a market study of how technologies can reach rural and dispersed areas through the private sector. An example is the Ecofiltro from Guatemala, where urban sales partially subsidize filters sold in rural areas to make these more cost-accessible.
6. There is a need to find a balance between subsidized technologies and direct sales: The sector that implements HWTS would have to know how to determine when the subsidy is necessary and when it is possible to work through local markets. In addition, implementers should be clear about who will cover the costs of replacements or spare parts for sustainability of HWTS systems in communities.
7. Improve monitoring water quality at the source; this is the basis for choosing the most appropriate technology. Therefore, it is a call for more research on environmental pollutants and on the development of accessible and low-cost methodologies / technologies to monitor pollution.
8. Improve monitoring after implementation and long-term follow-up programs of these technologies and water quality (after filtration).
9. Document how these technologies arrive to end-users to understand ecosystem of HWTS.
10. Improve systems for documenting of information, to create a robust database; promote sharing information, collaboration and support among stakeholders to avoid duplicating efforts.
11. Work closer with government agencies to narrow the gap for underserved communities, since ultimately the state is responsible for providing safe water.

There are several recommendations for information recollection, based on the constraints of the present research:

Data collection and data base improvement in general:

- Continue to collect more data to expand this database in terms of quantity and ecosystem dynamics of stakeholders.
- Encourage stakeholders to register other kinds of HWTS other from filtration
- According to tendencies and better understanding of the dynamics, have more defined parameters to avoid different interpretations by the organizations registering information in the database - such as efficiency of the HWTS technologies
- Current format for information gathering only includes year of implementation and last visit, however this does not allow much comparison. It would be interesting to include frequency of monitoring after implementation.
- Include specific follow-up questions, with a clear definition of the terms.

For NGOs, Rotary clubs, private businesses and other HWTS implementers:

- Improve data registration and availability to the public.
- Improve water quality monitoring, specially analyzing chemical contamination.
- Improve project monitoring after implementation to generate information on current state.

For Universities, government and other research institutions

- Improve project monitoring after implementation to generate information on current state
- Correlate place of implementation with population density.
- Compare these results to national records that they might be able to access
- Work closer to implementing organization to improve water quality assessment and monitoring before, during and after implementation.
- There is a need for manuals or guidelines for water quality testing and monitoring that are easy to use and integrate for implementers. (In this sense the work that the government is, developing related to HWTS Technology efficiency validation norms becomes very relevant).
- Investigate why there is a lack of registered information for the departments of Atlántico, Cesar, Guinía, Huila, San Andrés and Providencia.

7 Final Remarks

Ultimately, we encourage HWTS implementers to engage in more collaborations and work together to serve the people of Colombia. Being transparent with your projects, keeping an accurate record of past projects, and participating in cross-sector partnerships will ultimately improve the efficiency and efficacy of HWTS implementations nationwide. We encourage HWTS implementers to improve the quantity and quality of their records on HWTS interventions to ensure a more faithful evaluation of the state of these efforts in the country and allow decisions and actions to be directed where they are needed the most.

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Appendix 1: Household water treatment and safe storage Stakeholders in Colombia that participated in this study

Type of stakeholder	Number of organizations	Organizations' name
Non. governmental organizations (NGOs)	7	Fundación Luterana Mundial, Sociedad Nacional de la Cruz Roja Colombiana, Fundación Halu Bienestar Humano, WaterAid Colombia, Acción contra el Hambre, Fundación PAIS 21 Compartamos con Colombia-ICBF-U- Tecnológica de Pereira
United Nations-UNICEF	1	UNICEF
National Government	2	Instituto departamental de salud de Nariño-Agencia de Reincorporacion y normalizacion (ICBF)
Departamental Government	5	Instituto departamental de salud de Nariño , Instituto departamental de salud de nariño - PDA-cancilleria- UNIMAR, Corporación Regional del Quindio (CRQ)
Local Government	1	Instituto departamental de salud de Nariño - alcaldía Municipal de San Pablo
Foundations	5	Fundación Entropika, Fundación Red Proyecto Gente(RPG)/CAPD, Fundación Hilo Sagrado/CAPD, AGAPE, Instituto Mayor Campesino
Private business	3	Replacol, Agualogic,Goodtrade
Rotary Clubs	8	Rotary Club Nuevo Ibague, Montería II, El Cerrejón, de Santa Marta, de Ipiales, de Fonseca, de Bucaramanga Sotomayor, de Bucaramanga Ruitoque
TOTAL	32	

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