IRC Ethiopia

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REACH Water Security in Fragile Environments Observatory

Interim report on well upgrading interventions

Covering period 2017-2019

Arjen Naafs, Lemessa Mekonta, John Butterworth

Supporting water sanitation and hygiene services for life

Contents

This Intermediate research report has been produced as part of a research activity for the Water Security in Fragile Environments observatory of the REACH programme. REACH is financed by DFID through Oxford University with this activity implemented under the auspices of the Water and Land Resource Centre (WLRC) of Addis Ababa University. The research is being undertaken in two watersheds (Aba Gerima and Debre Yacob) in two districts (Bahirdar Zuria and Mecha) of Amhara National Regional State of Ethiopia.

Authors: Arjen Naafs, Lemessa Mekonta, John Butterworth
For questions or clarifications, contact IRC Ethiopia: ethiopia@ircwash.org
www.ircwash.org/ethiopia

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Abbreviations

CFU	Number of Colony-Forming Units
EC	Electric Conductivity
ETB	Ethiopian Birr
JMP	Joint Monitoring Program
KII	Key Informant Interview
MPN	Most Probable Number
SLM	Sustainable Land Management
WLRC	Water and Land Resource Centre

1 Introduction

This interim research report was prepared as part of the research IRC are implementing as activity on 'Groundwater Development' as part of the observatory research programme REACH. It covers the period from the baseline in 2017 to November 2019.

1.1 Context

According to JMP (JMP, 2019), only 31% of the 84 million people in rural Ethiopia have access to at least basic drinking water services. Following the historical trend of 1% improvement per year, it will still take a long time to have communal protected water sources near all households. In the interim, 23 million people (28%) resort to unimproved sources, with a total of 4.8 million (4.5%) of the rural population still depending on unprotected shallow wells.

Since 2009, the water supply policy of the Ethiopian government has given more emphasis to lower cost of technologies and the self-supply approach in rural areas. Self-supply was included in the 2013 One WASH National Programme phase I, leading to a Manual for Accelerating Self Supply Programme (MoWIE, 2014). Though the second phase of One WASH is targeted to professionalize rural water supply, other modes of implementation such as self-supply remain in place and 4,366 schemes are included in the planning for 2018-2020 (Federal Democratic Republic of Ethiopia, 2018).

Compared to basic and improved access, the unprotected wells and what drives their users to invest is relatively under researched, though research shows that they can have a complimentary role to achieve SDG 6.1 (Sutton, 2009).

1.2 The project

The aim of the Water Security in Fragile Environments Observatory in Amhara, Ethiopia is to evaluate the contribution of Sustainable Land Management (SLM) practices to water security in fragile ecosystems and to share results for evidence-based upscaling. There was limited prior assessment of the groundwater resources within these learning watersheds or understanding of the dynamics of groundwater utilisation. However, shallow groundwater development forms a critical component of government policies and strategies in both agriculture (e.g. the household irrigation programme) and rural water supply (Self-supply).

Figure 1 Location of study area

IRC are implementing an activity on 'Groundwater Development' as part of the observatory research programme. Working closely with The Water and Land Resource Centre (WLRC) of Addis Ababa University which leads the research observatory, activities are being in two learning watersheds (Aba Gerima and Debreyakob located in the districts Bahir Dar Zuria and South Mecha respectively). The overall research question guiding the activity is 'How do sustainable land management programmes relate to interventions promoting groundwater utilisation, and how can the benefits of groundwater development for the rural poor be secured and maximised?'.

1.3 Research questions

In the two selected learning watersheds, this research if focussing to understand the groundwater component of the water balance by investigating the following:

How do sustainable land management programmes relate to interventions promoting groundwater utilisation, and how can the benefits of groundwater development for the rural poor be secured and maximised?

Further sub-research questions are:

1. What are the drivers behind investment in groundwater development by families for agriculture (household irrigation) and domestic (Self-supply) uses, the existing performance of these facilities and the pattern of sharing of benefits?
    1. Are wealth, gender and education key determinants influencing investments and benefits?
    2. To what extent do access to inputs (technology, finance), information & markets influence investment?
    3. Are sustainable land management programmes directly or indirectly influencing investments in groundwater and utilisation?
2. What are the existing risks (and practices to reduce or mitigate risks) related to use of unprotected-or semi-protected water sources at household level, and the unregulated or uncontrolled utilisation of the groundwater resource at the watershed level?
    1. What are the water quality risks associated with family wells, and current mitigating practices and behaviours of households?
    2. To what extent are available groundwater resources being utilised, and what is the potential for further development?
3. How effective are low-cost interventions (improved well head protection and lifting devices) in reducing risks associated with family wells?
    1. does installation and use of such technologies improve water quality for drinking and minimise risks?
    2. What are the costs, and critical conditions for wider upscaling of interventions to increase supply, demand and improve the enabling environment?

1.4 Baseline information

In 2017, a complete inventory of all 570 family wells and the 19 community wells within the two watersheds (Table 1) was conducted. This covered well characteristics (e.g. depth to water level, well depth), technologies used in well construction and water lifting, reliability, use and satisfaction, sanitation around the well, and hygiene in handling water. Furthermore, the well-owner or another member of the family was interviewed to obtain family characteristics such as age, education level, number of family members and area farmed. Key watershed characteristics are presented in Table 1 and completed results have been published as report (Mekonta, James, & Butterworth, 2018) and a paper has been submitted to Waterlines (April 2020).

Table 1 Watershed characteristics

Characteristics	Aba Gerima	Debra Yacob
Altitude (a.s.l)	1893-2120m	2074-2262m
Agroecology	Woyna Dega	Woyna Dega
Average rainfall	1120mm/yr	1300mm/yr
Geology	Igneous rock	Igneous rock
Total area (km^2)	9.00	3.25

Characteristics	Aba Gerima	Debra Yacob
Population	1340	975
Pop density/km^2	149	300
# family wells	502	68
# operational	435 (87%)	60 (88%)
Density wells/km^2	48	18
# wells used for drinking	179 (41%)	30 (50%)
Average depth to water table during survey (May)	10.7 m	10.7 m
Average depth	12.7	12.7
# communal handpumps	12	7

source: **(WLRC, 2017)** and baseline data **(MEKONTA, JAMES, & BUTTERWORTH, 2019)**

The following results had been found:

1) Most survey respondents (>65%) have no formal education:
2) Frequently users have more than one well, in (>51%) of well-owners in Aba Gerima even more than 51%
3) Most wells constructed after 2006, peaking in 2013-14, with Most of the poorer well-owners constructed wells only after 2010
4) Most additional wells are constructed for irrigation
5) More family well-owners irrigated around 0.2 hectares of land using their wells
6) Most respondents drink water without any treatment
7) Significant numbers (24-50%) of the households do not have toilets and defecate in the open

Which have led to the following conclusions:

A. **The poor are late entrants into the well-owning class:** In both the Aba Gerima and Debre Yacob Catchments, most of the poorest-third of households surveyed had constructed their wells after 2010 – over 80% in Aba Gerima and 100% in Debre Yacob, whereas the richer categories already had wells before that time.

B. **There are significant water quality risks to family dug-wells used for drinking**. More than 90% family wells used for drinking tested had unsafe levels of faecal coliform bacteria.

C. **There are significant water quality risks to community water sources using dug-wells**. Half of all dug-well-based community water sources that were tested showed unsafe levels of faecal coliform bacteria.

D. **Threats to water quantity in family dug wells and community water sources are relatively small currently but could increase in future**. Currently there is hardly any motorized pumping of wells (though there is some pumping of surface water) and water lifting devices used on these family wells are low capacity. But increased demand for water in the future could see (competitive) water drilling and groundwater abstraction for irrigation – which could also affect drinking water wells.

E. **Comparison against the Control Watersheds is problematic, since there are statistically significant differences with the Learning Watersheds**. The 'Control' should be similar to the 'Treatment' set in all respects except for the Treatment being considered.

F. For experiments it may be better to re-select 'control' wells from among the same wells surveyed in the learning watersheds but to disguise the subsequent 'treatment'. The surveyed family wells in the same Learning Watersheds can be randomly designated as 'Control' and 'Treatment' wells, as in a randomized control trial, and water quality (and quantity) risk and threat reducing treatment provided to only designated 'Treatment' wells.

1.5 This report

Based on the baseline assessment the next phase of this research sought to investigate the effectiveness of improved well head protection and the uptake and safe installation of improved lifting devices to minimise water quality risks. This report documents and discusses the initiatives and activities on well upgrading (chapter 2) and includes the subsequent monitoring phase (chapter 3). Note that per original scheduled deliverables, the monitoring phase was not intended to be included in the intermediate research report, but due to the delays in reporting, it was chosen to include all activities up to November 2019 and align with submitted progress reports.

The final chapter of the report contains discussions and considerations for rounding off the research.

2 Well upgrading process

2.1 Approach

This phase was targeted to create sufficient wells with improved well heads and lifting devices to measure the effectiveness of improved well head protection. In order to achieve this, a phased approach was designed, based mainly on self-supply acceleration planning (Figure 2) (MoWIE, 2014; Butterworth, et al., 2014):

1. Potential assessment/mapping
2. Creating demand
3. Supporting technology choices
4. Promoting private sector involvement
5. Supporting access to finance
6. Ensuring coordination, innovation and learning
7. Planning and Implementation
8. Monitoring

Figure 2 Eight steps in self supply implementation

Note that the steps are not necessarily sequential and often are undertaken in parallel. The project had started in 2017 in with collaboration agriculture and water offices at woreda level; the woredas took the lead not only in assigning focal people from the respective offices but also in nominating and assigning data collectors with the support of the project implementors (IRC and WLRC). The baseline covered the first step and provided most of the basic information including the potential of shallow groundwater resources, the practices of family wells development and uses, exiting and potential technologies for family wells development, existing and the trend for family wells development, sources of finances to invest in own family wells (own saving or loan from micro finances for example), potential and available private service providers (well diggers, masons, rope pump manufacturers), etc.

The baseline helped to prioritize on which components of self-supply acceleration to focus. For example, less attention was needed for step 5 as ACSI (Amhara Credit and Saving Institute) is already on board to provide loans to interested consumers for family well development. This was part of a previous Millennium Water Alliances (MWA) intervention. A formal letter was shared by this government affiliated micro financing to all its branches at districts level to provide loans for provision of self-supply.

Similarly demand creation was focussed on well head improvement since there were already many households who have their own wells. The baseline highlighted that attention was needed particular to demand creation (step 2), technology introduction (step 3), and monitoring (step 8) (water quality, water level and the uptake of well head improvement).

However, due to the difficult political situation in 2017/2018 and the state of Emergency in Ethiopia, the whole research suffered delay. These were circumstances outside the control of any of the partners and led to a gap in activities between the baseline in 2017 to mid-2018. The flowchart and deliverables were updated in October 2018 accordingly and the process of mobilising for well upgrading was initiated.

Table 2 Key activities well upgrading

Activity	Period	Related to steps **(Butterworth, et al., 2014)**
Community meetings and service provider assessment	October 2018	• Step 2 and 4
Repeat family wells survey and water quality test	December 2018-January 2019	• Step 7 and part 8
Demonstration sites setup for well head improvement	February-March 2019	• Step 3 and 7

Following the initial research design this would lead to comparison of the performance of three groups of facilities by regular monitoring to track utilisation of wells, groundwater levels and contamination/safety (using E. coli as an indicator of contamination):

1) **demonstration facilities**: these serve to demonstrate locally applicable low-cost technologies to improve well head protection and/or ease water lifting. These facilities were to be directly facilitated and supervised by the research team working with the owners and local artisans. The costs of the improvements (based on locally estimated market prices) was intended to be borne by households which were self-selecting, with technical support of the project. It was aimed to rapidly develop 40 demonstration facilities but it was recognised that the sample achieved may vary.
2) **owner-improved facilities**: These were intended to be developed by owners with limited involvement of the research team with households expected to copy demonstration facilities. The sample that might be achieved was considered uncertain but was expected that a further 40 owner-improved facilities could be monitored.
3) **un-improved facilities**: the intention was that an equivalent number i.e. 80 (40 per catchment) of unimproved facilities would be monitored, to provide a control group.

This chapter describes the process that was undertaken to try and achieve this set-up and discusses that the achieved numbers were a magnitude less and led to a different approach for monitoring (described in following chapter 3).

2.2 Community meetings and service provider assessment

After the emergency situation ended, two rounds of community meetings were conducted in both watersheds to start raising demand from two sides – from household side and from service providers. The activities had the following results:

- The registration of 162 interested family well owners to improve their wells
- Identifying local service providers (manual well drillers, masons, suppliers and rope pump manufacturers)
- The prices of different services and products in line with family wells improvement

2.2.1 Approach community meetings

In October 2018, two field trips were undertaken by IRC (Lemessa Mekonta and Mathijs Veenkant) with the following objectives:

- Explain to households/ communities on the potential benefits of well improvement, improvement options and indicative costs of well improvement
- Identify experimental households through community meetings: Demonstration facilities, Owner-improved facilities, Un-improved facilities
- Identify private service providers (manual well drillers and masons) for well construction and upgrading, as well as suppliers of lifting devices (pulley, rope pump, etc.)
- Updating woredas (Bahir Dar Zuria and South Mecha) on the research.

2.2.2 Outputs community meetings

- During both visits, the woreda Agriculture Offices and Water, Mines and Energy Offices and Kebele structures facilitated the community meetings
- A total of 162 well owners expressed their interest and were registered (125 and 37 in Abagerima and Debre Yacob learning watersheds respectively) to improve their wells either fully or partially. These improvement involves well head improvement (parapet, apron, drainage), lifting devices and internal well lining
- Two rope pump manufacturers (one in Bahir Dar and the other in Gerchech- capital of South Mecha woreda) were visited and the team discussed experiences, costs of the product and the associated services of transportation and installation of rope pumps. The price of the rope pumps including concrete slab, transportation and installation services varies between ETB 4000 and ETB 5000 (USD 133 – 166).
- In both learning watersheds (Abagerima and Debre Yacob), masons were identified for future well head improvement services for those interested well owners.
- The prices of better quality metallic pulley checked at Bahir Dar; the prices vary between ETB 300 and 400 (USD 13-16).
- Most well owners are happy in the idea and want to improve their wells though still some of them are demanding for [paid] demonstration of the technologies
- Two trained manual well drillers from neighboring woreda (Dera) were taken to Abagerima learning watersheds to check the suitability of the area for manual drilling.

Figure 3 Community meeting in Debre Yacob watershed

Figure 4 Community meeting in Abagerima watershed

2.3 Repeated family wells survey and water quality test

The repeated family wells survey and the water quality test were conducted in two phases: 11th – 16th December 2018, and 2- 5th January 2019. This was a follow-up of the baseline in 2017. The repeated family wells' survey and the water quality tests were conducted for those wells that were registered for improvement.

2.3.1 Approach survey

In both watersheds, woreda staffs (Agriculture and Water Offices) were trained along with two WLRC field officers on data collection in a similar way to the baseline survey before the commencement of the survey. The training included the objective of the project, the purpose of the repeated survey, the content of the survey, water sampling for water quality test, how to use mobile phones for data collection and the submission of the collected data. The survey and the water quality tests using Compartment Bag Test (CBT) (Aquagenx, 2013) were undertaken by these enumerators and IRC WASH team.

During the first phase (field visit) of the survey, the following activities were undertaken:

- All wells of the registered households were surveyed (162)
- Water samples were collected and analysed for E-coli for 146 wells.

2.3.2 Output Survey

- Evidence to select most suitable locations for demonstration wells (next activity)
- Engagement and wider understanding by woreda's and community in water quality testing.
- Unfortunately, due to incorrect data storage, half of the water samples could not be correlated to water point information and have been omitted from current analysis. Recovery of this data may still be possible and the team hopes to include it in the final research report.

Table 3 Water quality (E-coli) results 2018 (only traditional wells)

CBT Health Risk Category*	MPN/ 100 ml**	WHO risk category***	Total	%
Low Risk/Safe	0 to < 10	Low -intermediate	1	1%
Intermediate Risk/Probably Safe	10 to < 40	High	2	3%
Intermediate Risk/Possibly Safe	40 to < 90	High	1	1%
Intermediate Risk/Probably Unsafe	90 to < 136	High-very high	8	11%
High Risk/Possibly Unsafe	136 to <326	Very high	2	3%
High Risk/Probably Unsafe	326 to < 1000	Very high	19	26%
Unsafe	>1000	Very high	40	55%
Summary			73	

*** These categories derive from using the special Aquagenx Compartment Bag Test (Aquagenx, 2013)**
****MPN/100ml = Most Probable Number of Colony-Forming Units (CFU) per 100ml as determined using the Compartment Bag Test**
*****Note that WHO guidelines also include sanitary inspection – see table 5.4 Guidelines for drinking water 4th Edition (WHO, 2011)**

- The key outcomes of the survey are the following:

    1) It was confirmed that all selected households used the family well for drinking water with 64% indicated that they collect water near daily, 30% occasionally and 6% seasonally.
    2) 95% of the traditional wells had High risk water quality according to WHO standard (Table 3).
    3) 64% indicated that they want to improve both the well head and the lifting device and 39% indicated to want to indicate internal lining. 85% indicated they want to make the improvements within the next 3 months.

In line with the 2017 baseline, these survey results show that there is both a strong need for improving water quality and also a good willingness to start making improvements.

2.4 Demonstration sites setup for well head improvement

During February and March 2019 four demonstration well head improvement were setup, two for each watershed.

2.4.1 Approach of demonstration sites

- Based on the information and data from baseline survey, community meetings and repeated survey, some areas (villages) were identified as a suitable demonstration for well improvement areas. From Abagerima watersheds, Kecha and Tach Mender were identified as the potential villages as they have limited community water supply for drinking; hence, they were preferred villages for demonstration of well improvement; similarly, Debirmender was identified as a potential demonstration village to setup well improvement.
- Our initial approach, also based on the baseline was to get voluntary well owners that would want to upgrade their wells. The idea was that there would be no cost sharing except technical support from the project side. However, there was no interest for this and the project adapted by introducing cost sharing for the demonstration wells.
- With the discussion with the woreda offices (Agriculture and Water) and Kebele Cabinet members, criteria were put in place to select family wells for demo well head improvement; the criteria were interest of the well owner for cost sharing to improve the well (availing locally available materials such as sand, stone and labour within the agreed time framework), interest to explain to other visitors (farmers) who wants to learn from him/her, etc. A period of one month (longer time frame would have brought activities into the rainy season) was indicated for households to register willingness. Accordingly, only four demonstration wells for head improvement were identified (two for each watersheds). The demonstration wells were also used as a training sites for masons; and the costs of the well head improvement were also documented.
- Though rope pumps were intended to be part of the demonstration wells, we could not get any voluntary well owner to invest in a rope pump. Further discussions revealed that people were disappointed by the quality of the rope pumps (especially in Debre Yacob) that had previously been distributed by agriculture. The project has tried to address this by engaging with four rope pump manufacturers and sharing manuals and standards (two in Bahirdar, one in Gerchech- South Mecha, and one in Debretabor)..

Figure 5 Improved well head of Ashagire Agumas (Abagerima)

Figure 6 Improved well head of Minalu Alehegn (Debre Yacob))

2.4.2 Outputs of demonstration sites

- Bahir Dar Zuria Agriculture office marked all the activities of repeated well survey, community sensitization meetings, and demonstration well head improvement setup as one of its core activities and reported to the zone (West Gojam Agriculture Department).
- More well owners were interested to be the model in Debre Yacob than in Abagerima learning watershed. This confirms the baseline finding that more well owners use their wells for drinking in Debre Yacob than in Aba Gerima
- In Debre Yacob, local mason is available with reasonable skills to construct well head; the price of the Mason for one well head improvement was ETB 400 (USD 13). However, this may change depending on the diameter of the well and depth of excavation. In the case of Abagerima learning watershed, masons were recruited from Bahir Dar town; they are more professional but also more expensive; two teams of masons were contacted in Bahir Dar: the first was Artisan team trained by the woreda Water office who quoted a minimum price of

ETB 4,000 (USD 133) per well head improvement; and the second team private masons working on different construction activities who quoted a minimum of ETB 2,500 (USD 83) per well head improvement. We engaged with the latter.

- After the community learning visits to the demonstration well head improvement, the uptake of the well head improvement is monitored in both watersheds.

In the period April - June 2019 a number of support visits were conducted (by Lemessa Mekonta and Arjen Naafs) focussing on support to the WLRC colleagues and discussions with woreda colleagues. WLRC and trained woreda staff remained available for support for upgrading and contacts to local contractors and prices were available, no new upgrades were reported up to November 2019.

Figure 7 Improved well head of Ashagire Agumas (Abagerima)

2.5 Reflections on well upgrading

1. Based on the 2017 survey and confirmed in the 2018 survey, 162 out of the 337 households (48%) registered a willingness and interest to upgrade their well. This high percentage **demonstrated the demand and the importance that people place on water quality.**
2. That said, a learning has been that this did not translate into a willingness to invest into well improvements, even with the possibility of cost sharing.
3. The demonstration sites showed that **improvements are viable and affordable**, though costs varied considerable between the watersheds ETB 400 (USD 13) to ETB 2,500 (USD 83).
4. The discussion on the "**menu" of technologies and potential improvements** identified the following technological improvements (also presented in Table 4 Water technology ladder):
    a. Well head improvement – using traditional material such as drums or pots to raise the well head
    b. Impermeable parapet
    c. Impermeable apron; to avoid infiltration by stagnant water. Preferably made from concrete
    d. A lid to protect the well mouth

    e. Improved lifting method/devices to replace the bucket and rope:
        i. Pully system
        ii. Rope pump
5. Though the **eight steps for accelerating self-supply are a very useful structure** to shape the approach, it has proven difficult to address all of the steps with sufficient attention and result. For example, we have tried to organise private sector involvement (step 4) where we have tried to bring manual well drillers to the site, contacted rope pump manufacturers and engage local service providers for well head improvements. However, the scale is very individual and our learning is that it is difficult to maintain or scale (see also Box 1).
6. Overall, this lead to the result that in the months after the demonstrations, **uptake and was minimal** with just a three farmers reported to take well improvements up. The farmers were able, willing and financially able to make improvements, yet something held them back and they choose not to. It is thought to be related to timing of the activities, dependency (previous projects provided goods for free) and unproven benefits (water quality data not correlating clearly with improvements). To follow-up, the team scheduled Focus Group Discussions for March 2020 to obtain further insights.

In order not to lose the possibility of monitoring both a wet and a dry season, the next phase, water quality monitoring was initiated in May 2019, before the rainy seasons started.

Box 1: The limited scale of micro enterprises

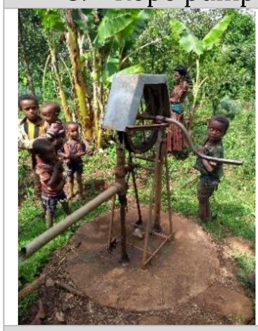
Paying for well construction is not common. Rather, households mobilize either neighbours and friends labour or own labour to dig or construct their wells. The number of private well diggers/artisans ranging between 4 and 6 per kebele. They have no training on well digging and construction but learn by doing. The well diggers do not rely on well digging only for their livelihood but have farm land and provide well digging services as an alternative source of income during low agricultural season. A given artisan can get a maximum contract of two wells digging per year as one informant mentioned. This illustrates the small market for well digging services in the area. Well digging prices vary depending on location, soil type (soft or hard rock) and season (peak or low farming season). Prices varied from $60 to $175 for well complete construction. There are three modes of contracting for well digging in the area: lump sum (full contract irrespective of depth until water is available), unit price (per meter) and daily rate. There are different reasons for not having one's own well including lack of suitable land for well digging (rocky, no water at shallow depth, etc.), well collapse/drying up, and lack of interest.

3 Monitoring phase

3.1 Approach

Sutton et al. (2012) found a relationship between level of well protection and water quality risk with semi- and fully-protected household wells showing reduced risks of microbial contamination. Based on that approach, the “menu” of technologies, and the demonstration wells, a water technology ladder was designed for use in the research areas (Table 4) and a monitoring plan designed (Table 5). Objective of this phase was to gain insights for sub-research question 3 related to improvements on water quality and reduced risk. In addition, it was intended to understand the correlation with water availability/quantity (difference rainy and dry season).

Table 4 Water technology ladder

Type	Description	Frequency
1. Unprotected traditional well		
	Unlined hand-dug well with no apron, and often no parapet or top lining; may have oil drum, pot or wooden superstructure to stabilise and prevent water running back in (Gelaw Mengesha-1).	Total in area: 473 (97%) Selected for monthly monitoring: 12 (3%)
2. Semi-protected traditional well		
	Unlined hand-dug well with top lining including impermeable parapet (until the oil drum rots), closable top opening, joined to an impermeable apron; Apron seldom of adequate width. Note: most sources fail due to lack of lid	Total in area: 5 Of which are part of the monitoring: 5 (100%)
3. Rope pump		
	Rope pump usually sealed into well, sometimes without top slab; typically mounted on traditional or fully protected well; not usual for top slab to be raised above ground level or for effective drainage, so returning surface water has easy access back to the well, which is often constructed primarily for irrigation.	Total in area: 17 (3%) Of which are part of the monitoring: 3 (18%)
4. Handpump		
	Afridev (18 in total) or India Mk 2 (just one) on larger diameter community well or borehole, with full lining, apron and drainage. (Gadila School) Average borehole depth is reported to be 56 m Average well depth is reported to be 10.8 m	Total in area: 19 Of which are part of the monitoring: 5 (26%)
Source: adapted from (Sally Sutton, 2012)		

As indicated in chapter 2.1, the initial research approach was designed to have 80 semi-protected traditional well that could be monitored every four months. However, due to the extremely low uptake a different approach was designed, focussing on the demonstration wells and comparing those results with handpump improved wells and open wells located near-by. This lead to a selection of 20 water points (Figure 9) of four different technologies, following the water technology ladder spread in clusters through the watersheds and Figure 9. Due to the very low number of semi-protected wells, the sampling could not be randomised, but instead clustered where variety of technologies were present near each other (thus assumed to be in same hydrogeological units):

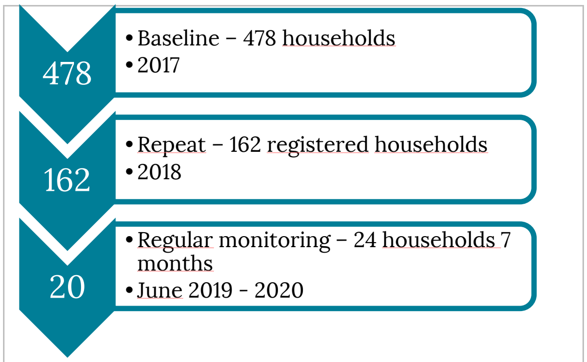
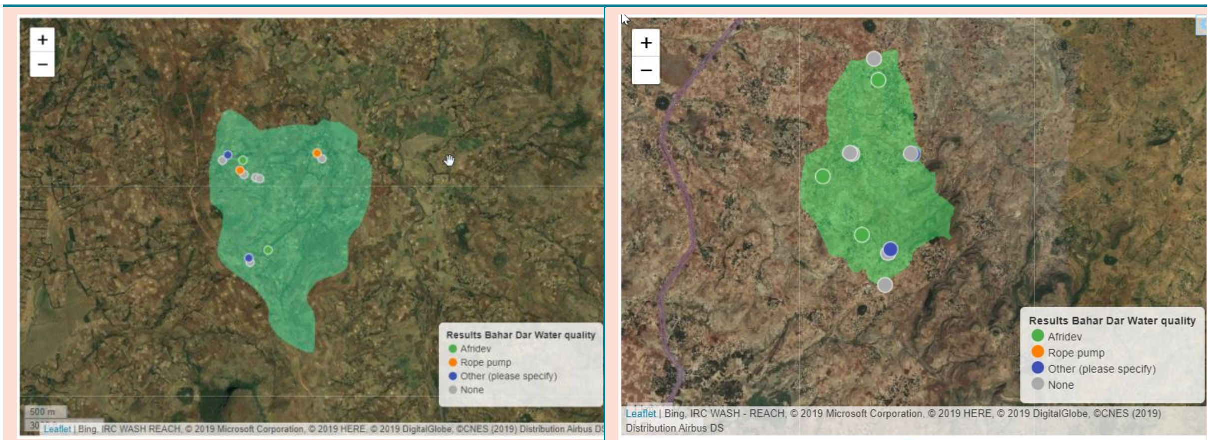


Figure 8 Zooming into monitoring locations

- Debra Yacob had two clusters with 4 types: unimproved; semi-protected traditional well; rope pump; handpump and one with 3 types (no handpump)
- Aba Gerima had three clusters with 3 types: unimproved; semi-protected traditional well; handpump
- Two traditional wells were added to Aba Gerim for special distribution



Locations Debra Yacob: 2 Afridev; 3 rope pumps; 2 semi-protected wells, 5 traditional wells	Locations Aba Gerima 3 Afridev; 3 semi-protected wells, 8 traditional wells

Figure 9 Location of water quality monitoring locations

In order to assess the quantity of available water, and to correlate it to the water quality, participatory water level measurements were initiated water level's were taken with a manual piezometer at time of water quality sampling. In addition, every month, the WLRC colleagues would make a cross section and sample 10 water levels in traditional wells to get understanding of fluctuations in water levels outside the clusters.

A final component has been to initiate participative monitoring and engage the well owners in water level measurements at the water quality sampling locations.

Table 5 Monitoring plan

Activity	Period	Remarks	Total intended sample
Water quality monitoring by team	June – December 2019	Monthly	160
Water level monitoring by team	June– December 2019*	Monthly	144
Participatory water level monitoring by farmers	June – December 2019	Weekly	544
Monitoring uptake well improvements (if any)	June – December 2019*	Monthly	-
* Based on the revised call down agreement and extension till June 2020 for submission of deliverables, these were later extended to March 2020.			

3.2 Water quality monitoring

The water quality (E-coli) has been measured by woreda staff, supported by WLRC colleagues. Though the used Aquagenx kits (see box 2) are one of the most user friendly E-coli tests on the market, it is still prone to incorrect handling and polluting the sample during sampling. Therefore, it was decided to keep the water quality monitoring with WLRC and woreda staff. This also allowed using the mobile to web application to submit and store results.

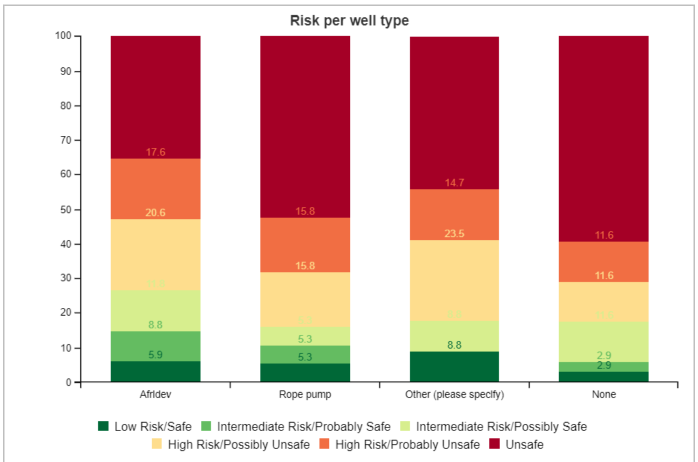


Figure 10 Water quality results

In line with the 2017 survey, the sampling was done to capture the water quality as delivered by the system and therefore, the sprouts of the handpumps were not sterilised. Also the same bucket/rope combination was used as the family normally uses. It is recognised that therefore the pollution caused by the bucket will be affecting the results, but this is more a reflection of the reality.

A total of 156 samples have been approved. Initial results indicate that only 19% are categorised as possibly safe with intermediate risk (Table 6). The water quality across the board is poor and better performance of in theory safer technologies such as Afridev and rope pump is not visible.

Box 2: The CBT tests

This project has been using Aquagenx® CBT tests to conduct *E-coli* water quality testing. These tests are a balance between portable kits, which provide detailed quantitative results but are cumbersome to use, and simple presence/absence tests that do provide any quantitative information. The CBT tests are relatively easily to apply and with local temperature no incubator was needed. A distinct advantage of CBT tests is that results are in categories – which enables to understand differences in degrees of pollution. This was an essential part of our approach, as otherwise the small step wise increases in well improvements would not be visible. Also quantitative results assist in potential water safety planning. The use of the Aquagenx® CBT Most Probable Number (MPN) Table may be confusing if used in the field. However, using mobile apps such as AKVO and mWater with integrated functions for the Aquagenx bag enables correct categorization and classification. The cost is between 8-10 USD per test.

Table 6 Water quality (E-coli) results

CBT Health Risk Category*	MPN/ 100 ml**	WHO risk category***	Total	%	Afridev	Rope pump	Semi-protected	Open Well
Low Risk/Safe	0 to < 10	Low - intermediate	8	5%	2	1	3	2
Intermediate Risk/Probably Safe	10 to < 40	High	6	4%	3	1		2
Intermediate Risk/Possibly Safe	40 to < 90	High	16	10%	4	1	3	8
Intermediate Risk/Probably Unsafe	90 to < 136	High-very high	26	17%	7	3	8	8
High Risk/Possibly Unsafe	136 to <326	Very high	22	14%	6	3	5	8
High Risk/Probably Unsafe	326 to < 1000	Very high	78	50%	12	10	15	41
Unsafe	>1000	Very high	8	5%	2	1	3	2
Summary			156	100%	34	19	34	69

*** These categories derive from using the special Aquagenx Compartment Bag Test (Aquagenx, 2013)**
****MPN/100ml = Most Probable Number of Colony-Forming Units (CFU) per 100ml as determined using the Compartment Bag Test**
*****Note that WHO guidelines also include sanitary inspection – see table 5.4 Guidelines for drinking water 4th Edition (WHO, 2011)**

3.3 Water level monitoring

These water level measurements are done by the farmers themselves. Each farmer with a monitoring location[1] received a simple 25 m tape measure together with a paper form. Taking water level measurements in open wells is very easy and they were requested to measure each week. Often one of their school going children would be involved to fill the form.

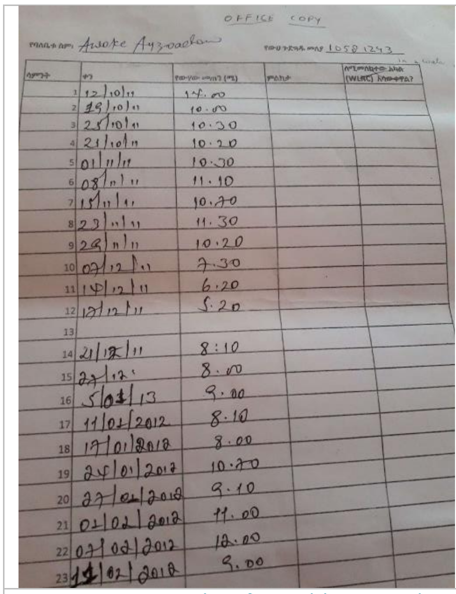


Figure 11 Example of weekly records

The WRLC colleague would visit once a month and measure with a proper groundwater dipper for correlation. He would then copy the results of the past 4 weeks on paper and later submit all data via the mobile. By the end of November 545 water level measurements had been approved, with some farmer results still to be digitised.

The water levels in both watersheds showed a similar trend with August having the highest water levels of about 4 m depth. Debre Yacob seems to have a larger fluctuations and drops down to 9.1 m at end of November versus 7.5 m for Aba Gerima. As most of the water lifting happens by hand, or by pully, the increased in depth may lead to less extraction for irrigation and potentially drinking.

[1] The wells with a rope pump or an Afridev couldn't be measured directly, so the nearest open well was chosen.

The final research report will include more spatial analysis over the whole data set up to March 2020 and will link to social data from the 2017 and 2018 surveys.

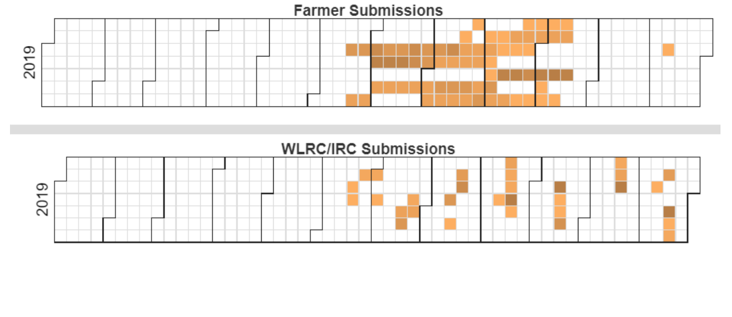


Figure 12 Participatory monitoring achieves a high regularity

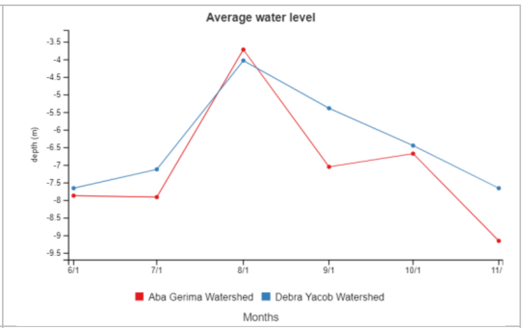


Figure 13 Average monthly water levels

3.4 Reflections on monitoring phase

3.4.1 Water quality and water levels

The first consideration is that the sample size of the water quality is very limiting, particular to allow meaningful disaggregation between the various models of the water technology ladder. As discussed in the previous chapter, this is a consequence from the disappointing uptake of well improvements. It is not thought that an increase in sampling would have been viable as all semi-protected wells were included and nearly all other rope pumps were close to each other (which is related to historical intervention by agricultural department). Increasing the sample of handpumps may have been possible, but analysing water quality of improved wells was not the priority.

The second consideration is more than 80% of the population is using water that is highly or very high risk, regardless of the source. This is in line with both the 2017 and 2018 study and thus promoting of groundwater and sustainable land management till date does not seem to have led to safer access to water. Based on the unclear results and the challenge in significant sampling, it was decided not to continue with the water quality sampling beyond December 2019.

A third consideration has been to understand the link between water quality in the rainy season and the dry season. Water quality is known to have major seasonal variations and getting data from both dry and rainy season may avoid systematic bias (Central Statistical Agency of Ethiopia, 2017). The results are visually represented in Figure 14 and seem to indicate that water quality improves in the dry season when water levels are lower. This seems counter-intuitive as in the dry season the wells are used more intensively and more pollution enters by the bucket and rope. A more detailed analysis per type will be included in the final research report.

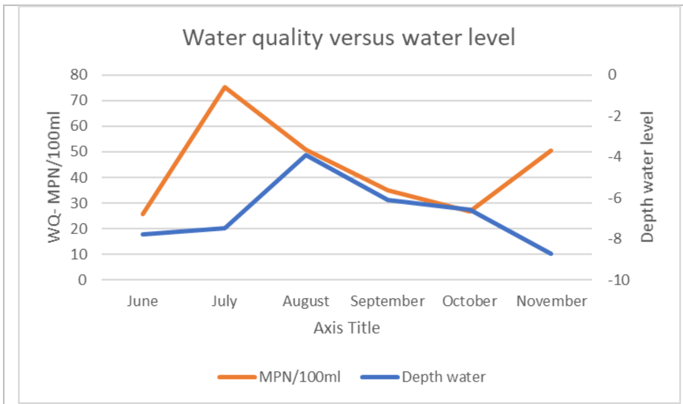


Figure 14 Visual comparison water quality and water level

3.4.2 Online monitoring

Already from the onset of the research, mobile phones have been used for data collection. In 2017 and 2018, the AKVO FLOW app was used, allowing higher data integrity and immediate storage of data on the cloud. In 2019, it was decided to shift to mWater, mainly because of costs (the organisational AKVO license had expired and renewal was a few thousand euros) and mWater had a much better user friendliness and nifty dashboard capabilities. The WLRC colleagues used the mWater app to submit water quality results, water level results and corresponding photos. An approval system was in place, which included possibility to return for correction and resubmission.

A big advantage of this system is that it allows immediate visualisation and sharing. There is a potential to develop this participatory monitoring further and use it for government officials and farmers to understand how scarce/rich a certain year is in water and if irrigation patterns need to be adapted.

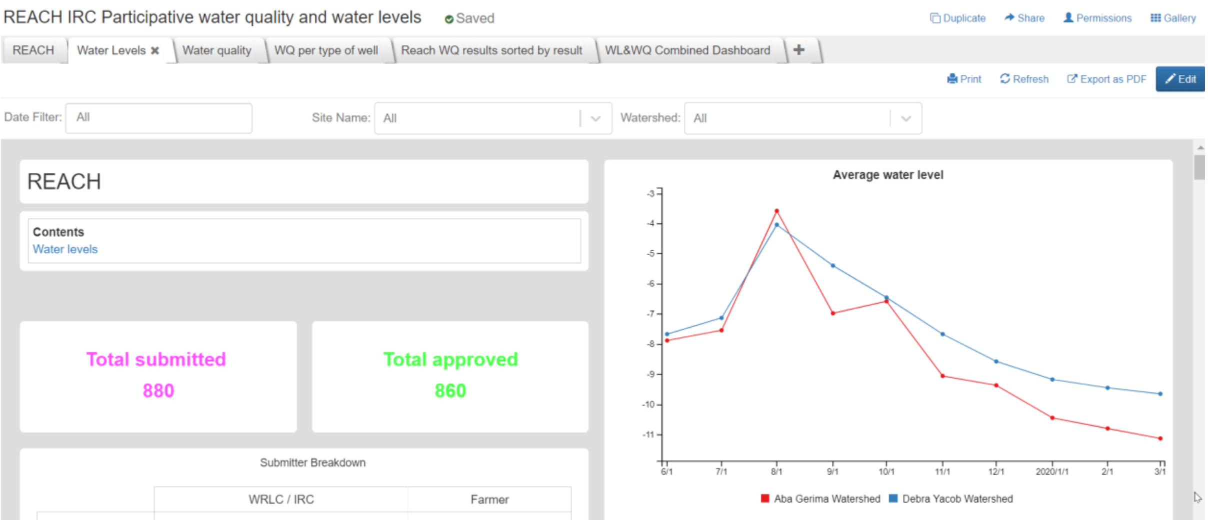


Figure 15 Sample of the online dashboard

3.4.3 Scaling up – is there potential for water safety plans?

The initial plan foresaw a workshop in March 2019 to share interim on water quality surveillance and water safety planning for household level water. This was intended to lead to further engagement with regional and national programmes such as Conrad N Hilton Foundation Funded Millennium Water Alliance programme activities in nearby Amhara woredas, the Household Irrigation Programme, Self-supply Acceleration within the One WASH National Programme, and authorities responsible for water quality. This also would include engaging with actors in the uptake of (climate resilient) water safety planning, and supporting the consideration of household level sources in these efforts.

The government of Ethiopia has developed extensive guidelines for climate resilient water safety plans. Applying an approach that would do justice to the intrinsic challenges of rural water supply would require considerable time and efforts. Considering where the project is at the moment, the extensive delay in overall implementation, the limited success in uptake, lack of clear water quality gains, the team feels that developing water safety plans in the few months left, would not be viable. The team therefore agreed to reduce the overall budget and limiting the project time to end of June 2020, as suggested in the amended call-down agreement.

4 Discussion and next steps

Overall, this research has been going different than planned and designed. First of all, there has been a much longer timeframe than was foreseen when the project was initiated in 2016. This was due to the difficult political situation in 2017-2018 and related insecurities and has provided difficulties in staffing and consistent follow-up. It is recognised that the project suffered considerable delays in submitting deliverables as well.

Secondly, the results of the uptake of semi-protected wells has been disappointing and has hampered the original sample size for the monitoring phase. Though the research itself is not about actually achieving self-supply, the limited outputs in terms of physical improvements seems discouraging for promotion of self-supply. The chosen approach of trainings and well demonstrations, the linkages with agriculture and water woreda colleagues were apparently not enough for the timeframe available. Nevertheless, the self-supply approach itself has learning as a identified step (number 5) and the faced challenges shows that a wider (system approach) may be needed for achieving such a change. The farmers were able, willing and financially able to make improvements, yet something held them back and they choose not to improve. It is thought to be related to timing of the activities, mismatched expectations (previous projects provided goods for free) and unproven benefits (collected water quality data does not correlating clearly with improvements). To follow-up, the team scheduled Focus Group Discussions for March 2020 to obtain further insights.

Though the original research questions were adapted in October 2018, some of the research questions will be challenging to address, particular related to effectiveness and market investments. This will be reflected and analysed in the final research report and paper (Table 7) before closing of the project in June 2020.

Table 7 Details on deliverables

Deliverable	Remarks
5. Journal paper/ conference paper 2	Conference paper, where we explain what we tried to do and why weren't successful, explaining the remaining need for evidence and policy impact to reduce risks from such wells, and what evidence is still needed
6. Final research report	Includes results of FGD and analysis looking into what happened, why was uptake low, what are the next steps that various stakeholders will take. Includes more details on water quality results, participatory research

That said, the research shows that there is willingness and ability to make well investments, with many wells being constructed by families. The main driver for this is irrigation, but once present, many sources double up as domestic source as well. With the current household-irrigation strategy that promotes '1 family, 1 well' and targets 10% Ethiopian households (MoA/ATA, 2014), combined with the roaring Ethiopian economy, investments as we see in the research areas are expected to increase around the country.

The results throughout the study indicate that water quality is a difficult entity to define. It has been argued that a more graduated approach to monitoring than the "improved"/"unimproved" dichotomy is required (Bain, et al., 2014) and the proposed water technology ladder fits in that discussion. Though the semi-protected traditional well may improve water quality, the contamination from the bucket at rope itself will remain, unless a proper lifting device is applied. Yet even then, aside of the challenges in supplying safe drinking water, water handling and the deterioration of water quality at point of consumption, which is estimated to happen in 40% of the cases (Central Statistical Agency of Ethiopia, 2017), creates further health risks. In various discussions with the woreda colleagues, the possibility of Household Filters to strengthen the self-supply approach has been mentioned. This would fit with recommendations to develop one approach with other household-focused development interventions such as Community-led Total Sanitation and Household Water Treatment and Storage (Butterworth, Sutton, & Lemessa, 2013).

The reason for the lack of prioritising of water quality is probably partly because farmers traditionally were not being told by agriculture department that there is this opportunity or need. The agriculture department focus on irrigation and they do not have a mandate to say anything about drinking water. On the other hand, the domestic water sector has already its challenges on supplying community water supply and hardly focus on households. A promising exception in the woreda's of the research is that there are signs that the water department is making rope pumps available to those that have upgraded their wells to semi-protected.

The study has a couple of innovate components that have been applied over the course of the research. The use of CBT bags, which were fairly new in 2017 have proven to be relatively easy to use, particular if mobile phone apps help on the categorisation of the results. The consequent use of these mobile phones (first through AKVO and later using mWater) has improved monitoring possibilities, particular if combined with participative monitoring. This participative monitoring has been an efficient method to obtain information on the availability of groundwater. With hindsight, it would have been useful to have initiated this at a much earlier stage as it would have allowed a multi-year assessment of the available water quantity and enabled communities to follow their groundwater developments – and trigger discussion/debate on how (improved) land use results in changes in water levels and maximise their benefits.

Finally, a recent REACH paper raises that inequality is twofold: rural areas have less access both to safe water and to water quality information (Nowicki, Koehler, & Charles, 2020). Though we may not be able to improve many more family wells under this project, we are conscious to ensure that the water quality results and final findings reach colleagues in woreda's. As travel is currently restricted, it is intended that the final research report will have an accessible general summary to allow our Bahir Dar colleagues to engage with woreda staff when appropriate.

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Visiting address
Golagul Towers Building
Bole sub city, Woreda 4
House no 275/276
Addis Abeba
Ethiopia

Postal address
P.O. Box 2
Code 1251
Addis Abeba
Ethiopia

ethiopia@ircwash.org
www.ircwash.org/ethiopia