SUSTAINABILITY OF WATER SUPPLY POINTS CONSTRUCTED BY THE MADAGASCAR WATER PROJECT (MWP) IN EAST MADAGASCAR

By

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A dissertation submitted in partial fulfilment of the requirements for the award of the degree of Master of Science of Loughborough University

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List of abbreviation

WB	World Bank
MDG	Millenium Development Goals
SDG	Sustainable Development Goals
HDI	Human Development Index
NGO	Non-Governmental Organisation
AfDB	African Development Bank
UNICEF	United Nations Children's Fund
UN	United Nations
WFP	World Food Programme
WHO	World Health Organisation
UNDP	United Nations Development Programme
O&M	Operation and Maintenance
VLOM	Village Level Operation and Maintenance
WWF	World Wildlife Fund
JMP	Joint Monitoring Programme (WHO/UNICEF)
PND	National Development Plan
USD	United States Dollar
MGA	Malagasy Ariary
ADF	African Development Fund
PARSE	Energy Sector Reform Support Programme
ONE	Office National pour l'Environment
MEEH	Ministry of Water, Energy and Hydrocarbon
DREAH	Directions Régionales de l'Eau de l'Assainissement et de l'Hygiène
INSTAT	Institut Statistique (National Statistics Bureau)
STEAH	Service Technique de l'Eau, Assenissement et Hygiène
PNPEAH	Platform National de Promotion Eau Assainissement Hygiene

Executive summary

In today's world still 1.6 million people with 90% of children under five, die every year from diarrhoeal diseases due to the lack of access to safe drinking water and basic sanitation. These diseases are now the leading cause of child death in Africa and the second leading cause of child death globally. With almost 25 million inhabitants in 2016, 85% of the population of Madagascar lives in rural areas where only 35% has access to improved drinking water sources. Dominated by subsistence agriculture, providing a livelihood for almost 80% of the population (ADF, 2005), the Malagasy economy is one of just a handful having experienced stagnation in per capita income coupled with a rise in poverty (WFP, 2016). The low coverage of drinking water and sanitation services has serious consequences on health, education and economic development. The country has the world's fourth highest rate of chronic malnutrition. According a World Bank report:

"*Over half of children are chronically malnourished and more than one-fourth are severely malnourished*" (WB, 2017).

It is estimated that 10,400 Malagasy, including 6.900 children under the age of five die each year as a result of diarrheal disease. It is reported that 88% of these deaths are attributable to poor access to water, sanitation and hygiene.

This research study focuses on the provision and sustainability of the water supply points (hand pumps) that "The Madagascar Water Project" (MWP) organisation, has installed in rural communities in the East coast region of Madagascar. Since 2012, The Madagascar Water Project has been among the only rare organisations providing water services to the local population in the area of the Canal of Pangalanes. To date, they have provided a total of 42 suction hand-pumps in 23 different localities. Examining what can be learned from the way MWP contributes to increase the number of communities with appropriate water supplies is one important focus if this research. The second aspect of the research is examining how sustainable the MWP water supply points are. Both findings will lead to recommendations to MWP and other organisation(s) willing to provide sustainable water services in rural Malagasy areas.

The aim of the report is to determine to what extent community managed and VLOM (Village Level Operation and Maintenance) technologies are appropriate for rural communities in Pangalanes region,East Madagascar. To analyse rural water supply sustainability, various conceptual frameworks include seven fundamental dimensions: Environmental, Financial, Technical, Institutional (organisational), Socio-cultural, Economic and Health (Parry-Jones et al., 2001). These services are undermined when the effectiveness of one or several of these parameters fails or stops to exist. These dimensions are correlated and context specific. There are only few good examples of sustainability in practice because each situation takes a different shape (Lockwood, 2002). According Carter, sustainability is compromised without a real expression of demand. The difficulty in implementing rural water supply programme resides in part that different communities have different needs, and also different capacities (Carter, 2011).

Acknowledgment

I would like to particularly thank my supervisor Brian Skinner. Without his support and flexibility this report could not have been possible. His experience and advices were priceless and my gratitude is simply beyond words.

I want to express all my gratitude to The Madagascar Water Project team and especially to its founder Rittelmeyer Frederick for his unlimited generosity. I always felt like I was part of the team.

I also want to thank all the WEDC team. With a contagious passion, these formidable people accomplish a tremendous work behind the scenes for the well-being of World citizens. They show to students how to broaden their vision with optimistic insights and develop durable opportunities. By themselves, they constitute an inexhaustible source of knowledge. I wish one day follow their path.

I also want to thank the Malagasy officials and all individuals who have contributed to the realisation of this research report.

I also want to thank my parents, family and friends who supported me psychologically and financially. Without them, it would have been impossible to accomplish this research report.

I also want to thank my dear friend Michel for his precious help. I could not hope for better collaborator.

Finally I dedicate this work for all the people I had the chance to meet on my way. It is with great gratitude that I thank all these persons who welcomed me in their communities like if I was one of them. I want to use wisely all they have taught me.

1- INTRODUCTION

1.1- Background

In today's world still 1.6 million people with 90% of children under five, die every year from diarrhoeal diseases due to the lack of access to safe drinking water and basic sanitation. These diseases are now the leading cause of child death in Africa and the second leading cause of child death globally. Thereby priority needs to be given for improving and developing drinking water supplies that represent the greatest public health risk (WHO, 2016). According to the WHO/UNICEF Joint Monitoring Programme (JMP):

"844 million people still lack a basic drinking water service in 2015 either use improved sources with water collection times exceeding 30 minutes (and) 2.4 billion people still lack basic sanitation service" (JMP, 2017).

Since the setting of the Millennium Development Goals (MDGs) in 1990, 2.6 billion people in the world have gained access to improved drinking sources. 96% of the global urban population uses improved drinking water sources against 84% for the rural population. Eight out of ten people without improved drinking water sources live in rural areas (JMP, 2015). The Least Developed Countries (LDCs) such as the Sub-Saharan Africa did not meet the MDGs target but achieved a 20% increase in the use of improved sources of drinking water which represents 427 million people or an average of 47 000 people per day. Launched in 2015, the Sustainable Development Goals (SDGs) call for universal access to drinking water, sanitation and hygiene, before 2030. These goals cannot be achieved without resolving inequalities in access between groups such as rich and poor, rural and urban etc…Still in 2015, the *Progress on sanitation and drinking water* report presented Madagascar at the top of inequality for access to improved sources of drinking water between rich and poor in rural areas (JMP, 2015). It was also reported that in Malagasy urban areas, 82% of population had access to improved drinking water sources whereas it was only 35 % in rural areas. Yet in the island, almost 85 % of the population lives in rural areas, where living conditions have been declining over the past decades, particularly in terms of health, education, transport and market access (WFP, 2011).

Dominated by subsistence agriculture, providing a livelihood for almost 80% of the population (ADF, 2005), the Malagasy economy is one of just a handful having experienced stagnation in per capita income coupled with a rise in poverty (WFP, 2016). The low coverage of drinking water and sanitation services has serious consequences on health, education and economic development.

"Although Madagascar made some progress in the achievement of the Millennium Development Goals in the 2000s, the political crisis from 2009 to 2013 seriously undermined that progress. Today Madagascar's education, health, nutrition and water access outcomes are among the poorest in the world" (WB, 2017).

1.1- Research focus

1.2.1- Focus on rural communities in the East-coast of Madagascar

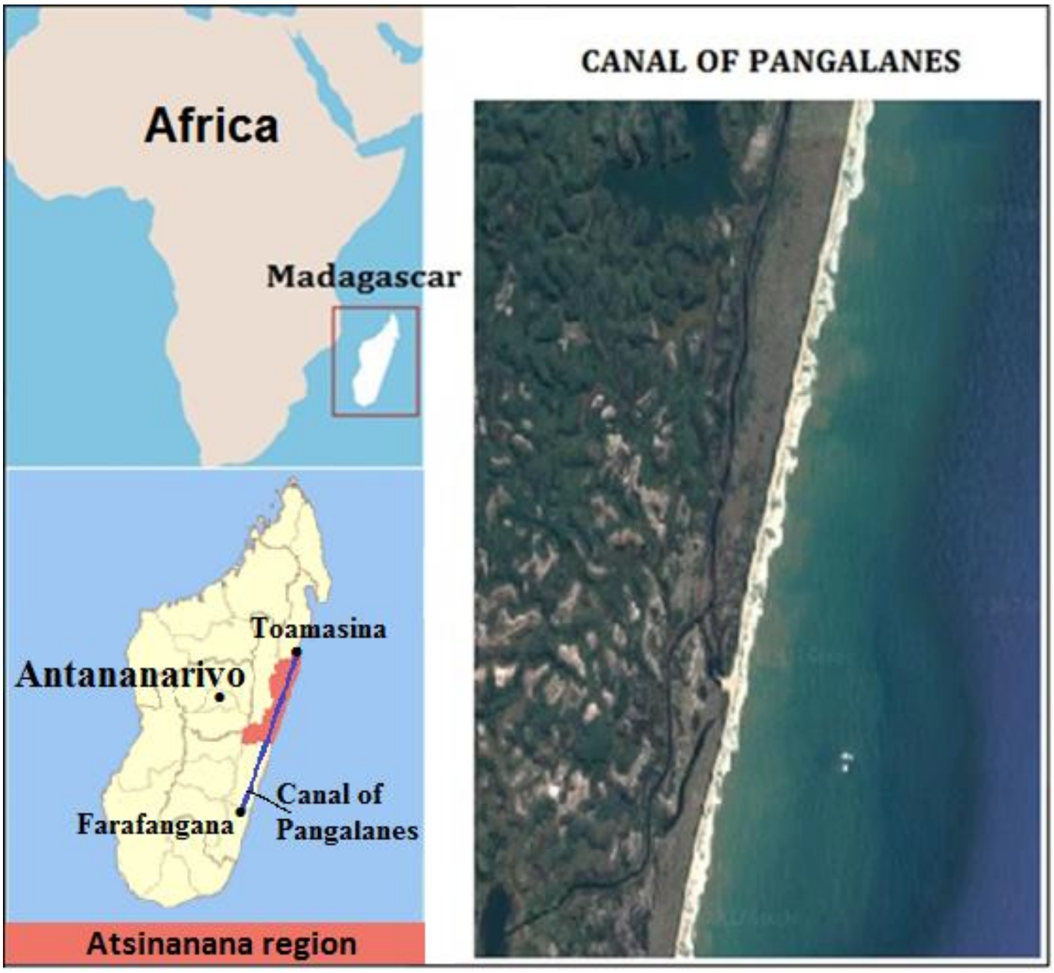
This research study focuses on the provision and sustainability of the water supply points (hand pumps) that "The Madagascar Water Project" (MWP) organisation, has installed in rural communities in the East coast region of Madagascar.

This research investigates MWP water supplies in 15 villages located on the East coast of Madagascar in Atsinanana (Eastern) region and more precisely in the Canal of Pangalanes area. In these rural zones, public services such as electricity and health care are inexistent but sometimes few associations and Non-Governmental Organisations (NGOs) give help to local population. The last national report (Source ONE, 2009)(p.175) gives a drinking water access rates in Atsinanana region of 51% in urban areas, 14% in rural areas, and a total coverage of 24%. These figures are far below the national average of 51% (Table 1.1) (JMP, 2017) and even more from SDGs target of 100% access, so it is clear that there is an important need to considerably improve the provision of drinking water supply in rural communities in Madagascar.

(Table 1.1: Water sources categories and access rate, Source JMP 2017)

COUNTRY, AREA OR TERRITORY	Year	Population (thousands)	% urban	NATIONAL					RURAL					URBAN				
				At least basic	Limited (>30 mins)	Unimproved	Surface water	Annual rate of change (basic)	At least basic	Limited (>30 mins)	Unimproved	Surface water	Annual rate of change (basic)	At least basic	Limited (>30 mins)	Unimproved	Surface water	Annual rate of change (basic)
Luxembourg	2000	436	84	100	-	0	0	0.00	100	-	1	0	0.00	100	-	0	0	0.00
	2015	567	90	100	-	0	0		100	-	1	0		100	-	0	0	
Madagascar	2000	15 745	27	37	2	21	41	0.93	25	1	24	50	0.60	69	3	12	15	0.86
	2015	24 235	35	51	3	31	16		34	2	41	23		82	4	12	2	
Malawi	2000	11 193	15	52	15	25	8	1.04	46	16	29	10	1.16	84	9	6	1	0.15
	2015	17 215	16	67	20	10	3		63	22	12	3		87	9	4	0	

N.B: The national rate of access to at least basic drinking water source(s) reaches 82% in urban areas and 34% in rural areas. In rural areas, only 13% of water sources are accessible on premises against 43% in urban areas. (Table 1.2) (JMP 2017)(p66).



(Figure 1.1: Canal of Pangalanes, Atsinanana region, Madagascar)

(Table 1.2: Water source accessibility and availability, Source JMP 2017)

COUNTRY, AREA OR TERRITORY	Year	NATIONAL: Proportion of population using improved water supplies						RURAL: Proportion of population using improved water supplies						URBAN: Proportion of population using improved water supplies					
		Safely managed	Accessible on premises	Available when needed	Free from contamination	Piped	Non-piped	Safely managed	Accessible on premises	Available when needed	Free from contamination	Piped	Non-piped	Safely managed	Accessible on premises	Available when needed	Free from contamination	Piped	Non-piped
Luxembourg	2000	98	98	-	100	100	0	-	97	-	-	-	-	-	98	-	-	100	0
	2015	98	98	-	100	100	0	-	97	-	-	99	1	-	98	-	-	100	0
Madagascar	2000	-	6	30	-	24	14	-	1	20	-	11	15	-	17	54	-	59	14
	2015	-	24	41	-	34	19	-	13	28	-	15	20	-	43	64	-	68	18
Malawi	2000	-	6	49	-	22	44	-	1	51	-	12	49	-	34	42	-	79	14
	2015	-	16	65	-	22	65	-	9	70	-	10	75	-	49	43	-	81	15

1.2.2- Focus on The Madagascar Water Project activities

Since 2012, The Madagascar Water Project has been among the only rare organisations providing water services to the local population in the area of the Canal of Pangalanes. To date, they have provided a total of 42 suction hand-pumps (Figure 1.2) in 23 different localities. Examining what can be learned from the way MWP contributes to increase the number of communities with appropriate water supplies is one important focus if this research. The second aspect of the research is examining how sustainable the MWP water supply points are. Both findings will lead to recommendations to MWP and other organisation(s) willing to provide sustainable water services in rural Malagasy areas.

(Figure 1.2: MWP hand-pump in Tsivangina locality. Source: The MWP, 2016)

The Madagascar Water Project Management team:

Founder: Frederick Rittelmeyer

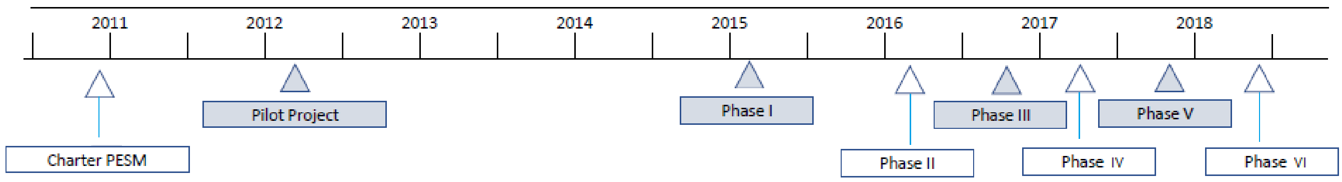
Frederick Rittelmeyer has been working for Exxon Mobil for nearly 30 years as a Petroleum Geologist. In 2006, he arrives in Madagascar as the Exxon Mobil Operations Manager that will bring him in many rural parts of northwest of the island. Later, he will become the Madagascar Oil Operations Manager and move to Tsimiroro area in the south west. He creates the Petroleum Exploration Services of Madagascar (PESM) and then develops The Madagascar Water Project within its Charter. The story said that during a visit on the east coast, someone asked him a handpump before he takes his retirement and return to his country. Since then, Frederick has returned to the U.S but comes back every six months to Madagascar, to pursue what he has started.

Field Operations Manager: Solo Andrianavalona

Community Relations Coordinator: Hilaire Razanadrafely

Geologist: Larry Rabenorosoa

Historical of The Madagascar Water Project



1.2- Research aim and objectives

1.2.1- Aim

The aim of the report is to determine:

- *To what extent community managed and VLOM (Village Level Operation and Maintenance) technologies are appropriate for rural communities in Pangalanes region, East Madagascar.*

1.2.2- Objectives

Accordingly, the primary research objectives of the report are:

1) To assess the current situation of water access with respect to water facilities and their management in the Pangalanes Region.
2) To investigate the methodologies used by The Madagascar Water Project for providing water points.
3) To investigate the quality of the water points, their effectiveness in meeting user's needs, their management and their sustainability.
4) To discuss and make recommendations for improving the development of sustainable water supply services in rural Malagasy communities.

1.2.3- Structure

Chapter 2 is a literature review about topics treating on the long term success of rural water supply systems in low-income countries. It also includes an overview of the rural water supply in Madagascar and introduces the reader to The Madagascar Water Project's context. From the available documentations it is clear that in order to achieve the research objectives, some specific areas require more investigation. These gaps have been identified in the form of "Research questions" summarised at the end of chapter 2.

Chapter 3 presents the methodologies used to fill the gaps in order to answer the research questions.

Results of investigation and analysis are presented in Chapter 4, followed by the discussions and recommendations in Chapter 5.

1.3- Literature review methodology

Table 1.3: Search strategy

Source of information	Search strategy	Justification of approach
WEDC Resource Centre	The section 628-3 contained several specific textbooks treating about "Rural water supply" and/or "Low cost technologies for developing countries"	The Resource Centre allowed access to a large variety of documents such as specialised textbooks, journals, magazines, research thesis…All regrouped in one place, these materials are very useful for any researcher
Library Catalogues	By using "advanced search tool" browser, specific and related words were entered (e.g. rural areas, water supply, developing countries, low cost technologies, water committee…)	The library catalogues provided a significant list of relevant textbooks but also journal articles, research papers, authors…These data permitted to find many references but also electronic versions of many related documents
Personal Contacts	Asking professionals' opinions often gave clues for building research strategies. Thanks to their experience they (almost) always provided important information about where to look at and how to proceed to continue (e.g. different existing technologies, research strategy tools and methodologies, references, other personal contacts…)	Professionals' advices were always helpful. Their knowledge has helped to gain precious time and the opportunity of discussing with expert and passionate people was always priceless.
Google/Google Scholar	Google was the simplest and quickest way to find literature on the subject. The difficulty was to separate the most relevant data from the less and determine the pertinent key words. Google Scholar helped to exclude unrelated documents and find more specific articles.	Google Scholar provided scientist and scholar references. It was helpful to find more relevant and specialised documents.
Institution websites /NGO websites	Looking at information provided by specialised and dedicated websites, these data were used as references of basis. The difficulties resided in the selection of the most appropriate information and afterward the correlation and interpretation of these data (e.g. date…)	Considered as accurate, the data provided by international organisations (such as the World Bank, United Nations…) are commonly accepted as references.
Bibliographies	Looking at bibliography of specialized publications permitted to find other related references (e.g. authors, institutions, journals…). Bibliographies also gave clues on authors' research strategies (e.g. information sources etc…)	Bibliographies were database of correlated information. Allowing making links between different sources, it provided names of authors, organisations, dates, places etc…It could also indicate whether or not publications were recognized.

2- Literature review

2.1- Sustainability of rural water supply

In the past, programmes and projects of water supply implementation did not consider the nature and history of small communities:

"Implementation followed the same national design criteria and the same technical and social processes everywhere, irrespective of local social and economic conditions. It is hardly surprising that the resulting services were often unsustainable" (Smet, 2002).

Abrams defines sustainability on whether or not water services and good hygiene practices continue to work over time (Abrams, 1998). He specifies that durability should not only focus on technical aspect but should rather make references to services. According to Smet, the specificity of each region suggests that means of getting access to drinking water differ from one place to another. Consequently water supply schemes must be set up and adapted to local conditions. (Smet, 2002).

"*Functionality is not the same as sustainability*" (Carter et al. 2010).

Even if "functionality data" have limited value, they provide a "snapshot" view of whether or not a water supply system is working at the time of inspection. They stay the best indicators to detect inadequacies in service provision sustainability. (Carter et al. 2010).

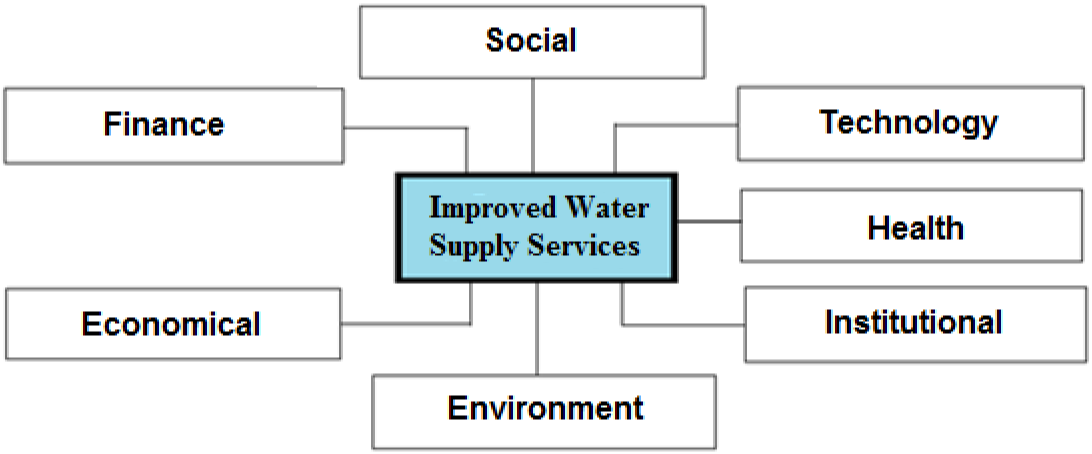


Figure 2.1: Factors influencing water supply sustainability

To analyse rural water supply sustainability, various conceptual frameworks include seven fundamental dimensions: Environmental, Financial, Technical, Institutional (organisational), Socio-cultural, Economic and Health (Parry-Jones et al., 2001). These dimensions are correlated and context specific. There are only few good examples of sustainability in practice because each situation takes a different shape (Lockwood, 2002). According Carter, sustainability is compromised without a real expression of demand. Users will not value and prioritise services that do not meet their needs. If communities are satisfied with their current sources of water then they will not understand the need for another water point and therefore not contribute to maintain the new services. Firstly, the difficulty in implementing rural water supply programme resides in part that different communities have different needs, and also different capacities (Carter, 2011).

Jansz (2011) explains that durability of services is based on interdependence of:

- Capacity (including availability of spare parts, finance for operation and maintenance…)
- Effective management models
- Effective policy and other external supports.

These services are undermined when the effectiveness of one or several of these parameters fails or stops to exist. Secondly complexity of sustainability also resides in its analysis as it must be linked to these four success criteria: Effectiveness-Efficiency-Equity-Replicability. Numerous studies have treated on sustainability of water supply (and sanitation) projects in developing countries and the determinant key factors are:

"*Minimal external assistance in the long term, Financing of regular operation and maintenance by users, continued flow of benefits over a long period"* (Parry-Jones et al., 2001)(p.7).

Table 2.1: The causes of failure to water supply project in developing countries:

The most applicable causes of failure to water supply projects in developing countries
- Inefficient system of cost recovery for maintenance due to inability or lack of willingness to pay fees by users.
- Lack of perceived ownership by users due to lack of community involvement in choice of technology.
- Failure of community to take decision for preventive maintenance (e.g: when members involved have moved away…). Water committees are not well organised and unable to durably manage the systems. It is principally due to inadequate community participation as all sections of communities are not fully involved, especially women who do not participate in project development nor have responsible leadership roles.
- Lack of perceived health benefits from water system. Health and hygiene education are not adequately and sufficiently implemented to raise awareness and change behaviours. This is often confirmed by the on-going use of alternative (non-potable) sources
- Lack of support from government and/or other external stakeholders for implementing effective policy and capacity (e.g: water quality monitoring is rarely done at a regular basis, inadequate training and ongoing support for community…)
- The number of implemented water and sanitation projects is not sufficient to give significant effect of development. The excessive number of users of water supply systems results to rapid deterioration and abandonment of the infrastructures.

Adapted from (Parry-Jones et al., 2001), Warner & Abate (2005), Jansz (2011), Maccarthy (2014)

Maccarthy reports:

"*Long-term sustainability rates in rural Madagascar stay questionable as water supply services stay stubbornly low coupling with considerable challenges for maintaining existing coverage*" (Maccarthy, 2014)(p.13).

2.2- Madagascar profile

a) Environmental context

Located in the Indian Ocean and passed through by the tropic of Capricorn, Madagascar is the fifth-largest island in the world. The country's climate is highly variable but generally the island has two seasons: a hot, rainy season from November to April and a cooler, dry season from May to October. Mean temperatures vary from 16 to 20°C in the highlands. The West coast is warmer than the East coast with a mean maximum temperature of 32°C compared to 28°C. Madagascar is listed among the biodiversity hotspots. As a result of its isolation from neighbouring continents, over 90% of its wildlife is found nowhere else on Earth. The coast of Madagascar is dominated by mangroves and marshes along the west coast, by dunes in the South-Western part and extreme South, and by sandy beaches in the East. However, the diverse ecosystems and endemic wildlife are threatened by human activity and other environmental threats (Kramer, 2017).

Capital : Antananarivo
Official languages : Malagasy – French
Area : 587 041 km^2
Currency: Malagasy Ariary (MGA)
Government: Republic

Figure 2.3: Map of Madagascar

Madagascar is one of the top ten countries most vulnerable to natural disasters. About a quarter of the population live in areas highly prone to cyclones, floods or droughts, climate change and environmental degradation exacerbate the risks. Today the major issues facing by Malagasy people include cyclones, deforestation, soil erosion, endangered species… (World Bank, 2013). Eighty-five percent of Madagascar's rain forest has been lost due to logging and coal-making for household use, slash-and-burn agricultural practices, and illegal exploitation" (WFP, 2016).

b) Socio-Economical context

Over the past two thousand years the island has received waves of settlers of diverse origins including Austronesian, Bantu, Arab, South Asian, Chinese, North Indian and European populations (Ames, 2003)(Gommery, 2011). The Malagasy population is officially composed of 18 ethnic groups who all speak different dialects. Formerly an independent kingdom, Madagascar became British and finally French in 1896. The first republic was formed at the independence declaration in 1960. Since then, the country has confronted repeated political crises occurring every decade on average (1972, 1991-92, 2001-2002 and 2009-2013).

"*Dominated by subsistence agriculture, the Malagasy economy is one of just a handful having experienced stagnation in per capita income coupled with a rise in poverty*" (WFP, 2016).

Agriculture is the backbone of the economy and provides a livelihood for almost 80% of the population (ADF, 2005)(IFAD, 2016). In 2010, 81.3 % of the Malagasy population was reported to be extremely poor living with less than 1.25 USD per day (UNDP, 2013).

The UNICEF Country Programme (March 2015-2019) classifies Madagascar as one of the poorest countries in the world, with a gross national income per capita of $440. In 2015, the island is ranked 158th out of 188 countries with a Human Development Index value of 0.512. This places Madagascar above the average of 0.497 for countries in the low HDI group and below the average of 0.523 for countries in Sub-Saharan Africa.

The industry represents 14.8% of the GDP, much less than the majority of other African nations. The country relies on micro and small enterprises, mostly in the informal sector (Dayo, 2017). Given its rich mineral and natural resources, the country also faces illegal trade and over exploitation. Growth is mainly driven by secondary sector (extractive industry, wood industry, agro-industry and export processing zones) and the services sector (banks, tourism, construction)(AfDB, 2017).

c) Demographic, health and education features

In 2002, a cholera outbreak ravaged the country. In 2017, a plague epidemic kills hundreds of people, in the port city of Toamasina (eastern region) and in the capital.

Table 2.2: Madagascar demographic features

Population (2016)	24 890 000 (with 50.5% of women)
Population under 15 (2013)	47%
Population growth (annual %) (2016)	2.7
Population density (people per km^2) (2016)	42.8
Rural population (2015)	15,727,662 (65% of total population)
Urban population (2015)	8,507,728 (35% of total population)
Fertility rate, total birth per woman	4.4
Birth attended by skill health staff (2016)	44%
Doctor(s) per inhabitants on national territory	1 for 5 000
Mortality rate, infant (per 1 000 live births) (2013)	39.6
Mortality rate, under 5 (per 1 000 live births) (2016)	50
Life expectancy (2016)	65
Total adult literacy rate (2012)	64.5%

(Adapted from WHO, 2015 and INSTAT, 2016)

The country has the world's fourth highest rate of chronic malnutrition. According a World Bank report:

"*Over half of children are chronically malnourished and more than one-fourth are severely malnourished*" (WB, 2017).

A poor primary health care system including insufficient health personnel, lack of medical provisions, long distance and high fees of services are the major obstacles affecting the majority of rural population to access and use services. Limited access to clean water and poor sanitation and hygiene practices are of particular concern, especially given the link with chronic malnutrition (Galasso, 2016). The National Nutrition Damage Assessment Report (DAR) indicates that over $740 million is lost annually as the result of high rates of acute and chronic malnutrition which $400 million is due to stunting. According to current thinking more than 50% (Spears, 2003) of stunting is directly caused by poor sanitation, hygiene and water-borne diseases. (UNICEF, 2016)(p3).

"*For every $1 invested in sanitation, $9 are returned to national economies in increased productivity and a reduced burden of healthcare*" (Hutton et al, 2006).

Almost 12 million of people living in rural areas practise open defecation due to lack of adequate infrastructure. Only 51% of overall population including 34% of rural population have access to improved water sources, with 23% of those in rural areas relying on surface water for drinking (JMP, 2017). The consequences of these many deficits in water management and sanitation are colossal by affecting directly health (especially children), education, environment and productivity of the country (Minten, 2002) (p.4). It is estimated that 10,400 Malagasy, including 6.900 children under the age of five die each year as a result of diarrheal disease. It is reported that 88% of these deaths are attributable to poor access to water, sanitation and hygiene while hand washing with soap reduces the risk of contracting diarrheal diseases by 44% and access to sanitation facilities by additional 32% (WaterAid, 2005).

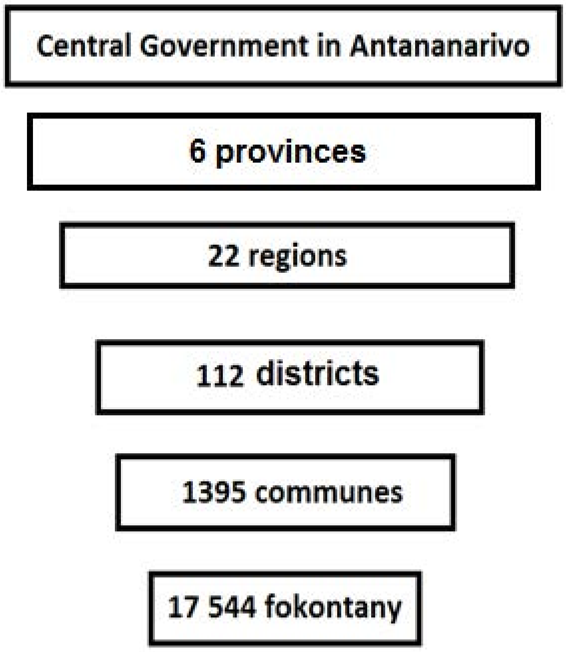
"*Significant and sustained investments are urgently needed to strengthen the health system and to reduce under-five mortality*" (UNICEF, 2012).

An estimated 3.5 million school days and 5 million working days are lost per year due to diarrhoeal diseases. Approximately 1.5 million primary-school-age children are currently out of school and only 3 out of every 10 children who are enrolled complete primary school. The principal barriers to education include outdated programs, poorly trained instructors and low quality of instruction (as two thirds of primary school instructors have not received any formal training), insufficient number of school facilities and increasing costs of education. (UNICEF, 2012).

"*In order to confront the serious situation faced by the people in Madagascar, our country strategy plans remain ambitious despite the limited growth projected during the period to 2015. The challenge remains clear, the need to deliver solutions to the WASH crisis is evident*" (Wateraid, 2010)(p.7).

2.3- Institutions and water sector

Since the Law 2004-001of 17th June 2004, Madagascar is subdivided as follow:



(Figure 2.3: Madagascar decentralized administration)

The province, the region and the district are respectively administered by the "Chief of province", "Chief of region" (or Prefect) and "Chief of district", all nominated by Central Government.

In 2008, the first Ministry of Water is created as water policies were previously under the jurisdiction of the Ministry of Energy and Mines (MEM). It is an indication of the Government willingness to give the WASH sector its due credit. In 2013, the institution is renamed Ministry of Water, Energy and Hydrocarbon (MEEH) and finally Ministry of Water, Sanitation and Hygiene in March 2018.

At the regional level, all the decentralised services of the State are present including the Regional Directorate of Water, Sanitation and Hygiene (Directions Régionales de l'Eau de l'Assainissement et de l'Hygiène or DREAH).

The commune (or municipality) is a local authority of public right with financial and administrative autonomy. The mayor and councillors are elected by direct universal suffrage and freely administer the commune.

The fokontany is the most basic administrative subdivision under commune level. It includes hamlets, villages and sectors and is headed by its President or (Chief of fokontany). Formerly elected by the community members, the Chief of fokontany (or President of fokontany) is now designated by the Chief of district since the Decree N°2009-990 of 2nd July 2009. The inhabitants of the fokontany constitute the "Fokonolona" which can be translated as the Community council.

Malagasy Water Code

The Malagasy Water Code of 1998 stipulates that "Water is part of the common heritage of the Nation. Each community is the guarantor in the framework of its powers" (Article 1) and "Water is a public good in the public domain"(Article 2).

Concerning infrastructure of water supply, the Article 39 stipulates that "Potable water supply and access to collective sanitation of domestic waste water is a public communal service. Auto production does not constitute a public service. However, in case of absence or inadequacy of provision of public service potable water supply in the concerned area, a private service may operate a public potable water supply […]. »

"Access to public water service, whether at collective water points or at individual connections, is paid for. The applicable tariffs must allow the financial equilibrium of system managers and aim for a full cost recovery" (Article 54)

(Source Ministry of Water, Energy and Hydrocarbon, 2017)

JIRAMA, (Jiro sy Rano Malagasy or Malagasy Electricity and Water) is the national para-statal water and electric company supplying 65 urban municipalities. The company is afflicted by operational inefficiencies and lacks the capacity to upgrade its aging infrastructure:

"*JIRAMA's poor performance is partly attributed to high operating costs, uneconomically low water rates, and affordability issues among target customers*" (USAID, 2010)(p2).

In accord with the National Development Plan (PND) of 2015-2020, a grant of 20 million USD loan from the African Development Fund (ADF, 2016)(p.15) has been attributed to the Malagasy Government for financing the Energy Sector Reform Support Programme (PARSE).

According the Malagasy Water Code (Art. 39), NGOs, associations, private operators and local communities can provide and manage infrastructure in rural areas. The main types of water supply infrastructure used in Madagascar are:

1. Gravity potable water supply
2. Protected spring
3. Hand-dug well
4. Artesian well
5. Borehole with hand pump
6. Borehole with mechanical pump
7. Borehole with immersed electric pump
8. Catchment of surface water: dam
9. Rain catchment by roof
10. Piped water distribution to households taps
11. Piped water distribution to public taps

In general, the infrastructure 1, 3, 5 and 9 are more often encountered in rural areas. In urban areas, the JIRAMA uses the infrastructure 2, 4, 8, 10 and 11(Rabenitany, 2009).

2.4- Decentralisation

As a former French colony, Madagascar has adopted a French type of decentralisation. Since independence in 1960, the country has tried different models of decentralisation which were more politically inspired than intended to sustainable service delivery (Annis, 2006). Decentralisation is limited to administrative aspects and capital investment budgets for Public Investment Programmes are still decided at central level :

"*The national WASH investment plan has not been decentralised; the ministry's central staff manages most contract and service tenders. The budget allocated to the recently formed regional offices remains inadequate*. (Wateraid, 2010)."

The authorities and decentralised services depending on their sector ministries are not concerted nor implicated in budgeting or planning decisions (Wateraid, 2010)(p.13). Marcus relates that central government collects 97% of the total revenues while the *Communes* (Municipalities) receive 2 to 3% coupling with important urban bias. The legal procedure is that each *fokontany* (the lowest administrative unit of the national governance system) requests its *Commune* for water (Marcus, 2007)(p210-216).

Theoretically each *Commune* is in charge of its water supply and sanitation development plan. Unfortunately most of them lack funding and staff to apply effective policies. According a Wateraid report in 2005, the 1400 Communes received only 3900 USD per year from central government which is barely enough for basic running costs. A focus group of 1392 Communes carried out by the National Statistics Bureau (INSTAT) revealed that water services are not a priority in Communes' Development Plan. Water is ranked at the sixth position with 6% of allocated budget after agriculture (27%), transport (26%), security (15%), health (14%) and education (10%) (Wateraid, 2005)(p4).

"There is no standardised formula for allocating the bulk of water financing between local administrative bodies." (Wateraid, 2005)(p4).

The Madagascar's water code states that water is a public good in the public domain. Not considered as a free good, water can be managed either by a public or a private entity. The tariffs must allow the financial equilibrium and the full cost recovery of the entire supply system. Malagasy policies are therefore consistent with international norms supporting Integrated Water Resource Management.

With decentralisation, local population should gain more power as accountability for service delivery and maintenance are devolved to community level. The transfer of responsibilities from central government to communities should increase equity, efficiency and local 'ownership' of governance. However in the case of community-based water supply management in Ambovombe (Southern Madagascar), the author Marcus witnessed that decentralisation has resulted in a total disengagement of the state, and ultimately to a disempowerment of the community:

"(In Madagascar) *decentralisation is failing to allow for downward accountability to local institutions in a vertical manner* […] *Local empowerment quickly translated to you're on your own*". Marcus (2007)(p.203).

His article relates the situation when complete delegation of powers to communities, as opposed to a progressive transition supported by capacity building has resulted to increase poverty and worsen water supply in Southern Madagascar.

The author Parry-Jones explains that in majority of African countries, water institutions are generally under-resourced and lack the capacity to accomplish their role. The author gives the cases of Nigeria and Zambia where the absence of co-operation and trust between the different layers of government and NGOs has led to overlaps, conflicts and omissions in water supply services (Parry-Jones et al, 2001).

In Madagascar, there is clearly poor coordination between the State and the community and the lack of adequate resources at all levels worsen the situation. The author Ryan declares:

"*Communities in Madagascar can expect no support from their local government in the event that they have a significant problem with their water service*" (Ryan, 2014)(p.28)

According Marcus, private vendor may only increase the problem as the costs of delivery mechanisms themselves are too high for majority of population. Obviously insights go towards an increase community participation in infrastructure management and finance systems. It is therefore necessary to define the communities, understand their dynamics and boundaries. Marcus adds that water user's groups are essential but need to be re-designed. In some contexts, *communities* may be more efficient at *fokontany* or other levels. In other situations, M*unicipalities* themselves should undertake local management. The p*ower* of water user's group should be able to vary by place according its relationship to the municipality. The author also underlines that the most important goal of the local water user's groups should be political rather than operational because they know where the corruption and other governance blockages are.

"*They need to have the authority to do something about it. To handle the responsibility of ensuring propriety of officials, as they have been handed, they need to be granted the power to censure officials who have done something wrong. At present they neither elect regional state water officers nor hold any judicial sway over them*."(Marcus, 2007)(p.223-225).

In 2010 reports, WaterAid enumerates what they consider as principal constraints for the application of the existing tools, policies and plans of IWRM:

- Institutional instability (during the past three years 4 ministers, 2 general directors, 4 directors), resulting in discontinuity and lack of consistency, variations in priorities and objectives and disregards of former accomplishments;
- Insufficient staff for the Ministry of Water particularly senior technical staff guaranteeing satisfactory programming, monitoring, coordination and giving much required support to Communes, private entrepreneurs and NGOs;
- Failure in budgeting efficiently at central level as decentralised authorities are not associated in preparation of plans and budgets;
- Poor awareness, knowledge and commitment of the different legal tools due to inadequate dissemination.

"*The main obstacles come from the prevailing political tumult which has, among many other things, led in the nomination of a new sector Minister and changes in senior staff at regional, district and municipality levels. Decentralisation, started under the previous government, has basically been dropped. Accordingly, the investment and institutional reform plans under the former and ambitious Madagascar Action Plan (MAP) prepared and implemented by the previous regime has just been discarded*" (Wateraid, 2010)(p.12).

The relationships between local government and civil society are complex and fractious. In some communes there is confounded demarcation, in others, civil society leaders hold office while mayor have little respect despite being elected officially. With decentralisation, there are clear winners and losers for power gain as individuals at the local level. Community-based institutions have benefited some people but have also divided communities (Marcus, 2007).

"*The institutions seeking sustainable water services have undermined equity in accessing existing social norms, classes and kinship relations. The answer is not a return to centralised management. The answer lies in better understanding the state-local nexus (as) there is a mosaic of informal and formal institutions at the local level*" (Marcus, 2007)(p.210-225).

In its 2010 report, the British organisation Wateraid proposes a picture of different stakeholders involved in the country water sector (Annex 2).

2.5- Community management model

By the time of the new Millennium Development Goals (2000-2015), the focus was clearly established as community-driven approach involving partners from local and national government, non-governmental organisations and the private sector. Community management has become the leading concept for implementing water supply in rural areas in many countries around the world (Schouten and Moriarty, 2003)(p.288). It is the case in Madagascar, where community management has been the adopted model for the management of water supply systems in rural communities. (Maccarthy, 2014)(p13).

The International Drinking Water Supply and Sanitation Decade (1981-90) led to further enhancements in technological, social approaches and institutional policies. Experiences learned have proven that to make durable progress, people are the most important factors to consider. Water agencies started to recognise the benefits of involving local people in construction, operation, maintenance, management and financing of their own water systems. Efforts were put on creating ownership on the part of local communities and providing services on demand rather than using the conventional supply driven model. It was the birth of community management. The new vision was that outside stakeholders involved in water projects such as politicians, planners, engineers, sociologists, economists or educators cannot impose a service.

"Effective and sustainable programmes for the management of community drinking water [supplies] require the active support and involvement of local communities" (WHO, 2008).

However despite its popularity, the long-term sustainability of community management model of water systems is less than impressive. Studies have shown failure rates between thirty and sixty percent in Africa and failure rates between twenty to forty percent in Latin American countries (Maccarthy, 2014)(p.2). Lockwood (2002) explains that community management has limits and requires some level of external assistance:

"*There is also a real danger in failing to acknowledge that community management has its limitations. Every year in Latin America tens of millions of dollars are invested in constructing new community-managed projects by a combination of central government funding and international donor agencies, but a significant proportion of these projects will fail to sustain the intended benefits over time*" (Lockwood, 2002).

The researcher Annis states that one of the major reasons for promoting community participation in developing countries is government's inability to build and maintain water supply infrastructure. It is the case in Madagascar where community management became the only alternative after a collapse of all non-essential government extension services. Indeed, the community management fitted with government trend for services *decentralization* in order to transfer responsibilities to lower levels of authorities and ultimately to communities themselves (Annis, 2006).

"*In Madagascar [...] effectiveness of community management of water supply systems has been beset with problems since the mid 1980's. Over half of the existing infrastructure, including wells and piped water supply systems, installed in rural areas are not working properly. Poor management and subsequent failure of existing structures have leaded many communities to abandon improved water points and return to traditional, unimproved water sources."* (Annis 2006)(p1).

In their article, Carter et al. suggest a Conceptual framework for an effective externally supported community based management (See Annex 3).

In many developing countries, collecting water is a women and/or children task which sometimes takes as much energy as the heaviest agricultural tasks done by men. Involving women as determinant actors in water supply projects suggests that local resources are recognised and utilised. Several African countries have developed policies in favour of women participation (e.g: Uganda National Water Policy requires a minimum of half women members within Water committees). However, studies revealed that often it was still their husband who undertook the responsibilities (Parry-Jones et al.,2001)(p.19). The UNDP (2006) reports successes in Indonesia where the empowerment of women (via separate meetings) led to greater participation in water users associations and ultimately pushed them to occupy important positions such as treasurer or secretary (St Jacques, 2009). It has been observed from a case study on gender consideration within Betsimisaraka farmers (the preponderant ethnic in eastern Madagascar), that men generally dominate community decision making. However senior women and grandmothers have the right to speak in community meetings, are respected, and have a role to advise younger people (Catholic Relief Services, 2012)(p.18).

It is important to establish some form of committee or authority in order to manage operation and maintenance at community level. Evidences have shown that the form of the committees is not as important as the prevalence of a dynamic local leader. It is therefore primordial for the supporting agency to analyse and follow the existing power structure as many traditional leaders still play key role in African rural communities. A UNICEF rural water programme evaluation has revealed that committees formed by users themselves were more active than the ones required to be settled as prerequisite for project participation (Parry-Jones et al., 2001)(p.19). Identification of the social structure must include all the different stakeholders by paying particular attention to the vulnerable and marginalised groups. The demand-driven approach comprises the adequate support to communities in creating their own management structures that suits their needs. It is essential to assess the local needs in term of quantity, quality and reliability of water, and determine to what extent the demand is satisfied. The crucial information needed to be gain include:

- Population number and variances
- Location, reliability, safety of water sources…
- Time and duration of water collection

All these data will help to identify the existing barriers for meeting the demand (such as high cost of water, lack of infrastructure, etc...).

"*It is not an intellectual stretch to consider international actors as an integral part of the power relationship, particularly in cases like Madagascar where international and state policies are virtually fused.*" (Marcus, 2007)(p7/30)(p208)

Specialists support the fact that responsibilities must not only be shared between communities and government but should also include a wide range of actors such as NGOs, the private sector, bilateral donors, research institutions, etc...

"*Beyond simply defining roles and responsibilities for each, mutual trust between the community and external actors is essential for the viability of community management*" (St Jacques, 2009).

In order to achieve sustainable services, every stakeholder needs a degree of training to undertake its responsibilities efficiently. It is therefore necessary to build adequate capacity at all levels, but particularly at local levels by ensuring that service delivery and maintenance systems are working correctly. National government need to develop appropriate policies and enabling environment. Communities need to be helped on how to properly manage and maintain water supply systems with limited external support. In partnership with local authorities, donors need to develop skills in participatory approaches in order to increase emphasis in demand responsiveness (Parry-Jones et al., 2001).

2.6- Information, education and communication

Defining and stating objectives for water supply projects is often related to health improvements and time savings for water collection. The project objectives must be clearly defined in order to be measurable and to ensure effective planning, monitoring and evaluation (IRC, 1998).

Flow of information is a determinant factor for sustainable services. If all stakeholders are well informed, decision process is more effective. Performant ways of communication need to be implemented between all levels.

"*A national database held by the Ministry for Water (BDEA) is one key source of sector monitoring information. Recent collaborative efforts with the* National Statistics Bureau (INSTAT) *supported by WHO, UNICEF, WaterAid, and the Ministry for Water are striving for improved sector information and harmonisation with JMP standards.*" (Wateraid, 2010).

Monitoring and evaluation is essential for providing both users and support agencies the adequate kind of information and to guarantee the well-functioning of the system. Each data should be collected and used for a specific purpose. In Shinyanga (Tanzania), community are in charge to collect performance data and send monthly report to local authorities. This is a more cost-effective method than top-down data collection, but more difficult to put in place (Parry-Jones et al., 2001).

In its reports of rural water supply in Madagascar, the analyst Daw underlines the lack of inventories of water supply installations and quasi-absence of information on the work already done. By highlighting the necessity of data collection, he explains that an in-depth analysis of technical available choices must be done in order to make adequate national policies for the sector:

"*Monitoring systems for evaluating performance of maintenance systems, spare parts distribution networks and comparative performance of pump types should be integrated in project design, without which valuable information and lessons will be vanished. Cooperation with groups like WaterAid, Medair, SKAT Switzerland would be worthwhile*." (Daw, 2004)(p.10)

In her survey results of Integrated Water Resource Management (IWRM), the Malagasy analyst Rabenitany summarizes the main obstacles of water supply projects in Madagascar:

Table 2.6: The causes of failure to water supply in Madagascar

The most applicable causes of failure to water supply project in Madagascar
- The difficult identification of user needs. The country is vast and the space dispersion of users is significant.
- Lack of relationship and terms of involvement between the institutions and stakeholders at all levels
- Insufficient technical and financial capacity: Database, water resources inventory which requires additional equipment, counting of use, accessibility of information for stakeholders, operationalization of the Human Resources
- Monitoring is not practiced well enough for quantitative and qualitative water management, management of releases and evaluation of compliance with legal provisions, organization and procedures.

Adapted from (Rabenitany, 2009)

2.7- International donors and NGOs

For its Integrated Water Resource Management (IWRM) development, the increased government engagement was evident as the sector's budget was multiplied by ten from 2000 to 2008. However, rural interventions still lacked a US$ 255 million investment as only US$ 110 million were available. The urban situation was worse with an estimated deficit of US$ 472 million. At the national level, the allocated budget to the sector remained weak and never exceeded 1.6% of the national budget (except in 2008 when it represented 2.38%). The sector is largely financed by external donors. The author Marcus states that the Government assisted by international donors is the only existing mechanism for financing national water supply projects (Marcus, 2007)(p.224).

Between 2000 and 2006, the Water, Sanitation and Hygiene (WASH) sector dependence on external subsidy averaged 65% of the national budget with 32% as donations and 33% as loans. The African Development Bank (AfDB), the European Investment Bank (EIB) and World Bank (WB) delivered loans and United Nations Children Emergency Fund (UNICEF), Japanese International Cooperation Agency (JICA), United Nations Development Programme (UNDP), African Development Fund (ADF) and the European Union (EU) provided donations (Wateraid, 2010)(p.14). Different analysts such as Iannis, and Daw add into the list of donors, international NGOs such as WaterAid, CARE, MEDAIR, Catholic Service Relief (CSR), Hydraulique Sans Frontière …All are considered as the main financers and builders of rural water systems.

By the end of 2019, UNICEF will spend more than 20 million USD in its Water, Sanitation and Hygiene (WASH) strategic plan in order to reach 50% of rural population using improved sources of drinking water (See Annex 1).

Within the context, community management model gave to NGOs and donors opportunity to bypass inefficient Malagasy institutions. Considering the different priorities among the different stakeholders, international lenders (e.g: World Bank, USAID…) saw in community management the appropriate solution for working directly with communities to manage rural water supply. However Annis reports that still not enough time is spent to build adequate capacity within village water committees and consequently cost recovery and maintenance requirements persist inevitably as the recurrent issues not thoroughly assimilated by the communities (Annis, 2006)(p.4). All these inadequacies show the evidences of the high failure rates of most rural water supply systems in Madagascar despite the years of international investment within the sector.

National NGO's like FIKRIFAMA, TARATRA, and Voahary Salama are generally the partners and implementers of water supply projects. FIKRIFAMA, particularly, was the principal implementer of the World Bank project (PAPAEAR) that funded the implementation of hundreds of water supply systems throughout Madagascar between 1999 and 2003. Participatory approaches were used for building infrastructure while promoting management capacity within communities (USAID, 2005). Fortunately, Daw also reports encouraging example on community management in southern Madagascar after its PAPAEAR evaluation (see Operation and Management section). He also enounces additional national NGOs such as SAHA and Frère de Saint Gabriel (Daw, 2004)(p.2).

In its 2010 report, WaterAid describes the diversity of civil society and its evident benefits in the scope of WASH projects. Women's and farmers associations and farmers are common and active in many communities. The church also plays a preponderant role in the island. A high proportion of adherence to both protestant and catholic churches places them as an important social, cultural, and political force reaching out across the country to both remote rural and urban communities. Nonetheless numerous constraints afflict the Malagasy civil society:

- Poor governance, organisational, technical and operational capacities including limited access to information and human resources.

- Limited institutional capacity and knowledge of legal framework leading associations to work in weak structures.

- Difficulties in accessing funds and consequently limited opportunities to act.

These problems limit the civil society in its engagement for implementing local and national policies. The outcomes are:

- Inability to intervene on behalf of rights holders or to call duty bearers to account
- Incapacity to act as a social warning mechanism or contributor
- Low-level of credibility within the communities, state actors or potential financial and technical partners. (Wateraid, 2010)(p.10).

To encompass all these difficulties and in respect to legal procedure, an assessment of national legislation and administrative framework need to be undertaken. A detailed assessment of the different stakeholders is necessary before undertaken any water supply implementation projects.

In accordance to the National WASH strategy and Outcome 3 of the UNDAF2015–2019, the UNICEF Water, Sanitation and Hygiene (WASH) Programme promote the implementation of sustainable models such as the integration of WASH, health and nutrition strategies through delivery and use of WASH packages in schools and health and nutrition centres. The main partners of the WASH programme are the Ministry of Water, UNDP, NGOs, users' associations, traditional leaders and local authorities. (UNICEF, 2015)(p.6).

2.8- Private sector

The difficulty of many governments in providing sustainable water services has placed hope in private sector involvement. Unfortunately still many projects fail to identify appropriate strategies or mechanisms for adequate partnership (Parry-Jones et al., 2001). In his Public-Private Partnerships strategy, WaterAid positions the private sector as key actor for bridging the sector's capacity gaps and building a degree of sustainability in WASH service provision. Apart the national utility company JIRAMA, two-thirds of service providers are small to medium operators with less than 10 employees and all essentially working in the capital. The key blockages to effective private sector involvement are:

- Poor accessibility of information especially outside the capital city, about programmes, projects, calls for offers , access of sponsoring from different institutions
- Lack of technical and professional support for capacity building and training (Wateraid, 2010)(p.13).

Annis relates the scope of piped water supply systems managed by public-private partnerships in Malagasy rural communities that shows great potential for sustainable water delivery services. Nevertheless household self-supply methods continue to fill the gaps in water service provision in both urban and rural areas (Annis and Razafinjato, 2012). By definition, "Self-supply" is a water supply system committed to private families or neighbourhoods (i.e. small groups) and financed by their own investment. The self-supply concept is motivated by households' interest of accessing affordable and convenient water supply system(s) independently of public investment in hardware.

In east Madagascar, the locally manufactured Pitcher Pumps (or Pump "Tany" meaning "ground" in Malagasy) are handpump systems widely provided by the local private sector. They enable households in accessing shallow groundwater. The market has reached a level of maturity and scale for many decades. More than 50 small businesses manufacture and install a system for about US$35- 100 which is a lower price than a connection to the piped water supply facility (~ US$ 300). Currently more than 9000 of these systems are estimated to be functioning in the eastern port city of Toamasina. This market is assumed to be the most important documented example of sustainable and unsubsidised household handpumps market in sub-Saharan Africa. However the market is totally informal and neglected (MacCarthy et al., 2013).

It is worthy to note that several African countries (e.g: Mozambique, Uganda, Tanzania and Nigeria) are now manufacturing public domain handpumps (such as the Afridev and the India mark III). Unfortunately, these locally manufactured pumps are often of poor quality and nearly always more expensive than imported ones from India and/or Pakistan. Indeed, these countries have advantages of economy of scale thanks to a more highly developed industry and competition that keeps the prices low (Parry-Jones et al., 2001)(p.15). Later in this paper, different authors also make references to different private companies all involved in water provision sector either in retail, manufacturing or consultancy.

2.9- Health

It is commonly proven that long-term results on health improvements do not only come from water supply improvements. Indeed, water contamination can emanates from multiple routes (See “Route of diseases”, Annex 3), thus low cost and households water treatments are of capital importance in developing countries. Purification methods include pasteurization, filtration, chlorination and ultraviolet disinfection (Brikke, 2003 p.71, Burch & Thomas, 1998, p.1). In August 2001, CARE Madagascar launched the project SWS (Safe Water System) to increase households access to water chlorination and safe storage in remote rural communities of eastern Madagascar. Community-based sales agents were supplied with both diluted chlorine solution, with the brand name *Sûr'Eau*, and jerry cans with taps. The article relates:

- Almost all villagers were aware of the household disinfection product
- About half of the population was confirmed to use Sûr'Eau
- Jerrycans with taps were only used by a minority of the target population (Ram, 2007).

Households may collect water from different sources for diverse purposes. In this fact contamination of water can occur between the source and the point of consumption. In the other hand, studies have shown that increasing domestic water usage improve health (See annex 6):

“*The use of increased quantities of water have a larger impact on the burden of disease than improvements to water quality at the source*” (Maccarthy et al., 2013)(p.425).

Providing sustainable water supply system is only one element of a project objective. As we discussed earlier, the reason why facilities are not maintained by community is because people usually prefer to return to their traditional water sources after a breakdown. This may significate a poor understanding of relation between dirty water and diseases but especially a lack of attention of technology preferences of community. It is primordial for external agency to join hygiene promotion and maintenance training using participatory approach in order to determine the wants and the needs of users. The solution for better acceptance and therefore improved sustainability could lay on upgrading traditional sources and promoting combined alternatives such as rainwater collection in conjunction with handpumps (van Wijk, 1987). To work effectively with communities, team project needs to be flexible by adapting adequate participative approaches, for instance by using PHAST tools for different situations (Parry-Jones et al. 2001)(p.23). Assessment of hazards and potential risks of microbial contamination is crucial for any water project implementation. Hygiene behaviour and sanitation evaluation implicates to know:

- The methods of collection and storage, quantity and principal water purposes
- The incidence of diarrhoeal diseases on population
- The use and access to improved latrines

2.10- Technology

Generally depending on low-cost technologies for groundwater extraction or rainwater collection, some types of household water supply (or self-supply) technologies include:

- family wells (which can be hand-dug or mechanically drilled)
- water-lifting devices (which can range from a simple bucket attached to a rope, to a manually operated, electric or fuel-powered pumps),
- rainwater collection arrangements
- Household water treatments, which is generally done through boiling, filtration or disinfection.

Table 2.10: Factors influencing the selection of community water-supply technology

Technical factors	O&M factors
-Demand present and future consumption patterns) versus supply -Capital costs -Extension capacity -Compatibility with existing water supply systems -Comparative advantages -Technical skills needed within or outside the community	- Dependence on fuel, power, chemicals -Quality and durability of materials -Availability of spare parts and raw materials -O&M costs -Compatibility with users' expectations and preferences (men and women) -availability of trained personnel within the community -availability of mechanics, plumbers, carpenters and masons within and outside the community -potential for local manufacturing -potential for standardization

(Adapted from Brikke, 2003 and Hofkes, 1983)

The acceptance of a technology within a community is a crucial sustainability factor. In Zambia, people were not interested in handpumps as they had seen so many broken down pumps in the area. Instead, they wished assistance for hand-dug wells furnished with windlass and bucket, which they knew how to maintain. In South Africa a project report facts that women do not like using Monolift pumps because their breasts get in the way when they are leaning over to rotate the handles of the pump (Parry-Jones et al., 2001)(p.19). An assessment of the water supplies historical gives indication on strengths and weaknesses of different technologies in order to formulate recommendations for more potentially viable alternatives. This help to understand why a system was not sustained (e.g: poor management, lack of maintenance and/or skilled personal, poor quality materials and equipment, unwillingness or unaffordability to pay…). An in-depth analysis of available technologies (including methods of installation), actual state of facilities, durability of materials and recurrent dysfunctions, water treatment methods…is required in order to determine the most suitable solutions in terms of costs, liability and preferences.

Along the coast, traditional water sources in the form of shallow dug wells are very common as groundwater is relatively easy to reach. Traditional water supplies need to be carefully studied before opting for new technology implementation such as deep drilling. In some cases improvement of existing infrastructure is more adequate than introduction of new technologies such as handpumps which involve irremediably O&M and spare parts distribution mechanisms. The author Daw states that hand dug wells are clearly viable and cost effective method of drinking water supply in coastal areas.
However to improve and protect these water sources, lining, handpump, platform and drain

are necessary. Besides water quality for dug wells (both chemical and bacteriological) must be monitored.

Suction pumps and direct action pumps, which are relatively cheap and easy to maintain, should also be considered.

Local low cost well construction, household level bio-sand filtration, rainwater harvesting are some of the water supply alternatives attempted by the Frère Saint Gabriel organisation in urban fringe of Toamasina (eastern Madagascar). They are implementing community based water supply and sanitation projects and are supported by WaterAid and UNICEF.

Furthermore there is great potential for rain harvesting methods in eastern areas as rainfall rate is high and spread over a long period during the year. (Daw, 2004)(p.4,9,10,17,49).

2.11- Environment

Usually, handpumps level of abstraction does not have effect on the long-term depletion of groundwater. Though in some cases, some aquifers can dry up very quickly due to poor properties or simply because of technical reasons such as poor well siting techniques, inappropriate well development or screen blockages due to bad design (e.g missing gravel packs…).

Madagascar has abundant water resources. Rainfall rates average 1 500 mm annually. By considering the reserves of underground water, the island has a potential provision of 18 500 m^3 per person in 2016 (for 25 600 m^3/person/year in 2009) (Rabenitany, 2009). It is four times the value of the indicator in France. Yet the water exploitation index is less than 5% (compared with 26% in neighboring Mauritius or 65% in Morocco). A country is considered as "water-stressed" when its potential supply of water is less than 1700m3/ person/year. It is "water-scarce" when the supply of water is lower than 1000 m3/ person/year (UNDP, 1998). Although Madagascar has satisfactory rainfall, water resources are unevenly distributed. Water resources are abundant in the North and the East regions but are scarcer in the south. Furthermore more than 90 percent of annual precipitation occurs during the November to April period (see Annex 6), and the precipitation from May to October is less than 150 mm/year, drier than Morocco. Since precipitation between April and October is very low, it is necessary for Madagascar to develop storage capacity in order to transfer water collected during rainy months to dry months (WAVES, 2015)(p7). However even if water is abundant in the East, it is increasingly polluted (Rabemanambola, 1997)(Minten, 2002)(p.5).

"[In] *Toamasina, on the north east coast of Madagascar, groundwater has been contaminated by industrial pollution*." (Daw, 2004)(p.4).

Furthermore, chemical composition of water can affect durability as aggressive water accelerates the corrosion of metal components. Chemical composition can also have impact on sustainability in terms of taste, colour and smell acceptability by users. Aesthetic factors must not be underestimated in risk of rejection by users. Even if the bacteriological quality of water from handpumps is often qualified as good (i.e with no faecal coliforms) this may not always be the case if the facilities are badly installed (e.g bad drainage and infiltration of surface water, installation close to pit latrines with soils with high transmitivity…). This suggests the necessity of assessing the reliability of the water sources such as: quantity of water (availability and accessibility of aquifer), quality of water (chemical composition, taste, and odour), and potential risks of pollution…

2.12-Drilling techniques

Over the past decade, several manual drilling techniques have been introduced in Madagascar. Firstly "hand-augering" method was introduced followed by "well-jetting" technique initiated by the organisation MedAir in 2004. "Rota-sludge" drilling method is introduced by the Practica Foundation in 2006. Today, the company Bushproof use the hybrid "percussion-jetting-rotation" manual drilling technique. All of these technologies have played important role in increasing access to groundwater in rural areas of Madagascar, however none of them have reached yet scale of unsubsidised Self-supply market (MacCarthy et al., 2006)(p.426).

Over 2 000 manually drilled wells have been built using these techniques, more than 90% of them were financed by WASH projects and 63% were drilled by private enterprises. Even if factory slotted casing is not readily available, the search for low-cost solutions should not push WASH projects away from higher standards of installation with respect to diameter, casing quality, drilling fluid and well development.(Danert, 2015)(p.14). Nowadays, the trend is the use of plastic rising mains and other down-hole component to extend handpumps spanlife in aggressive water. (Parry-Jones et al., 2001)(p.18). According to Maccarthy, the coastal areas of the island have shallow aquifer and sandy soils which are appropriate for manually drilled wells and suction pumps that are already commonly used by households. (Maccarthy, 2013)(p.426). The author Danert confirms that:

"*The east coast of Madagascar and the western sedimentary areas have great potential for manual drilling*." However "*Some issues have been encountered in siting manually drilled wells for schools which were elevated and therefore not always appropriate*" (Danert, 2015)(p.6,14). (see Annex 4).

Daw also recommends water jetting, auger drilling and hand sludging techniques for *these* areas characterised by shallow aquifer (Daw, 2004).

2.13- Handpump technology

In Africa, handpump has been the most common technology for rural water supply since the early 1980's. However, handpumps fall very often into disuse rapidly after installation and service sustainability continues to be an intangible goal for numerous projects. According to the Rural Water Supply Network, it is estimated that only two out of three hand-pumps installed in developing countries are working at any given time (RWSN, 2010). In the IRC Symposium of 2010, Carter says that several causes contribute to service failure but the adequacy of financial flows for covering recurrent costs is vital. (Carter et al. 2010). Again, Parry-Jones highlights that the major causes for handpump project to fail are linked to a problem of need and demand as people quickly return to their traditional sources when infrastructure breakdown:

"*In Chimbonila, Mozambique, people are choosing not to maintain handpumps, even though they have access to spares, because water supply is not their number one priority for their scarce resources*." (Parry-Jones et al., 2001)(p.19).

The RWSN report estimates Madagascar with the highest rate (90%) of handpump functionality among 20 countries in sub-Saharan Africa (See Annex 3).

Table 2.13: Standardised pump varieties by country

Country	Type of Standardisation	Standardised Pumps
Madagascar	Endorsement	Tany, Vergnet, India Mark II, Canzee
Malawi	Endorsement	Afridev, Malda
Mali	Regulation	India Mark II, Afridev, Duba

(Abstract from Handpump standardisation in Sub-Saharan Africa by MacArthur, 2015)(p.7)

The Canzee (Direct action) Pump was initially introduced by the international organisation MedAir after a cyclone in 2004. A commercial market for this direct action pump was later established by a national company Bushproof, just after this period (Mol et al., 2005). However the market for the Canzee Pump in Madagascar has been limited almost exclusively to donor-supported projects (Maccarthy et al., 2006). Similarly to Medair pilot project in south coastal areas, Daw encourages the replication of use of direct action pumps in other identical areas for household water supplies (Daw, 2004)(p.10).

Suction pumps are the most common handpumps around the world because there are cheap and easy to maintain. Located above the ground, the wearing parts are easily accessible and furthermore water is quickly delivered thanks to a large cylinder diameter. The accessible depth is limited to seven meters and priming (adding water into the cylinder) is needed to make the pump work. This increases the risks of water contamination. Also its use is limited to 50 people per day unless frequent repairs and replacements become necessary (Skinner & Shaw, 1999).

The author McCarthy reports that the locally manufactured pitcher (suction) pump or pump “Tany” is commonly sold in Toamasina at an accessible price of US$ 35 to 100. This includes installation with price variances according well depth. Families typically paid themselves the full price of these suction Pump systems without subsidy. Maintenance and repair costs are generally shared by the families using the system. After a survey done to 53 households, half of families said they had consequent repairs or upgrades after one year of use. This includes: well casing pipe addition or replacement (9%), replacement of pump head (4%) but replacement of the leather pump valves is the most recurrent problems as it is required every few months. Less frequent minor reparations include replacement of well screen, well pipe cleaning due to sand infiltration and minor repairs on pump head such as nut, bolt or handle replacement. Generally done by local technicians, replacement of leather valve costs 2 to US$ 6. 25% of respondents reported doing their reparation themselves and 23% others planned to purchase a new Pitcher suction pump system. Also, some concerns have risen about suitability of these handpumps after the detection of lead poisoning from the components. (Maccarthy, 2014)(p.96)(Danert, 2015)(p.14). Moreover majority of pumps need to be prime by adding water through the top of the piston valve to make it functions. Pumping rates ranged from 4 litres/minute to 11 litres/minute. All of this suggests numerous potential entry points for improvements of manufacturing and installation methods of the pump Tany (Maccarthy, 2014)(p.viii-96).

"*The rope pump has been promoted in Nicaragua since the 1980s and has gaining popularity. It has frequently suggested that the pump has a great future in other countries with similar economic conditions [...] There has also been limited technology transfer to Madagascar, Angola, Zambia.*" (Parry-Jones et al., 2001)(p.17)

The Rope Pump was first introduced in Madagascar in 2000 by the national NGO Taratra (with support from the Swiss organisation SKAT), and later by other international organisations (Daw, 2004). Based upon the original design from Nicaragua, The Rope Pump is now manufactured by several local workshops throughout the island including Atelier T+ in Betioky, South Madagascar. This confirms its growing acceptance in Madagascar, especially in areas with shallow groundwater table conditions. Case studies in Nicaragua have shown that all users, even those with donated pumps, carry out their own maintenance. Relatively cheap (around US$110) all parts can be manufactured and repaired locally (WSP, 2001)(Parry-jones et al., 2001)(p.17). After a visit on field, Daw reported the great performance of one rope-pump after 3 years of relatively intensive use by 50 households in southern Madagascar. However one other rope-pump needed replacement of pistons after one year of use by 40 households. He says:

"*Locally manufactured, the rope pump presents very promising opportunities in coastal areas with shallow groundwater level such as the city port of Toamasina* (north east coast of Madagascar)" (Daw, 2004).

Considering its simplicity and its accessible price, some issues on water quality seem to persist because of some gaps in the design allowing some risks of contamination. However studies from Nicaragua show that rope pumps lower coliform concentration by 60% when compared to traditional bucket wells. (Parry-Jones et al, 2001) (p18).

The author Daw also reports its visit of nine India Mark III handpumps installed by UNICEF, in south-Madagascar during mid-2001. Between 30 to 100 households were dependent on each of the pumps and 8 of them did not need any repairs since installation for about 3 years. This was excellent performance. All the pumps were in relatively remote locations with difficult access. Generally environment around the pumps was clean, with fencing and access gate. At some sites, repair of fencing was needed after damage from the last cyclone. However some pump sites showed problems of waste water disposal. (Daw, 2004)(p.17)

Daw adds that Vergnet pumps were also installed in the area on deep drilled wells and have functioned well. However as they were recently implemented their long-term performance and costs analysis is not pertinent.

Furthermore in 1994, 150 (India Mark II) handpumps are implemented under the UNICEF assisted AAEPA project in south Madagascar. Ten years later (in 2004), Daw also reports that these drilled wells with IM II handpumps have proven to be viable rural water sources (Daw, 2004). According Parry-Jones et al. the India Mark II (deep well) has a working lifespan varying from 18 to 25 years (Parry-Jones et al., 2001)(p 16).

2.14- Operation and maintenance

"*No pump should be installed unless a proven handpump maintenance system is also established to support it*" (Mudege, 1993), "*It is the system which keeps the technology functioning which is important, not the actual technology.*" (Parry-Jones et al, 2001).

When responsibilities of maintaining handpumps have been delegated to communities, this concept took the name of VLOM for Village Level Operation and Maintenance. The VLOM idea was firstly dedicated to hardware aspect by introducing new handpump designs (e.g: India Mark III or Afridev) considered as easier for communities to maintain. Even if decentralization of maintenance is definitely more adequate for improving services, it has been noticed that communities typically lack the capacity to manage their own services without any external support.

Availability and quality of spare parts are the main factor influencing the suitability of a particular technology especially in unstable economies where inflation and the availability of imported goods and spare parts are difficult to predict. Before opting for a technology, the mechanism for supplying spare parts must be evaluated and assured. In parallel to that, the availability of raw material and the potential for local manufacturing and standardization should also be investigated. Indeed, the issue of spare parts often arises only after the technology has been selected and installed, which puts sustainability at risk. Different issues can appear such as buying large stock of spare parts that may only asphyxiate the private sector involvement and therefore affecting the long term sustainability (e.g: in Ethiopia where Oxfam purchased for ten years of Afridevs spare parts). In Mozambique, the issue was more on willingness of buying spare parts rather than their unavailability (Parry-jones et al. 2001)(p.12). The wise selection of handpumps is therefore necessary in order to develop an adequate spare part distribution mechanism (See Annex 8).

Table 2.14.1: Categories of hand pumps

Pump type	Depths (m)	Yields (L/min)	Cylinder location
Suction pump	0-7	24-26	Above ground
Direct action pump	0-25	26	Underground
Deep well pump	> 100	11-17	Underground

(Adapted from Skinner and Shaw, 1999)

In 1994, The project India Mark II (AAEPA) pumps installation was supported by UNICEF for its operation and Maintenance (O&M) with supply of spare parts. Over the years, the project has undergone several reorganisations. Evaluated in 2004, Daw reports that the spare parts distribution of the India Mark II project (AAEPA) was subsidised and not well organized for example some stock was kept by the mayor, others by the management committee and in some cases the replacement of broken parts waited until the regional authorities visited. In addition, the handpumps lacked a country level distribution network. Similarly, the project (PAEPAR) for the vergnet pumps implementation, the cost projection for O&M was too high and consequently could not be fully met by the present users participation. However some issues related to supply chain of spare parts started to have a clearer definition (with at least two established national level dealers for IM- II and Vergnet handpumps, SMEF and SOMECA (Daw, 2004)(p.1,8,33,49). The author explains that:

"*The long-term O&M strategy for the PAEPAR Project of Vergnet pumps seems to be dependent on establishing decentralized pump technicians within user communities supported by a network of spare parts dealers, managed by individual water committees around individual pumps. No institutional arrangements were evident for ensuring the sustainability of the overall system"* (Daw, 2004)(p.8).

Some design criterion for handpump usage advices 250 people per pump per day. However, in practice the number of handpump users is generally much higher because of the lack of water sources in rural areas. Studies from Zimbabwe have shown that pumps installed for schools and clinics broke down more often.

Spare parts can be divided into three categories:

Table 2.14.2: Spare parts categories

Frequently needed	Occasionally needed (every 6 months or every year)	Major rehabilitation or replacement
Accessibility should be as close as possible to the village (shop, mechanic)	Accessibility can be at a nearby major centre	Accessibility can be at the local or regional level, or at the state capital

Several countries have chosen to standardize the choice of technology. This choice has positive as well as negative aspects, which should be carefully considered before applying such policy. A principal guideline of the VLOM concept is that the supply of spare parts can be improved if the parts are manufactured within the country of use. Visscher (2006) suggests that this clearly shows that VLOM technology also needs an enabling environment that often has to be created by the government (Visscher, 2006)(p.30).

Table 2.14.3: For and Against standardization

For	Against
- Standard products allow a "guaranteed demand";	- The technology does not fully respond to the needs and preferences of users;
- Storage and supply are easier thanks to the inexistence of multiple brands	- The market is closed to new, innovative and cheaper technologies;
- Prices and market of spare parts are easily determined;	- Little incentive for private and research sectors to get involved
- Increase users' familiarity with one type of technology	- Limitation of price competition and inhibition of optimization;
- Personnel training can be standardized	- Potential conflict(s) with donor policies

(Adapted from Brikke, 2003 and Smet, 2002)

According Daw:

"*Pump types should not be mixed up in the same geographical area in order to keep O&M logistics simple*." (Daw, 2004)

Even if supply chains in Africa are still poorly developed, the private sector should be encouraged to get involved in supply. In parallel, external support agencies that have established supply chains should adopt exit strategies (Parry-Jones et al., 2001)(p.22).

A centralised maintenance system based on breakdown repair is always costlier in travel and logistics. Effort should be done in implementing decentralised system based on preventive maintenance as repairs need to be programmed in advance by constant monitoring. However, decentralized maintenance system needs a large number of staff, working part-time in many locations. This not necessarily involves important expenditure if preventive maintenance and monitoring are done regularly. A detailed financial analysis of O&M system is necessary to identify the activities with consequent costs. Cost information and maintenance records will give pertinent indication on the usage of spare parts and lead to more adequate stocking. These data will also help to rationalise dealer network in developing a more viable distribution system.

Subject to the findings of Daw's studies:

“*It should be possible to make the system more cost effective with partial decentralisation, which would cut down travel costs and increase salaries. A study of the exact locations of pumps would be needed to consider the locations of additional centre/s from which part-time technicians could work. Considering the fact that the maintenance workload is fairly low (248 maintenance interventions, over 27 months, for 144 pumps, translates to 0.77 interventions per year per pump), part-time decentralised technicians (with some existing means of livelihood, but looking for additional earnings) could be considered to minimize the expenditure on salaries.”* (Daw, 2004)(p.32)

2.15- Financing and cost recovery

“*The cost recovery system is the most critical and potentially weakest, link to project sustainability*” (Carter et al., 1996).

The capital costs of handpump projects are usually funded by donors, governments or NGOs, as communities do not have sufficient financial resources. Nonetheless majority of projects request the communities to contribute towards capital cost. According WaterAid communities should not be provided with handpumps unless they are willing and able to make a significant financial contribution. In fact functioning mechanisms for communal funds recovery are indicators of community commitment. They are evidences that water systems are demand driven and have tangible economic value to rural communities (Jansz, 2011). Today WaterAid requests an arbitrary minimum of 2% of the capital cost. According to Daw, the cost of an 80 m deep well was about US$ 32 000 (or 128 million MGA) and the cost of the Vergnet pump was about US$ 2 000 (or 8 million MGA)(Daw, 2004).

Rather than cash, contribution can also take form of labour or material. This will reduce the required capital cost, increase ownership feeling and management commitment. Unfortunately all of this is in direct contradiction to the principle that communities should pay for the ongoing maintenance of their handpumps (Parry-Jones et al., 2001). Annis states:

“*Madagascar failed to develop or implement adequate financial management schemes to collect money from community members for routine maintenance and purchase of spare part*s” (Annis, 2006).

The author Daw is more optimistic by relating some examples from southern Madagascar where communities pay the majority of the costs of the O&M system. During the implementation of handpump projects, the World Bank worked in partnership with the local NGO Taratra for doing the “sensibilisation”. This included initial contact with communities, assessment of willingness to pay and establishment of Water Committees. A community needed to collect 30 000 MGA before drilling could start. Funds were managed by the Water Committees and kept at the local rural banking network (SECAM). Most Water Committees were quite active. Collection of funds for O&M was generally good despite the recent cyclone of 2004 that caused financial issues affecting collection. Households’ participation records were readily available. Collection for maintenance ranged between 100 to 200 MGA per month and per household. The reported basis cost data of India Mark II handpumps were:

- **Cost of O&M per pump per year = MGA 74 766 (Roughly US $ 37.30)**
- **Receipts (from communities) per pump per year = MGA 57 875 (Roughly US $ 28.90)**

The community participation met 77% of total O&M costs of the handpumps. The cost of spare parts represented only 9% of total cost of O&M.
However, this was the result of direct subsidy of the O&M system including free spare parts provided by UNICEF. The maintenance was done by three technicians only when facilities broke-down. The remaining cost of the O&M system was high and principally comprised

travel and logistic costs since maintenance service was centralised in a distant locality. The more distant handpump was located 219 km away or at 8 hours driving time from the base. This obviously raises travel and other costs. (Daw, 2004)(pp.6, 17).

"*The remoteness of some rural communities in Madagascar is particularly pronounced*"
(Danert, 2015)(p.14).

Communities are rarely trained on simple accounting tasks and frequently do not have access to banks or any safe places for keeping funds. Many projects fail to look at the real cost of maintenance of handpumps. Even if Water Committees are often instructed to regularly collect water fees, they usually have no idea of what the implicated costs are. Estimates from Nicaragua indicate that a rope pump only costs a maximum of US$10 per year and usually less than US$5. However India Mark II can reach an estimated US$59-107 per year. (Parry-Jones et al., 2001)(p.21). The usual revenues collected by communities (around US$30-40 per year) may be enough for minor repairs, however these amounts are insufficient to cover the full life cycle costs estimated about 7 times this figure. Carter underlines that too often mismatches persist to exist between service providers' aspirations and communities' ability or willingness to pay the full costs of services. Until this gap is bridged, sustainable handpumps services will remain a dream. (Carter et al., 2010).

The financial scheme should be developed in consultation with the different stakeholders and especially with due consideration to the marginalised groups. Future users are the ones who will pay the tariffs, they are therefore the ones who will maintain the services. Accurate cost estimates are essential because if tariffs are too low, revenues will not be sufficient for covering the different costs and fail to ensure system sustainability. In the other hand, if they are too high, some households will not be able to afford water with the risk of exclusion of the poorer groups within the community. In their estimates for demand of improved water services in Madagascar, Minten et al. highlight that even small changes would have large effects on water use for the poorest as a consequent part of the population would not be able or willing to pay for improved water services (Minten et al., 2002)(p.18).

Budget needs to be established including capital cost, recurrent costs for maintenance (spare parts and availability) and administration. Assessment of financial management capacity of communities is therefore necessary. The development of a cost recovery system will suggest method and time of collection (who, when and how fees will be collected, as well as measures for non-payment). Enforcement of rules and regulations is usually the responsibility of water committee, through the charging of some sort of social sanction or fine. Finally, transparent accounting of community funds is essential in effective cost recovery schemes. Communities can use cash books that show all income and expenditures for the maintenance of the water systems. Names and the amount of contribution can be made public in order to insure equity, transparency and efficiency in finance.

One of the difficulties with this kind of study is that sustainability by definition suggests having a long-term view. However, most of the available literature on handpump evaluations has been carried out either during or at the end of the donor project cycle (usually 5 years or less after implementation). This does not provide a complete assessment of the long-term sustainability scenario. Also much of literature focuses on positive rather than negative aspects. Even if it is understandable, this does not provide an objective perspective of what the reality is (Parry-Jones et al, 2001)(p.25).

Table 2.16: Research questions

CONTEXT	RESEARCH QUESTIONS	COMMENTS	METHODOLOGY INFORMANTS	INFORMANTS
SOCIAL/COMMUNITY	1- How many people live in the locality?	To determine the need and the demand	-Semi-structured interview	-Fokontany chief and/or The Mayor
	2-What is the community organisation in term of water supply management? Is there a water committee in place? (If Yes, need to assess water committee organisation: Who are the members? How do they work? Do they have a legal status? How is the water committee settled? Who are the members? How do they work? How often do they meet? How do they communicate with external teams or external institution? Way and frequency of exchange? Is there any training programme?) (If No, need to assess local competence to manage: Is there a legal or traditional chief? Is there a women committee in place?)	To understand the organisation of the community in term of water services To determine the need to assess local competence to manage, to define individual responsibilities, training planning, cleaning schedules… Assessment of women involvement Determine ways of communication between stakeholders	-Semi-structured interview -Focus group discussion	-Fokontany chief and/or The Mayor (legal and/or traditional Village chief), MWP -Entire community

SOCIAL/COMMUNITY (suite)	3-To what extent is users' satisfaction?	To assess the need and demand Community satisfaction can be assessed by observing the number of users and the frequency of utilisation	-Observation -Semi-structure interview - Focus group discussion	-Users - Fokontany chief, Mayor -Entire community
	4-Where (else) do people use to collect drinking water?	Localisation, accessibility and convenience of water sources. Can water be collected at any time (e.g. at night…)? Is there any security issues? To know if people use several sources of water	- Transect walk, GPS (community mapping) -Focus group discussion	-Women, Entire community
HEALTH	5-Is there any health service(s) in the community?	To know how are community members dealing with health issues	-Semi-structured interview -Focus group discussion	-Fokontany chief -Women, Entire community
HEALTH (Suite)	6-How much water is collected and used per household for the daily domestic uses such as drinking, cooking, personal hygiene and laundry?	To assess the need and demand	-Observation -Focus group discussion	-Women
	7-Do people have health issues (presumed) related to water? How often?	To determine the consequences and ampler of water issues on health (WASH practices such as hand washing, waste management and contamination risks…)	-Semi-structured interviews -Focus group discussion	Doctor(s) -Women
	8-How do people collect, transport and store water?	To determine hygiene awareness and other sources of water contamination.	-Observation -Semi-structured interviews	Women Entire community

	9-Is there a hygiene sensitization programme in place?	To determine the eventual setting up of hygiene sensitization programme	- Semi-structured interviews -Focus group discussion	-Mayor, Fokontany president, MWP -Women
ECONOMIC/FINANCE	10-Is there a financial participation relating to the capital cost and/or the maintenance cost? (If Yes, What amount? Who is responsible of book keeping and accounting? How is money collected? How is it kept safe? Who checks it is not misused? At what frequency?) (If No, How are you funded?)	To determine willingness to pay To understand existing payment system(s) (amount, time, transparency, affordability, acceptance of all community members…) To assess adequate system(s) of funding for financial sustainability	-Focus group discussion -Semi-structured interview	-Women, Entire community -Fokontany president, Mayor, MWP, other profesionals (officials and NGOs…)
ECONOMIC/FINANCE (Suite)	11-What amount from their disposable income are they willing to pay towards the existing water service and whether they would pay more if the service were improved?	To determine main sources of income and seasonal variations that may affect willingness to pay	-Focus group discussion (seasonal calendar) -Semi-structured interview	-Entire community, women - Fokontany chief, Mayor
	12-What are the costs involved into a complete installation (capital and running costs e.g. materials, maintenance…)	To produce a list of materials necessary for implementation and maintenance To determine the costs of materials and maintenance	-Semi-structured interviews	-MWP, NGOs, suppliers…

TECHNOLOGY	13-What is the history of water supply systems into the community (What technologies have been used before and now to get water?)	To know historical of water systems (recurring problems etc…) To know if actual technology is suitable and reliable To know where else people use to collect drinking water	-Semi-structured interviews -Transect walk	- Mayor, Fokontany chief
	14-Why this particular technology is preferred rather than others? What are the types of hand pumps available in M/car that are suitable for the local ground characteristics	To know the advantages and weaknesses of available technologies	Semi-structured interviews	- MWP, NGOs
	15-What are the available resources in term of workforce and materials? Spare parts, cleaning tasks	To know what resources are available on the field To know the reliability of supply chain or the need to put in place (e.g. spare parts, training sessions…) To assess local competence to repair	-Semi-structured interviews -Focus group discussion	- Fokontany chief, Mayor, MWP -Entire community, women
TECHNOLOGY (Suite)	16-What is material's span life (e.g. recurrent dysfunction(s), corrosion on materials, solidity…)	To determine the recurrent dysfunction(s) and the need to put in place a reliable supply chain and/or regular maintaining services	-Semi-structured interviews	- Fokontany chief, Mayor, MWP
	17-What is the actual state of repair?	To assess the local competence to repair, the need of a supply chain for spares and/or external support	-Observation -Focus group discussion - Semi-structured interviews	-Entire community, women -Fokontany chief, Mayor

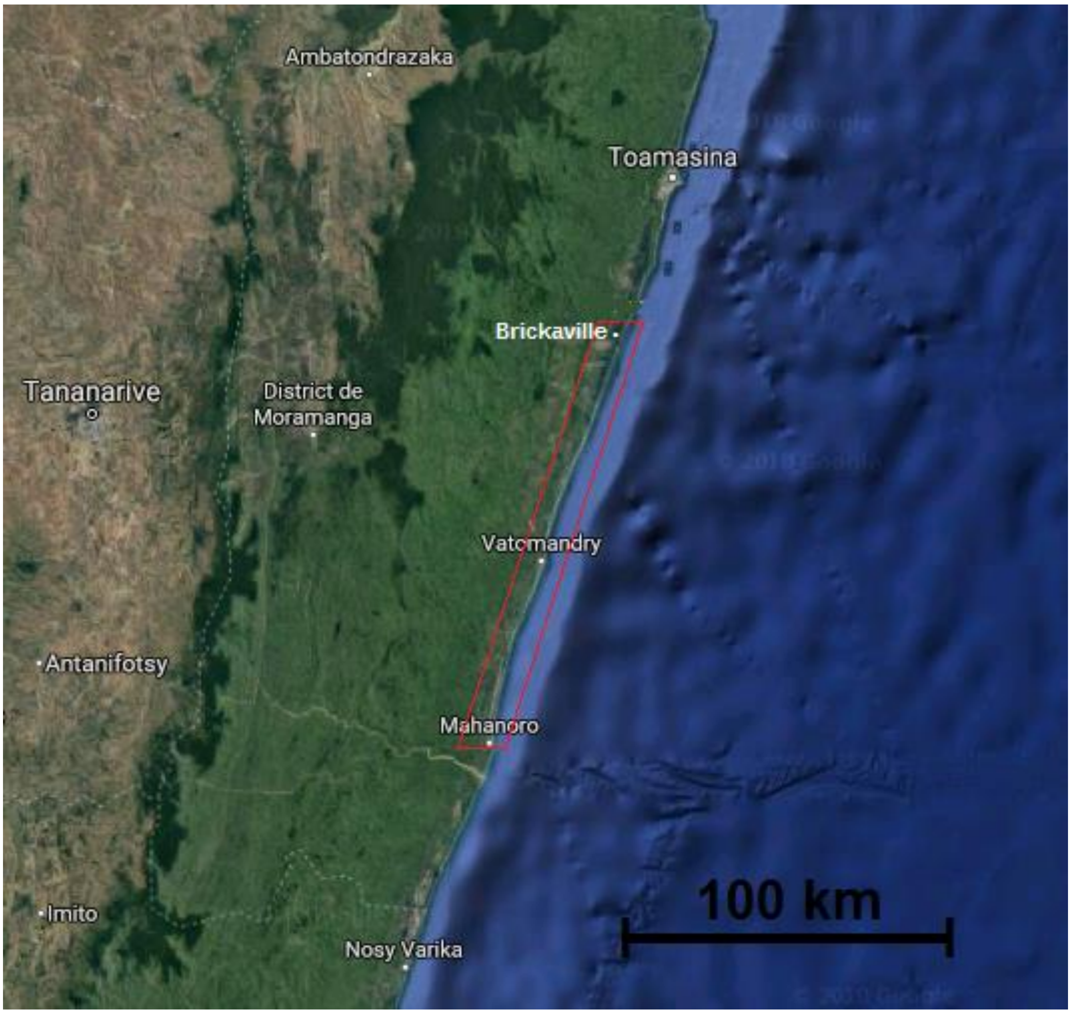
	18-Do people use to treat water before consumption? And if so how and why?	To assess hygiene awareness, accessibility and affordability of treatment methods Willingness to pay	-Semi-structured interviews -Focus group discussion	-Doctors -Women
	19-How a wellpoint/borehole in the type of aquifer in this area should be constructed in a way that maximises the yield and protects the groundwater from contamination? How handpumps can be installed to protect the groundwater and to avoid problems with wasted water?	To analyse drilling, casing, mounting techniques To assess the protection installation(s) (e.g. apron slab, support structure…)	-Semi-structured interviews -Observation	-MWP
ENVIRONMENTAL	20- How and what analysis are made before choosing the location of installation (environmental characteristics e.g. water table accessibility, reliability of sources? What are the water characteristics at the sources (quantity, quality …)? Is there any odour or taste issues? (e.g. salinity or any chemical composition issues?	To assess seasonal variations, quality and quantity of water	-Focus group discussion (seasonal calendar) -Semi-structured interviews -Observation	Women, Entire community -MWP
	21-What are the potential risks of pollution? What protection are needed?	To examine potential hygienic issues (e.g. insect proliferation, sanitation issues, wastewater evacuation and treatment…) Fence, slab apron sensitization programme	-Observation -Transect walk -Semi-structured interview	-Women, Doctors

INSTITUTIONAL	22-What is the legal procedure for installing water infrastructure?	To understand the administration framework and legal procedure To determine local and/or legal responsible(s)	-Semi-structured interviews	-NGOs, Ministry of Water, Mayor
	23-What is the legal procedure for setting up an official water committee?	To understand the administration framework and legal procedure	-Semi-structured interviews	-NGOs, Ministry of Water, Mayor

3- Methodology

3.1- Research area description

The research study takes place in villages located on the east coast of Madagascar, where The Madagascar Water Project (MWP) organisation has installed hand pumps. To date they are implemented in 23 localities with a total of 42 hand pumps covering a zone of 130 kilometers from Vavony to Mahanoro:



The research has been done in the region of Brickaville, Vatomandry and Mahanoro. The research area include 18 localities: Vavony, Andavakimena, Ambandrika, Andovona, Andovoranto, Mahatsara, Tsivangiana, Kalomalala, Sondrara, Amboditafara, Ambodivoara, Analalava, Vohitrampasina, Manakambahiny, Antsiramihanana, Ambilan'ny varanta, Amboakambatsy (See: MWP handpumps users map, Annex 7). Two additional localities, Ivato and Marosiky, were also visited during the research study. Situated at the extreme south of the research area, these localities are not yet referenced by MWP at the time of the research visit.

	Location	Hand-pump Number	Estimated Beneficiaries
1	ANDOVORANTO	MWP1, 2, 3, 4, 6, 7, 8, 9, 26, 38, 40	3300
2	ANDAVAKIMENA	MWP5, 20	400
3	AMPANDROANTSIRY	MWP22	300
4	MAHATSARA	MWP10, 36	800
5	AMBILABE	MWP11, 21	550
6	TSIVANGIANA	MWP12, 17	500
7	AMPASIMBE	MWP13, 27	400
8	AMBANDRIKA	MWP14	0
9	AMBODIARAMY	MWP15	0
10	AMBODIVARO	MWP16	250
11	KALOMALALA	MWP18, 19, 31	700
12	SONDRARA	MWP23, 35	600
13	ANDOVONA	MWP24, 28	300
14	AMBODITAFARA	MWP25, 33	800
15	VAVONY	MWP29	500
16	AMBODIVOARA	MWP30	400
17	AMBOAKAMBATSY	MWP32	300
18	ANALALAVA	MWP34	400
19	VOHITRAMPASINA	MWP37	400
20	MANAKAMBAHINY	MWP39	400
21	ANTSIRAMIHANANA	MWP41	400
22	AMBILAN'NY VARANTA	MWP42	400

Total estimated beneficiaries	12 100

(Table 3.1: Table of localities, handpump references and estimated beneficiaries, adapted from MWP)

2.2- Data characteristics

Due to sustainability complexity, qualitative research is more adequate for learning about the different key actors involved in Malagasy rural water supply. In some cases, quantitative data also help to support any agreed conclusions. The research information can be separated in two forms:

- The first would be internal to the communities, which includes socio-economic information and the community experience on water supply systems.
- The second involves the knowledge and opinions of external stakeholders to the communities. These include Malagasy government, NGOs, private individual donors, suppliers and informal market…Indeed, all of them have important roles in rural water provision in the country.

A triangulation methodology is used for minimizing the bias of data that can be originated both from researcher(s) and informant(s). The principle lays on gathering the maximum of information about the same theme by using different tools. Afterward, answers and perspectives of the different key stakeholders are compared; the relevance of findings is therefore evaluated by correlating information collected from the different sources.
Because of the high illiteracy rate in the region, a participatory approach is more adapted for collecting data from the different groups of the communities. Visual methods and focus group discussions are more adequate alternative techniques instead of usual structured questionnaires and Yes or No answers' surveys. Rapid Rural Appraisal (RRA) provides proven participatory techniques that can provide social data by using local knowledge. This methodology helps to understand why a situation has evolved in a certain way by looking at the community's dynamics. Furthermore, participatory approach also involves community members in the planning and decision making of water supply project development. However no tools are guaranteed formulas for success. Their efficiency depends of their flexibility and adaptability at each application. For each circumstance, the research team needs to customize or create new tools that fit the particular needs of the community.

2.3- Methodology tools

For this research study, the RRA tools include:

- **Participatory Mapping**

  Community members are asked to draw a village map in order to provide a village landmark. Scale is not essential rather it is more important to determine the layout of the village and to localize the water points.

- **Transect Walk**

  Identical to a visit inspection, nonetheless authorization needs primarily to be approved by local authorities as well as local guides. Then the research team visits the community zone by zone with a grid pattern in order to localise the water points and to list the important characteristics. A visualisation of the different water sources and/or latrines will help to determine their appropriateness and to indicate the specific location(s) that need to be inspected more in details.

- **Observation.**

  Unlike the transect walk, the strategy consists of observing the local practices by staying at strategic point(s), this would help to determine the traditional usages for collecting water including the quantity collected, the usual materials for transport and storage, the hour(s) of affluence, the number of users, utensils and hand washing practices etc…

- **Focus group discussion**.

  After been identified, members of the key stakeholders are regrouped in order to debate freely about specific issues with the minimum of habitual social constraints. (e.g. women are generally in charge for the collection and the use of water for the daily tasks such as meal preparation...Unfortunately they are traditionally considered as less important groups in many communities this is even more accurate in the developing world where their point of view is rarely taken in account. In order to mismatch this tendency, women will be asked to participate to meeting groups to debate about water access into their communities.

- **Semi structured Interview**

  It is a participatory technique during which the researcher asks more details to a key informant(s) from the community. This include local technicians for knowing the recurrent issues, local doctors to ask about major illnesses and children mortality and/or members of existing community management (e.g. water committee president, treasurer…)

- **Seasonal Calendar**

  This methodology allows to visualize how things can change within a community during different seasons throughout the year. A horizontal axis lists the 12 months and the community members are asked to show at what moment of the year the different investigated themes are the most prevalent: diarrhoea, migration patterns, water quality/quantity.

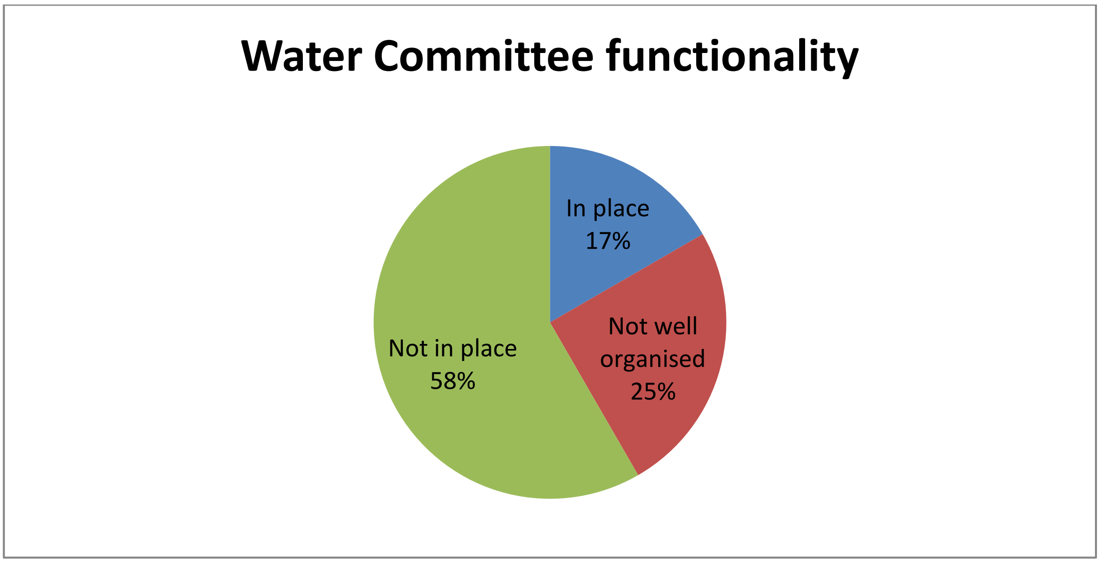
4- Findings

The localities where MWP is implemented range from very small and very remote communities of 72 inhabitants (or 15 households), such as Ambokabatsy, to semi-urban localities with populations of more than 2500, such as Andovoranto or Tsivangiana. These two localities are Municipalities, with officiating mayors. Generally, due to their size, these semi-urban localities are also subdivided into neighbourhoods headed by delegates called Chief of Carreau. Usually each Municipality has around 10 to 20 *fokontany* under its jurisdiction. Each *fokontany* is administered by its President or Chief of fokontany. The President of the *fokontany* is the local official, and the Mayor's delegate. He enables the registration of community members (for electoral lists, birth or death registrations), and the legalisation of official documents (such as deeds, or requests by communities or individuals).

4.1- Social

4.1.1- Community organisation

In accordance with MWP policy, one committee is responsible for each handpump. In each locality where MWP water points have been installed, water committees have been formed. However, many of them have not continued to work properly, or have even disintegrated as villagers were not able to identify who was involved or not. It has been contested that such committees were a new concept for all the communities.



(Figure 4.1.1: Water Committee functionality)

On the 24 handpumps visited, four had water committees in place, and six localities had water committees in place - but the members were not well informed about their duties and their responsibilities. It is worth noting that two of the water committees still in place were headed by women presidents, and were located in the locality of Andovoranto where the mayor is officiating. The two other functioning water committees are in Sondrara and Kalomala. These water committees are considered to function well, as the members are still meeting and have occasionally been able to collecte funds from the community members when the handpumps needed repairs (e.g: 500 MGA per household in Kalomalala). The fences are also considered: are they well maintained? Some fences are surrounded by plants (locally called Milliardaire and Sonjo), that are believed to reduce salinity in the ground. In Sondrara, schedules have been set up forbidding handpump usage at night. Even if the percentage of functioning Water Committees is low, this gives an indication that in some communities the principle of community management is understood and adopted.

Six water committees were considered to be not as well-organised. Committee members were known but they did not really know what to do in case of dysfunction. Some committees did not know the mobile phone number of the MWP coordinator, others had lost it. Among these dysfunctional committees, two were headed by women presidents (Ivato and Ambodivoara). This shows the trust of MWP team on integrating women within management of water points and the great result of involving them.

Even if they are active in water point management, it has been noted that parity is not applied in the communities. The President of the Committee of Ivato is also President of the *fokontany* and AC (Health Government Agent). The Committee President of Ambodivoara also has an AC's function. These two presidentd are reported to have little authority on management of water points by consumers. For instance, the committee president has tried to impose scheduling, and also a restriction on water point usage by children less than 10 years old. People do not respect this rule, especially children that are sent by their parents.

One child has been reportedly been severely injured by a metallic piece on the border of the concrete wells. To overcome this issue, a meeting with the traditional leader has been asked for by the MWP team, and further collaboration towards education dissemination has been agreed with the Elders Council (*Vavanjaka*), between the *Tangalamena* (traditional leader) and the *Vavanjaka*. It has been agreed that the *fokonolona* (community council) will be reunited to discuss these concerns. Indeed, in parallel with the legal framework of authorities, other forms of traditional governance are predominant. Despite appearing to be entangled, these different structures can in fact be complementary. Many localities have their respective *Tangalamena*, considered to be the spiritual chief. The *Tangalamena* is greatly respected, and it is up to him to give advice to people on various social problems, or to give his blessing to different aspects of the village. A council of *Vavanjaka* or *Zokiolona* (Elders) are also in place as spokespeople of *Tangalamena*. They are the guardians of the oral traditions and the ancestral rules (the *fady*).

The remaining communities did not have committees, as villagers did not know anymore who was in the committee. For all of them, support has been undertaken bythe MWP team to reconstitute the committees. New tasks have been requested such as book-keeping of user registrations, participation registration, and maintenance checklisting. The report needs to be registered at the municipality every month, and will be checked by the MWP team during its maintenance trip, occurring every 6 months.

Three out of the 24 water points are located in very small and remote localities which did not have a president of *fokontany* officiating (Ambokambatsy, Amboditafara). These localities are therefore under jurisdiction of their *fokontany*. It is not surprising that their water committees did not last, as local authorities are not officiating within the locality. Particular attention and support need to be given to these localities as they are among the most remote and therefore the most vulnerable groups. Communication for enquiries from the community, or for asking news from outside seems to be compromised as telephone signals do not reach these localities. However, the villagers report that the president of *fokontanies* are readily available when needed. It has been noticed that with the majority of water points, the presidents of *fokontanies* were involved in Water Committees.

Some women's associations under the name of *Voamamy* are also in place in some localities such as Andovoranto and Andavakimena. Exchange of ideas could be undertakaken as a potential future connection with MWP network; this is in progress.

4.1.2- Users satisfaction

Users' satisfaction is essentially assessed by observation, as only one household survey has been undertaken in Andavakimena locality. Three aspects were considered for assessing users' satisfaction:

– the state of repairs of the handpumps (proving frequency of use)
– the conditions of surroundings - if it is well-managed, they indicate that people are satisfied, and show indication of ownership
– the willingness to participate in management duties, such as existence of Water committees, affluence in community meetings, formulation of requests, registrations and book-keeping.

In general, users'satisfaction, the needs and demand, are high - according to villagers during community council meetings. This satisfaction has to be taken with prudence as in some cases, the demand can be high with a moderate satisfaction in the long term. For instance, in Sondrara, a water committee is in place and works well. However, it is the only improved water source within the locality of 950 inhabitants (250 households), so a committee member reported that queuing time exceeds 30 minutes in the afternoon during the peak time. People say they are grateful, but they really need more identical supply systems. Longevity of materials and user satisfaction is at risk due to overuse and the lack of available infrastructure. In other localities, people were still collecting water from unprotected and open bucket wells, even if they had access to handpumps less than 100 meters away, with no queueing time. This indicates the satisfaction of villagers to their traditional sources, and unawareness of the relation between diseases and unprotected sources.

From a family survey in Andavakimena, 78 households were asked about their satisfaction in terms of water quality, quantity and ease of access. The results are summarised below:

(Figure 4.1.2: Households satisfaction in Andavakimena)

The majority of unsatisfied households expressed that they wanted more clean water, and that handpumps were their preferred technology. 75 families outlined the time of day they collected water: 55 in the morning, and six in the evening. 14 households do not have a specific time. Some pupils (boys and girls) explain that sometimes they go fetching water before school, but most often they are in charge in the afternoon when they do not have class.

4.1.3- Communities water sources

From a total of 23 localities, 12 MWP water points are the only basic potable water source of the village (instead of surface water). By observation, in each locality people were seen using their former traditional water sources when available, such as open concrete bucket wells or rainwater catching systems. During a community meeting, people explained that before MWP implementation they used to walk or canoe for several kilometres to collect water from traditional hand-dug wells or surface water situated in the forest. During the hot season, occurring between September and November, the distance to available water sources doubles, and water become red and smelly at the sources.

This gives an indication that people have knowledge of distinguishing the different qualities of water from the each source, such as between the canal and water sources more difficult to reach, but seen as more adequate for consumption. Some people relate that especially during hot season some people used to collect water from the canal. This was confirmed by MWP team and by Dr Fournier of Sahambal NGO. He explained that especially during drought periods, people collect water in the middle of the canal (considered as cleaner than at the shores) and boil it before consumption. The canal is traditionally used for bathing and clothes washing, but also for tool washing. This has been noticed all along the canal, and it is confirmed by villagers.

Girls washing utensils in the canal of Pangalanes

A transect walk (see annex 10) in Andavakimena and the household survey indicate the location of different water sources still in use and the duration of travel to and from water collection. From a total of 66 replying households, 20 of them spend an average of one hour every day collecting drinking water. Nine families take more than 90 minutes. However, it is noticeable that 39 of them have access to drinking water within less than 30 minutes, knowing that two MWP handpumps are in function within the village.

On the 75 questionnaire respondents, 34 families (45%) need to cross the canal to get water. Some villagers reported that some people go in the forest to collect water from small surface water areas that people consider as traditionally clean when they work in the forest.

A simple rain catchment system during rainy season with a non- negligible amount of water

An unprotected concrete bucket well funded by the World Bank in the 2000s

4.2- Health

4.2.1- Healthcare services

On the 15 visited localities, only 5 (Tsivangiana, Ambodivaro, Manakambahiny, Ivato and Andovoranto) have the presence of a Community Agent (or AC for Agent Communautaire). The AC are government health agents in charge of births, vaccinations and other basic healthcare services. They also record natality, mortality and other health data for the Health Ministry. Two localities (Andovoranto and Ambodivaro) have Basic Health Centres (CSB, *Centre de Santé de Base)*. Even if data on health issues related to water are insufficient to give a proper visualisation of the situation, it seems that diarrhoeal diseases are decreasing for the last few years. Two ACs have reported alerts from the government of bilharzia cases in the areas of the Pangalanes Canal. Malaria and respiratory illness are still very common in the region.

This low coverage of health staff and information gives a clue about the difficulty of the situation.

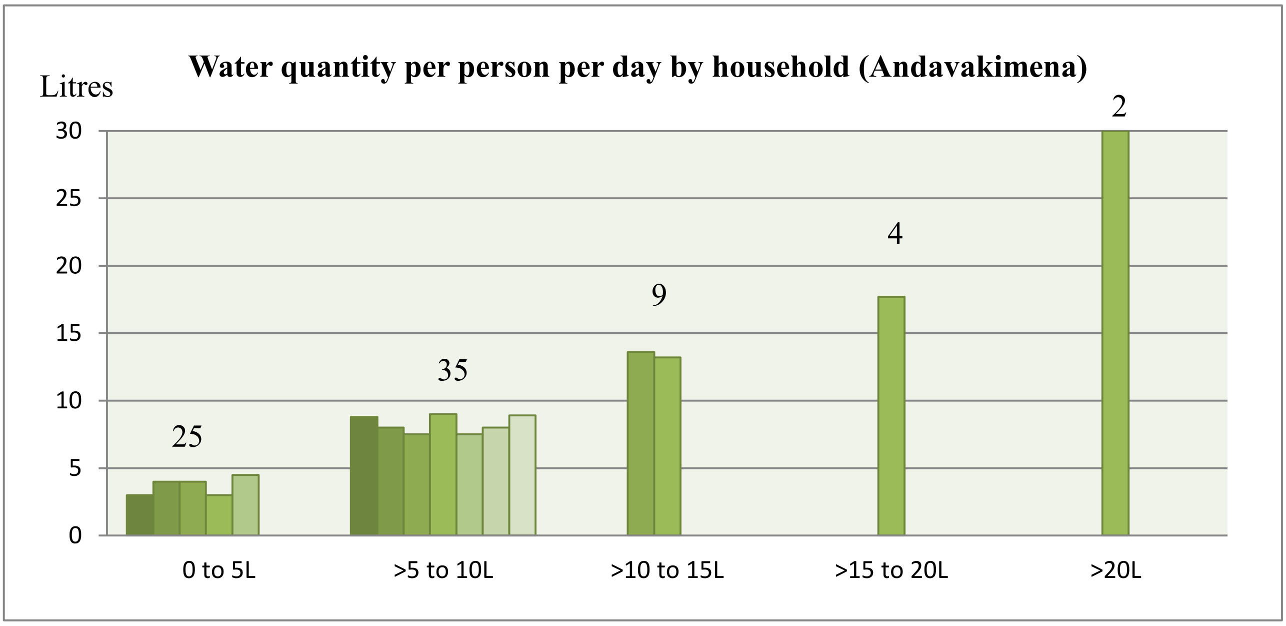
4.2.2- Water quantity for daily domestic uses

A survey in Andavakimena and observations in all localities have given clues about the quantity of water used by households for daily domestic uses such as drinking and cooking, as personal hygiene and laundry is generally done in the canal or other water surfaces. By observation, it has been noticed that people collect water in 15 litre (approx.) buckets. Few people were seen to collect water very often when they were installed very close to the water point.

In Andavakimena, 75 families stated quantities of daily water consumption:

(Table 4.2.2: Households' water consumption)

Quantity (L)	0 to 5L	>5 to 10L	>10 to 15L	>15 to 20L	>20L
Nb. of households	25	35	9	4	2

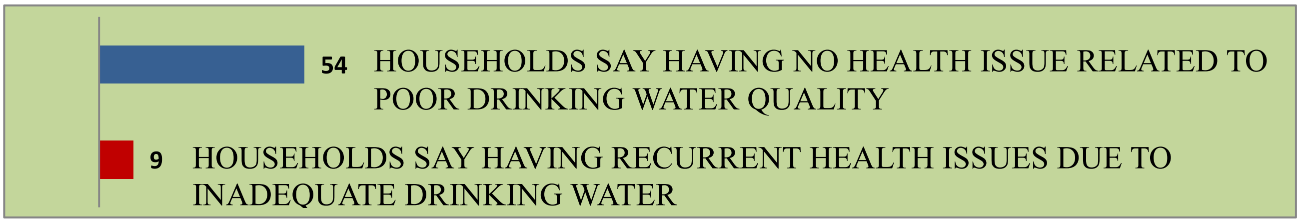


(Figure 4.2.2: Number of households in function of their water consumption)

It is noticeable that 80% of the population of Andavakimena uses less than 10 litres per capita per day, which is a very low rate.

4.2.3- Presumed health issues related to drinking water

The different ACs have reported figures of rate of diarrhoeal diseases that are officially registered at the ministry of Health. Even if the data are far from representative, a trend of diminution of diarrhoeal diseases can be noted for the last 4 years. In Andavakimena, with a total of 76 questionnaire respondents, households were asked if they think having issues related to inadequate water:



(Figure 4.2.3: Health issues due to poor quality of drinking water)

4.2.4- Method of collection, transport and storage

Households were asked about their method of transport: 75 families were said to use jerricans of 20 litre capacity for transporting and stocking water, eight use buckets, two have private rainwater tanks and one private well has been outlined. It can also be noted that people generally use a bucket at MWP handpumps, as it is more convenient for collecting.

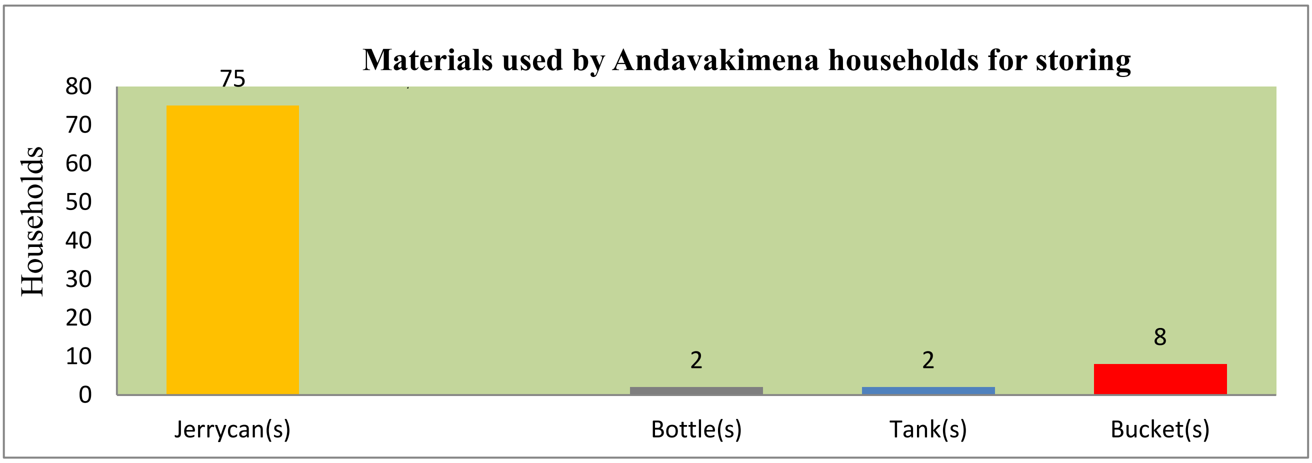


Figure 4.2.4: Materials used in Andavakimena for transporting and storing water

4.2.5: Hygiene sensitisation

Hygiene sensitisation is done by MWP at each visit of communities where the organisation is present. It is done during community meetings, and under the supervision of Mr Hilaire Razanadrafely.

Mr. Hilaire doing hygiene sensitization in Antsirimihanana

5- Economic and Finance

5.1- Financial contribution

Communities were asked if they contributed in cash or in other kinds of participation for installation of their water system. Another question was if they still contribute or pay (and what amount) for the service, and/or the maintenance of the system. These interrogations allow us to assess the feeling of ownership of the communities for their water supply system, and also to determine if enough funds are collected for permitting the financial viability of the service. In all the cases the answer was no. Indeed no water tariff was imposed by the MWP team, and no financial contribution was requested for installation. However, the committee is encouraged to collect funds in the scheme - an amount of their choice. They have to reunite the community council (locally called the *fokonolona*) and discuss the tarrif that suit them. Book-keeping is now required by the MWP team, and a version will also distribute to the Muncipality. A few communities have succeeded in collecting funds from users for minor repairs, such as in Kalomala where the committee has collected 500 MGA per housholds to fix a leaking pipe. At the MWP visit, the pipe was still leaking and the handpump had lost pressure, but people still used it even with a low yield. All of these are indications of high demand, knowing that there is another MWP handpump in the community at 500 m away. In some other cases, some local technicians fixed the handpumps, even if community members did not contribute (Antsiramihanana).

For installation of handpumps, local material such as stones and sand are requested for the construction of apron slabs. Fencing is also the community's responsibility, and the committee needs to organise maintenance tasks such as cleaning. In Sondrara, scheduling has been decided, with use forbidden between 8pm and 6 am.

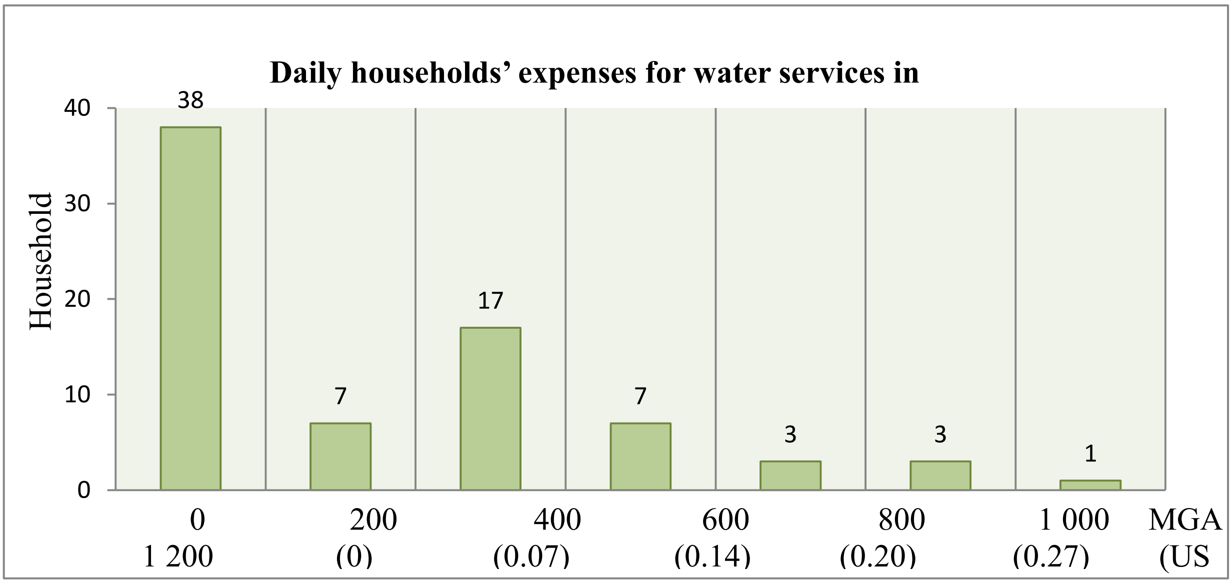
5.2- Expenses and Willingness to pay

It is difficult to determine what amount from their disposable income the communities will be willing or/and able to pay, as there will always be a gap between what people say and what they will really do. Some clues are given by the tarrifs that people pay for water carrying services, which is done by young men. This job is very common as many people collect water from sources in the forest kilometres away. In some localitities small shops also sell chlorine pills under the brand "Sur'eau". A household survey was also carried out to assess what price people would be willing to contribute. Firstly households were asked how much do they pay for getting water everyday:

- Of the 76 respondents, half of Andavakimena population pay for water carrying services:

Table 5.2.1: Households' daily expenses in Andavakimena:

Nb of Households	38	7	17	7	3	3	1
cost/day (MGA) (USD)	Do not pay (0)	200 (0.07)	400 (0.14)	600 (0.20)	800 (0.27)	1 000 (0.34)	1 200+ (0.41)



(Figure 5.2.1: Daily households' expenses for water services in Andavakimena)

38 households do not pay for water services.

A water carrier claims to transport an average of 5 jerricans of 20 litres every day. During high peak, he may reach up to 10 jerricans a day. Water transport is usually done by canoe, then by walking to homes. Services are generally tariffed 300 MGA (0.10 USD) per jerrican.

The second question was to find out the amount they would be able to pay for improved water services, such as installation of a handpump in their proximity, or any other services of their choice.

Table 5.2.2: Willingness to pay of Andavakimena households

Total of households	Amount MGA (USD)/Week	Total MGA (USD)/Week
1	100 - 200 (0.03-0.07)	150 (0.05)
19	200 - 300 (0.07-0.1)	4 750 (1.61)
2	300 - 400 (0.10-0-13)	700 (0.24)
6	400 - 500 (0.13-0-17)	2 700 (0.91)
1	600 - 700 (0.20-0.24)	650 (0.22)
1	2 000+ (0.70+)	2 000 (0.68)
30		10 950 (3.71)

In Andavakimena, 30 households are willing to contribute an amount of 10,950 MGA (3.71 USD) per week for improved clean water access.

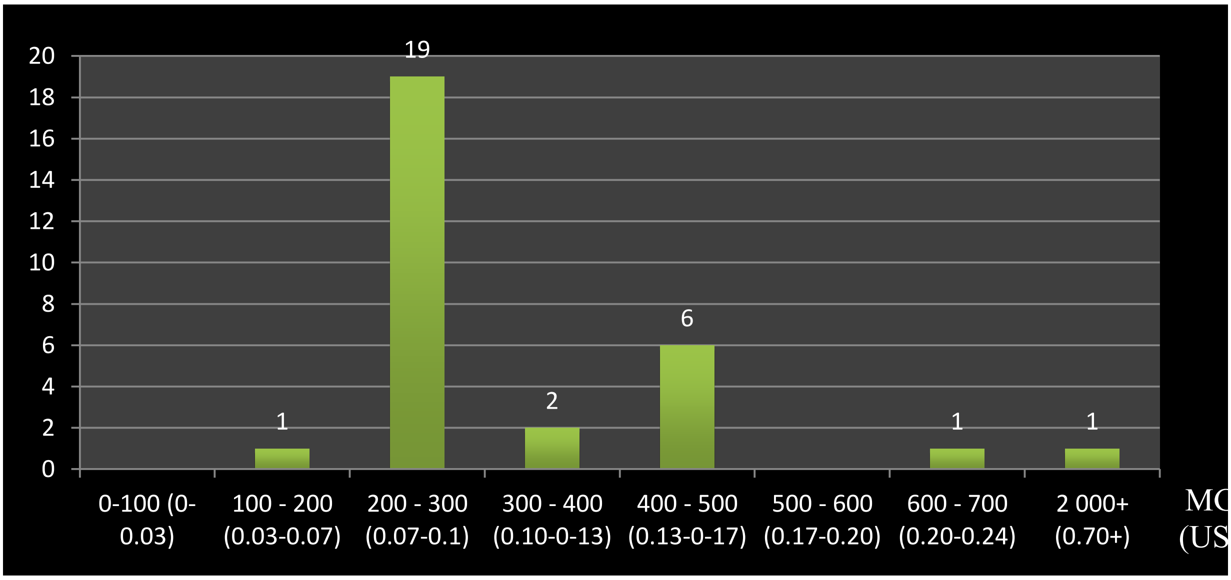


Figure 5.2.2: Willingness to pay of Andavakimena households per week

19 households would be able to contribute a minimum of 200 MGA per week, and therefore 800 MGA per month. As we saw earlier, the water committee of Kalomala collected a tariff of 500 MGA per household on one occasion. The gap between what people say and what they did (on one occasion) is relatively small. However this analysis is purely suggestive, as ability and willingness to pay can largely vary between proximate communities.

A local shop in Andavakimena claims to sell an average of 60 boxes of chlorine pills every month. From the brand *Sur'eau*, one box contains 20 pills and costs 200 MGA (0.07 USD). One pill is necessary to purify 20 Litres of water. Twelve households have claimed not to buy Sur'eau pills because of its strong smell and taste. It is necessary to note that Sur'eau pills are accessible and regularly supplied. However, the majority of communities have no shop, especially those along the Canal of Pangalanes that are not reachable by road, and where only boat is the only connection.

Important seasonal variations that affect household earnings need to be considered. Indeed, in this region people do several activities, due to seasonal variations. During the cold season (May to September), fish become scarce, thus the majority of fishermen shift to forest activities. The majority of households located between the canal and the ocean essentially make a living from fishing and wood retail. Agriculture and farming is not widely practiced: any agriculture is essentially for self-consumption due to the low availability of arable land parcels. Residents traditionally raise poultry, zebu or pork, for minimal commercial profitability. According to the presidents of the *fokontany*, people cultivate lands they do not own. In fact, most of the population do not h ave ownership. Goods and lands are still mainly transmitted by oral tradition. Expropriation and unauthorized slash-and-burn agriculture are recurrent issues.

The primary forest is not sustainably exploited. It is declining due to subsistence crops, charcoal production or private exploitation for fruits, agriculture and extractive industry. Wood is also greatly in demand for construction. Men traditionally build wooden homes with roofs made with palm leaves and banana trees. These typical habitations require regular maintenance and systematic replacement, especially after a cyclone. Many useful objects are made from reeds by women, including hats, baskets and carpets. The principal crops include: food crops (rice, cassava, maize, sweet potatoes), fruit (bananas, lychees, citrus, pineapples, coconuts), and industrial and trade crops (sugarcane, coffee, clove, pepper, ravintsara).

During the hot season (September to January), the water demand explodes as temperature rises and freshwater becomes scarcer. However, this coincides with the offshore fishing season when fish are mostly abundant. The demand for fish allows for an important augmentation of household income. “I may earn 80,000 MGA (27 USD) on good days. In contrast, between February to august fish are rare and it is difficult to earn 5,000 MGA (1.68 USD) a day” said one fisherman.

Dr Fournier, working for the NGO Sahambala, is regularly in the region and confirms that families earn an average of 40 USD per month.

In Andavakimena, 44 households detailed their principal activities:

(Table 5.2.3: Andavakimena economic activities)

Employment	Total
Fishing (Ocean/Canal)	22
Shops (including meal services)	6
Forest/wood activities (coalman, lumberjack, carpenter…)	7
Farmer	1
Guardian of private propriety	3
Breeder	1
Craft	1
Preacher	1
Ferry	1
No job	1

5.3- Cost of installation

According to MWP, the capital cost for one installation approximates 200$ to 250$ per well. The maintenance cost is about 50$ per well, per year. The cost of a maintenance and/or installation mission, which is done every six months, is about 250$ per day. This is our estimate. The management team, based in Antananarivo, hires a minimum of one car for transporting staff and materials. The travel from the capital to the east coast areas lasts 2 weeks in average. The bus ticket from Antananarivo to Toamasina (north-east) is about 10$ for 300 kilometres, roughly the same distance to Vatomandry (south-east) (see www.cotisse.mg for bus company information). The cost of fuel is now more than 1$ / litre in the country. Considering that a car consumes 10 litres/100 km, it is necessary to spend a minimum of 30$ just to arrive in Vatomandry, and 60$ for the return trip to the Capital. This implies that fuel for the car travels in the areas are not yet included. A car rental is about 50$ a day, which gives 750$ for two weeks of rent. The team needs to hire a boat to visit the different communities situated along and between the Canal of Pangalane and the Indian Ocean (Annex 12). The rent of a boat is around 150$ per day (according to villagers, a boat ticket for travelling from Brickaville to Vatomandry is about 2.5$ per person. Noting that these "bus boats" can transport a minimum of 60 persons per passages, this gives us the 150$ per day for transporting staff and materials). The total cost for a boat renting is about 1500$ for ten days as during certain periods, some communities located on the other bank (such as Tsivangiana, Ambodivoara, Andovoranto, Vavony…) can be reached by car. A strict minimum of 10$ for 3 meals per day per person, and an additional 10$ per day per person for accommodation represents a trip of 1800$ for 2 weeks. Considering a minimum of 6 staff (three management, and three operators), the total of the mission cost already reaches 4110$ for 2 weeks, or 275$ per day for 6 staff:

80$(gas) + 750$(car renting) + 1500$ (boat renting) + 1800$ (meals and accommodations) = 4110$.
This is 24 more dollars per day than what MWP accounts for, salaries not included.

The so called "7m depth type" handpump is sold by Batimaxx for 197,000 MGA or roughly 50$. The stainless steel screen is imported and costs around 65$, transport included. The checking valve, also imported, is found online for about 25 $, transport included. Galvanised pipes for an average well depth of 5m cost roughly 30$ in the local shops. In the same way, one local cement bag for the apron slab is about 10$. The wood for the support table costs roughly 2$. Sand and stones for making concrete are provided by communities. The total gives an approximate cost of 182$ for installation of the Batimax handpump. Online, the "9m depth type" handpump costs roughly 75$, transport included. Thus the total for its installation approximates 210$. A "20m depth type" handpump costs around 100$, or 25 more dollars. This gives us 235$. The cost estimations corroborate this.

A check valve

Batimaxx handpumps

If the more common maintenance task is the replacement of the leather cups, these are sold online for around ten dollars each. Noting that they are not distributed in Madagascar, their transport needs to be considered. Indeed only two leather cups are provided with the Batimaxx handpump. The retailer confirmed they do not sell them alone as a spare part. Estimates can therefore be made with an approximate cost of 15$ for one leather cup, transport included. Considering an intensive use, and two replacements per year (i.e: one maintenance/installation mission every 6 months), the minimum maintenance cost for one hanpump already reaches 30 dollars. In this case we do not include other potential replacement or repairs costs. This figure is also correlating with Carter's findings in its article in the IRC symposium of 2010. The author says that maintenance costs of one handpump are approximate 30-40$ per year, logistics not included. Indeed many studies, including previous researches in Madagascar, confirm that logistics costs are considered a consequent part of water service budget.

"*The Madagascar Water Project has been funded in a large part by the founder Fred Rittelmeyer with significant help from his brother. Contributions have also been solicited and collected on the website GoFundMe. In 2017, The Madagascar Water Project Inc. has been incorporated as a non-profit organisation to expand its fund-raising efforts in the U.S. With moderate success, there is still much room to grow.*" (MWP, 2018)

6- Technical context

6.1- Water supply systems historical

After visiting the different localities, three periods of water supply implementation campaigns can be traced during the last 20 years. The first was during 1999-2001, a governmental implementation project supported by the World Bank and the European Union installed hundreds of concrete-covered wells in remote localities along the Canal of Pangalaes (i.e: Andavakimena, Andovoranto, Manakambahiny). The covers are not there anymore, however the wells still serve hundreds of thousands of people all along the east coast. The second campaign was undertaken in 2012, by an NGO (Human & Nature according to Bushproof Company) which installed dozens of Canzee pumps retailed by Bushproof. Unfortunately all of the visited Canzee pumps were dysfunctional.

6.2- Comparative study of handpumps in Madagascar

The number of retailers and the number of handpump types are quiet limited in Madagascar. Indeed there are only few distributors and they seem to be the same for many decades, leading for little space for competition with no price diminution. However this suggests more opportunities for locally manufactured handpumps that need enabling environment as majority of these local made handpumps are from informal market.

Imported pumps comprise:

- Low depth suction pumps and India Mark II distributed by Batimaxx, located in Antananarivo.

-India Mark III retailed by SMEF, based in Antananarivo and Toamasina

-Vergnet pump sold by SOMECA in the capital Antananarivo

The locally manufactured handpumps include:

- Bushproof or Canzee (Direct action) pump distributed by the company of the same name "Bushproof"
- The Rope pump, manufactured by many local shops located in south Madagascar (Atelier +, in Betioky)
- The "Tany" (ground) pump, manufactured by more than 50 small informal shops in the eastern port city of Toamasina.

<u>Comparative study of handpumps:</u>

Table 6.2.1: Batimax "7m depth" pump:

Advantages	Disadvantages
- Iron cast (high quality material) - Low price - Technically simple	- Low depth - Imported good - No spare parts available especially leather cups that often need to be replaced

Table 6.2.2: India Mark II - III

Advantages	Disadvantages
- Solidity - Technically known by few distributors - High depth - Less maintenance	- High prices - Imported goods - Not locally maintained/No spare part available at local level

Table 6.2.3: Vergnier pump

Advantages	Disadvantages
- Solidity - High depth - Less maintenance	- Technically known by only one distributor - Imported good - Not locally maintained/No spare part available at local level - High price

Table 6.2.4: Canzee Bushproof pump

Advantages	Disadvantages
- Locally manufactured - Medium depth	- Medium price - Not locally maintained as technology only known by one distributor/No spare part available at local level

Table 6.2.5: Rope pump

Advantages	Disadvantages
- Locally manufactured - Medium price - Medium depth - Several manufacturers	- Not known technology in eastern areas - Not well disseminated technology throughout the country

Table 6.2.6: "Tany" pump

Advantages	Disadvantages
- Low price - Technically known by population in eastern areas - Local maintenance	- Low quality and need of recurrent maintenance (rub cup) - Need priming/risk of water contamination - Lead poisoning due to usage of low quality materials - Low depth

Table 6.2.7: Prices of the different handpumps

	Local Canzee Bushproof pump	India Mark II	India Mark III	Batimaxx	Local Rope Pump	Local "Tany" Pitcher pump	Vergnier pump
MGA	1 800 000	1 100 000	1 500 000	200 000	1 000 000	180 000	5 000 000
USD	450	275	375	50	250	35	1 250

6.3- Available resources

MWP used three different types of hand pumps generally chosen according the depth of the aquifer in the community: the Batimax pump (7m depth), the 9m depth pump and the 20m depth one. According the team, all the 20m depth handpumps were replaced by 9m depth or Batimax types due to their complexity and the important effort needed to operate them.
Of the 23 observed handpumps, 18 were batimax 7m depth handpumps (78%) and five were 9m depth (12%).

It is evident that spare-parts distribution is a major issue that affects service sustainability. The 7m depth pump is sold by Batimax, which is based in the capital Antananarivo, more than 300 km away. Batimax do not sell spare parts such as leather cups, nor indeed other components of the handpump. The 9m depth pump is purchased and imported by MWP from abroad. Spare parts are therefore not available locally. The 20m depth pump is not used anymore by MWP because of their complexity.

It is the same case for the direct action pump. Bushproof, also based in Antananarivo, is the only company manufacturing these handpumps (also called "Canzee pumps"). The closest retailers of VLOM handpumps (such as SMEF) are located in the port city of Toamasina, the second-largest city in the country situated, 150 km in the north of Vatomandry. All of these localities are connected by the artificial Canal of Pangalanes which is 600 km long from Toamasina to Manakara (south-east). During the colonial time, harvests and goods used to be transferred by boat from the plantation in the south to the largest port in the country, in the north-east of Madagascar. Today such boats and/or connections do not exist any more, and nature has taken back its right.

Wood can still be considered as available, even it is becoming a scarce resource because of deforestation for agriculture, habitation construction and wood charcoal (the principal energy resource for Malagasy population).

The Malagasy population is young as so is the eastern population. However, the education rate is low as only a few primary schools have been noted in the research areas and the majority of these are not full time. Children are mostly involved at a very early age in daily domestic tasks such as preparing meals and collecting water which may take several hours per day. They also assist their parents with activities such asfishing and agriculture. Fishing at sea is entirely done by men and sometime adolescent boys. Women and girls generally do fishing in the Canal or Pangalanes (Annex 12).

On the 16 visited communitites, only three had local technicians living within the community: Antsiramihanana, Sondrara, Andovoranto. The MWP organisation has 7 local technical teams in different strategic areas. One team based in Andovoranto has been followed for this study. The teams are generally composed of three or four operators which have been formed by by MWP for installation and maintenance tasks.

Retailers of construction materials such as cement, galvanised pipes and PVC pipes are only available in the main cities of the area such as Brickaville, Vatomandry and Mahanoro. The connection with the majority of the localities is by bus boat.

Sand is abundant and, paradoxically, water too.

6.4- Materials characteristics

According to the MWP (December 2017) report (available at: www.themadagascarwaterproject.com) :

"*On eight 9m depth pumps, all new when installed, five had no problems, and three had loose screws. On eighteen Batimax or 7m depth pumps, aged from new to three years old, four had no problems, 13 had used leather cups, and one had a mechanical problem.*" (MWP, 2017).

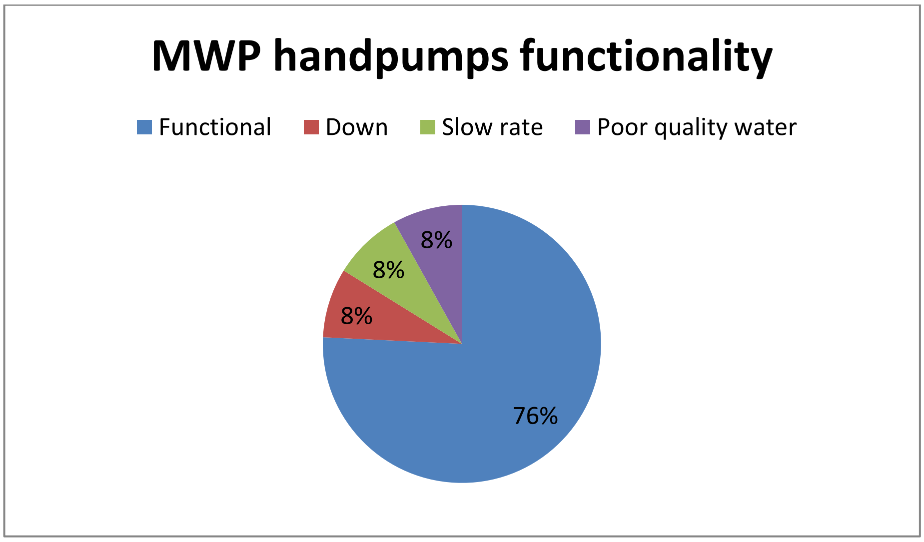
During the visits of 16 localities (four months after the last maintenance visit by MWP), a total of 24 handpumps were observed:

On 18 "Batimax" pumps visited, aged from one to four years at the time of our inspection, two had no problems (Manakambahiny and Analalava), 16 needed a new leather cup and one was broken (Antsiramihanana). On four "9m depth" pumps visited, all four were in good condition although one produced poor quality water and some screws were stolen (Ambilan'ny varanta). By only accounting for the Batimax handpumps, we can affirm that a minimum of 16 handpumps, that presented used leather cups, are under the risk of overuse. Therefore the demand can be confirmed within these communities.

On the 24 visited handpumps, two provided very slow flow (Kalomalala and Antsiramihanana), two were not functioning at all because of important repair requirements (Tsivangiana and Ambodivaro), and two other did not produced drinkable water (Sondrara and Ambilan'ny varanta).

This gives a rate of 75% functionality before undertaking maintenance. After repairs, three were fixed and were able to distribute clean water again (Ambodivoara, Tsivangiana and Antsiramihanana). The two handpumps remaining in Sondrara and Ambilan'ny varanta were still presenting poor water quality issues. In Sondrara, villagers have access to another MWP waterpoint but this situation has inevitably lead to a higher demand, and therefore to a higher risk of misuse.

Unfortunately, at Ambilan'ny varanta the population does not have any other choice than to rely on surface water, according to some villagers during our visit. Indeed, a Canzee pump was also installed by another NGO years ago, but the pump has also been dysfunctional for many years.



(Figure 6.4: MWP handpumps functionality)

The last 20m depth MWP handpump, in use for private testings

One of the two open concrete wells in Ambodivoara

On the 4 non-functional handpumps recorded, two had their pipe broken (Kalomalala and Ambodivoara). For both there had attempts to fix locally with plastic bags tightened around the pipe but the results were not satisfactory. In Kalomalala the handpump had a very low flow (at Kalomalala and Ambodivoara), but was still largely used, even if another working MWP handpump was situated 200 m away. This confirms the high demand in this community. However the MWP handpump in Ambidovoara was abandoned and people returned using the open concrete wells.

"People have always collected water from these wells and they are close by." Says a villager.

Indeed, the two concrete wells are less than 100m away each other and from the broken MWP handpump. The handpump has been repaired and is now producing clean water. These examples show the difficulties that communities faces to fix cracked or broken pipes. However this was not the case in Andavakimena, where people were able to use local material to fix several holes in the pipe, resulting in a satisfying yield resulting.

It has been highlighted by the MWP team that, often broken pipes are the result of damaged wooden supports. The handpump weight is therefore no longer supported and can lead to pipe failure. In the MWP (December 2017) report, MWP 26, 13, 10, 11, 21, 17 tables were reported to be damaged and were all repaired by the team. Only the case of Ambodivoara presented a broken table and pipe. This problem is not new, according to the team, as in Analalava the pipe was been broken as people were using too much force on the levers of the "9m depth" pump.

According to the MWP team:

"The "9m depth" handpumps are more resistant than Batimax pumps. They need less maintenance interventions and also have slightly higher depth capacity (i.e: 8 meters). However, the maintenance tasks are more complex than Batimax pumps."

"The Batimax pumps are resistant and are mechanically simple. Yet they need recurrent maintenance tasks especially the replacement of leather cups. Their depth capacity of 7m is low comparatively to others pumps on the market. Their simplicity suggests that their maintenance tasks can be done locally with minimal external support." (MWP, 2018)

(Batimax pump characterisitcs, see Annex 11)

A complete report of the visited MWP water points is available in the appendices.

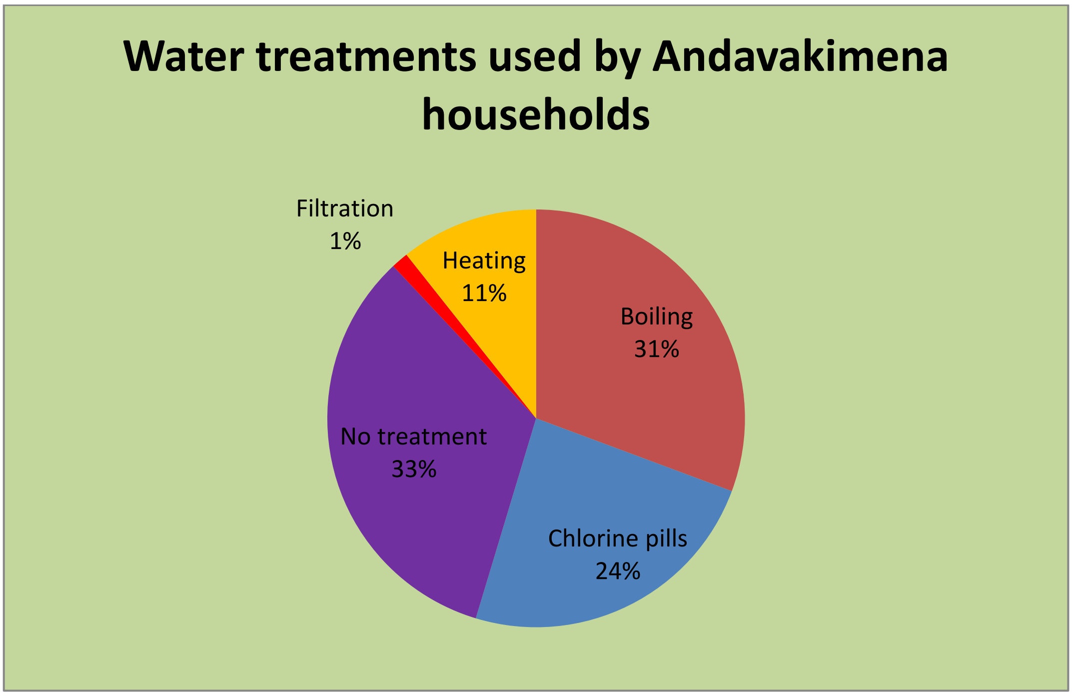
6.5- Water treatments

People use the same water to drink that they have boiled for cooking rice. This traditional beverage is called Rano'Ampango.

During the households survey held in Andavakimena ,74 families detailed what treatment methods they used before consumption.

Table 6.5: Households' water treatments

Treatment	Chlorine pills	Boiling	Filtration	Heating	No treatment
Nb. of households	18	23	1	8	25



(Figure 6.5: Households' water treatments)

7 households explained not using Sur'eau pills because of its strong smell and taste.

6.6- Drilling technique and handpump installation

When the handpump site has been decided then the team starts drilling the borehole with the augering method. The helicoidal auger head is fixed to a rod which is rotated manually by operators with the handles. Soil is brought towards the surface into the auger head as long as it penetrates the soil. Until an aquifer or unbreakable layer is encountered, the auger head is regularly uplifted to be emptied and then replaced into the hole until the desired depth is reached. Other rod sections can be added up for extending its length and pursuing the ground penetration.

	
The MWP team starting to drill in Ambodivaro	The auger is emptied and put back in the soil for continuing the drilling

When the groundwater is finally reached, the filter (stainless steel or a PVC screen) is fixed at the extremity of galvanised pipes that are added to reach the aquifer. The screen, which is one meter length, is totally submerged into the aquifer. At the surface, the check-valve is fixed, then the handpump body which is finally installed on a wooden support. Finally, a cement slab is built around the table.

The team introducing the filter and the galvanised pipe into the borehole

The stainless steel and PVC screens (1m length)

MWP generally uses galvanised stainless steel screens and galvanised pipes because of their solidity. Indeed, in order to make it penetrate into the soil, they often have to hammer the extremity of the pipes from the surface. Plastic components could not support the chocks. After unsatisfying drilling attempts in the community of Ivato, PVC screens and pipes were used as all the components were introduced (by community request) inside the communal concrete wells of the localities.

7- Environmental

7.1- Source water characteristics and analysis

For economic and technical reasons, MWP focus on communities according to a few criteria:

- Important need for clean water but ideally within reachable location to minimise logistics issues
- Suitable geologic characteristics such as shallow aquifers (ideally less than 7m depth), fragile layers such as sandy soil.
- Community willingness to manage the future water point, essentially evidenced by the establishment of a water committee.

The MWP team undertake drilling operations only during two seasons: September to November, and April to June. During these periods, aquifers are at their lowest levels.

During the research study, MWP received a call from the Mayor of Marosiky requesting a handpump implementation. The locality is on the south of Vatomandry, and there is limited knowledge of this site from respondents. During the first visit, the environmental parameters were evaluated. When a potential community is selected, Mr Larry Rabenorosoa, the geologist of the team, undertakes preliminary analysis through a transect walk to assess the different water points within the community. This includes interviewing local authorities and/ or individuals about water source location such as communal wells and individual pumps as well as the different surface waters including lakes or water courses.

During interviews, some information is crucial, such as the sea level during a cyclone, the location of water points with salinity issues, the differentiation of water level throughout the year (inside wells or rivers…)and, the depth of borehole of the individual handpumps.

Assessment of a communal well	Discussion with the owner of a "Tany" handpump	Assesment of a riverwith daily salinity variation

By mapping on a GPS the different water point locations and the different level of water tables, he can integrate this data with a topographic map showing different elevations within the community, and produce a theoretical piezo-logical map suggesting the potential water table levels under the ground. For assessing the characteristics of different layers of rocks some stratigraphic measures are often helpful, as water tables levels depend on permeability of the different rock layers. In August 2016 the team made stratigraphic test holes in Ambodivoara and Tsivangiana. Some basic maps are available online from different sources (Annex 14).

In Ambodiramy, a community of 350 inhabitants rely on one bucket well with 7m water depth. A request from the local authorities with the support of Peace Corp Volunteer has been sent to MWP for handpump installation.

According to MWP:

"*The well was drilled to a depth of 9 meters. The upper portion of the hole was sandy, but the lithology changed to a light brown clays-rich siltstone at 4m. The top of the water was encountered at 6m. Since there was free-standing water in the hole, a screen was set before handpump. After several hours of pumping during two days, no sustainable flow was achieved. The well was abandoned. The need for clean water in Ambodiramy is quite extreme. The MWP will continue to develop a way for providing water to this village and other ones with similar needs*."

"*Ambandrika is a community of 60 households for about 300 inhabitants relying entirely on a river for water. The village is not accessible by car so 20 minutes walking is required. Located on a12m high elevation comparatively to the stream running along the south side of the village, a core hole was drilled in August 2016 and good quality sand was found starting at 6m. As water table was not yet reached, we pursued drilling until 9m depth. Good quality of rock and water were found at 6.8 m depth which is approximatively our pumps limit. We decided to install a direct action (Bushproof) handpumps, well-known for their deeper well capacity. Since BushProof cut the pump kit for a 9 meter hole and the casing became stuck off-bottom at 8 meters, we were not able to get the proper valve spacing to produce water. This system or something similar has great potential for expanding projects into many areas where top of water table is deeper than 7m.*" (MWP, Phase III Programme report of Sep-Oct 2016)(p.8-11).

Although unsuccessful initial attemps with Canzee "Bushproof" pump, MWP is willing to develop the use of these deeper capacity pumps in the area.

The cement slab with the date of installation and the handpump reference number

Groundwater resources will be abundant in the area for many years to come as there are plenty of water courses in the region. However, as we have seen, in some sites very poor aquifer quality can be encountered. Furthermore salinity is a major concern in the coastal areas, besides other chemical parameters that are equally important.

Basic chemical and bacteriological analyses are undertaken after each drilling process (source MWP). These are done with water quality test kits that allow in-situ analysis which indicates the chemical water composition and the presence of E.Coli bacteria (responsible for diarrhoeal illnesses).

These analyses are not done regularly at each waterpoint during the scheduled maintenance visits but are instead conducted when suspect water appears. A basic water quality test costs between 30$ to 60$ and allows to make approximately a dozen of samples.

Completing regular analysis is a major issue that will be difficult to overcome. Indeed there is no laboratory in the region. The only way would be to transport samples from the point of collection to Antananarivo the capital which is at least a 12 hours journey whilst the samples need to be kept refrigerated and analysed within less than 24 hours.

In Andovona for example, despite the water having a light red coloration and an odour, people still continue to use this for drinking.

"*We are used to it because before the handpump installation people used to collect water in a lake in proximity with the same but more pronounced characteristics*," commented some villagers.

In Sondrara, one MWP handpump provides salty water, so no people use it. The community has requested a removal for another location. This will imply further analyses.

"*We need another pump, or the one producing salty water could be moved. We are too much relying on the unique pump. We often have to queue more than 30 minutes but it is worst in the afternoon when we come back home after the fields*" declared one woman member of the Water Committee.

In Ambilan'ny Varanta, the water is red and smells bad. No people use the handpump as villagers confirm having no appropriate water sources and are obliged to collect water from the rice fields in proximity to the Canal of Pangalanes. Unfortunately this seemed to be the case after a visit within the community even though they are surrounded by surface water.

After the site visit and arrangements between the different parties, the MWP team asks the community to propose three locations that would suit them for the handpump installation. A last analysis of the proposition is done essentially on the basis of:

- Potential environmental pollution risks
- Accessibility of a maximum of users
- Ease of the drilling processes

It has been contested that all the handpumps installed by MWP are far from latrines (more than 60 meters away). However it has been observed that latrines are often simple holes disseminated in the backyard of houses and hidden by simple walls of leaves. This suggests that the soil have high risk of contamination. Knowing that water table are shallow in the area, the risk of contamination amplified.

The apron slabs installed by MWP seems to not be appropriate for water evacuation as in almost all water points, water has been stagnating in the direct vicinity of the handpumps, increasing the risks of dirty water infiltration and insect proliferation.

Deforestation is noted to be extensive, resulting in poor soils and diminution of natural purification processes. The implementation of massive extractive industry requiring large quantity of woods as energetic resources has also been recorded for the production of chrome. No control of rejections seem to have been put in place, resulting in the assumption that this is dumped in the water courses including the Canal of Pangalanes, which is also used by population for bathing, clothes and dishes washing.

There is evidently a clear lack of knowledge of hygienic behaviours to reduce the propagation of diarrhoeal diseases, as people urinate in the vicinity as well as keeping their cattle along the canal shoreEven if the pollution risks are numerous, deforestation for wooden charcoal production (the principal combustible resource of Malagasy population) and open defecation are visibly the major problems that need immediate attention.

Clearly further bacteriological analysis needs to be conducted. The price of one bacteriological analysis at the Instituts Pasteur (Antananrivo) costs approximatively 20$ (see Annex 15).

Coliform presence test kit allowing the detection of eventual faecal contamination of water

Water quality test kit used by MWP team allowing to determine the chemical composition of water

7.2- Pollution risks and protection

The MWP team asked communities to propose a location of their choice for the handpump. They then decide if it is suitable or not, taking into account pollution risk and accessibility. All the handpumps of MWP are far from latrines. However it has been contested that latrines are often simple holes in the backyards of homes, meaning that the soil has a high risk of contamination. Knowing that the water table is shallow the increases the risk. Deforestation is known to be massive, resulting in poor soils. Massive industry wastes are not controlled and assumed to be rejected into water courses including the Canal of Pangalanes.

The canal of Pangalanes is also used for bathing and clothes washing. People used to urinate in the vicinity, and to bathe in the canal. All animals such as cows and ducks also live all along the Canal of Pangalanes. People used to wash their kitchen utensils in the canal. This proves a lack of knowledge of hygienic behaviour for reducing contamination and related diarrhoeal diseases.

8- Institutional

8.1- Water infrastructure implementation procedure

Implementation of a water point in a community is done on demand. Discussion between Municipality, President of fokontany, social leaders (i.e: Tangalamena) and MWP are made. When an agreement is found, MWP team requires a formal request from the *fokonolona* (community council) signed by the President of the *fokontany,* including a list of users to indicate the potential number of households which would rely on the handpump. MWP also require the formation of a water point committee that must comprise six persons minimum, including the President of the committee, the Secretary, the Accountant, a Technician and the councillors. Women are also asked to integrate with the committee, but with no parity requested. The committee is in charge of recording the number of users, collecting and registering their participation and of producing a checklist of maintenance, with the technical tasks undertaken on the handpumps such as repairs and cleaning. The books are in three versions: one for the Municipality, one for the committee and community, and one for the MWP team. They are checked at each maintenance visit, occurring every 3 months. The next templates show the books structure:

Table 8.1.1: List of users

Family Name	**Nb of people in the household**	**1 – 5 years**		**6 – 14 years**		**>14 years**	
		Male	**Female**	**Male**	**Female**	**Male**	**Female**

Table 8.1.2: Users' Participation

Date	**Name**	**Participation**	**Signature**

Table 8.1.3: Maintenance tasks of the handpump

Date	**Location**	**Tasks undertook**	**Cause of the problem**	**Name(s) of responsible**

The registration of the committees is done at the municipality that gave them a legal status. This book recording was implemented during the maintenance trip of March 2017. Before that no listing of users nor book keeping of participation and maintenance had been requested, so monitoring and well-being of committee duty will be known on future assessment. However a few committees have already provided user lists (Kalomalala and Sondrara).

According to the different interview with sector professionals, each municipality should have a dedicated service for water supply service – STEAH (*Service Technique de l'Eau,* *Assenissement et Hygiène*), or Water Sanitation and Hygiene Technical Service. None of the municipalities where MWP works had this kind of service, but MWP is supporting the mayors and their delegates in these tasks by implementing step-by-steps these books recording. Each mayor was satisfied by the waterpoints installed by MWP as they requested much more in other communities, and have signed the contracts for completion and delegation of infrastructure.

The new platform implemented by the central government in Antananarivo is called PNPEAH (*Platform National de Promotion Eau Assainissement Hygiene*).

Today, MWP has dozen of requests, if not more, for handpump installations. All these demands include list of potential users. The requests are generally submitted by Presidents of fokontany or Mayors but it happened that some individuals have attempted to by-pass local authorities. Nonetheless, the administration process required a formal approbation from the local authorities and specifically from the municipality that sign contract of achievement and delegation of water infrastructure. According the national Water Law, the municipality gives authorisation of construction and is the unique “maitre d’oeuvre” (or legal owner) in term of communal water supply. When a community has received the authorisation of installation, community members must propose three potential locations for the future water point. After the MWP assessment and the final decision of the site, the property must be legally attributed for communal usage. This is done through formal contracts with Municipalities if it is on land own by the State or with individual owners if it is on private property.

In order to centralize all the data and allow intermediation between all the stakeholders involved in the WASH sector, the Central Government has implemented in 2017 a new platform called PNPEAH (Plateforme Nationale de Promotion Eau Assainissement Hygiene). It is the initiative for replacement of the former Diorano WASH Platform.

5- Discussion and recommandations

Community

As we seen, communities are the most important factors involved in sustainability of community management for water supply services. One of the most difficult challenge to overcome for maintaining durability is the raising of awareness of the different benefits that can be brought by an improved water supply services. Through this study, we have seen that communities will not participate nor value the necessity of a new water supply scheme if they are satisfied with their traditional water sources. Therefore sustainability is strongly related to communication and education.

By maintaining regular maintenance visits, the MWP organisation has developed a relationship of mutual trust. This is fundamental as it can be difficult to move towards maintaining sustainable services.

For instance, the importance of keeping the agreement with spiritual leaders and elders is critical, especially in regions of the country where this will be seen as sign of respect and acknowledgment of the community itself as a body. This is clearly in contrast to the majority of governmental or other projects that impose procedures or infrastructure to gain time. This community participatory approach is primordial for sustainable solutions.

A participative approache should always be adopted with a constant flexibility in attitude, by developing trust between the agency and the communities. This means giving alternatives to communities in decisions and all aspect of services management (such as financial and technical choices). It is therefore necessary to implement technical programs, management support and health sensitisation at all levels by developing partnerships with different key stakeholders. When looking for support, the communities should be able to turn towards different actors and be empowered to make decisions that will benefit their community.

If MWP is not reachable, as mobile phone are largely unavailable, communities should be able to collect information and advice from different parties, whilst not relying on one centralised source of decision-making that often result in mistrust in the long term and corruption due to individual power gain. This encourages development, and strengthens connections between the different water committees, the *fokontany* presidents, and the municipalities - but also the local health agents, school educators, the different NGOs active in the areas and other civil society bodies. Furthermore, the different religions such as Christianity (Protestant and Catholic) and Muslims are strongly practised in the region, and should be approached in order to increase the dissemination of hygienic behaviour change programmes. Some training could also be proposed in order to develop potential skills and abilities within these spiritual communities. Collaboration in monitoring tasks should also be established.

Almost all the communities did not have any savings, nor carried out regular financial participation for operation and maintenance. Only a few (i.e Kalomalala and Sondrara) have shown the ability to collect fund as reactive solution when the water point has presented deficiency. This concern needs to be considered very closely, as financial sustainability is one of the most important concerns affecting long term sustainability. Furthermore people may not understand the necessity of paying for services, and having the responsibility of maintaining their own water supplies.

To raise community willingness towards regular contributions, a clarity and transparency of the different costs involved in water supply services is necessary. Improving water committees and other partners' capacity will help to increase community understanding of their roles and responsibilities to maintain services over time, as well as the benefits of improved water supplies

Economical and Finance

The lack of regular savings is often related to mistrust between community members and local authorities but also the lack of prioritisation for improved water supplies. The assessment of seasonal variations of households' income has shown two tendencies. The hot season between September and January, which corresponds to the season of fishing offshore is the major economic activity in the region. During that period households earn more money but the demand for water also increases as water natural resources drop whilst the temperature doubles. This period also includes the harvesting of several products designated to worldwide exportation such as lychees.

Several cultural events are celebrated in the region, such as the Remembrance of Ancestors (or *Fête des Morts*), Christmas, the *Saint-Silvestre* (end of the year) involves important population migration. However, between February and August, temperatures and fishing catches drop, suggesting that household earnings do also. This should be considered in the analysis of willingness and ability of communities to pay for services. Some design plans for promoting multiple water usages could be implemented, such as eco-tourism activities supported with the presence of clean and durable WASH infrastructure and services, or market gardening such as promoted by the NGO Frère Saint-Gabriel in Toamasina.

Some fund savings and public mechanisms should be put in place. Such organisms are not present in majority of the communities reached by MWP and furthermore only a little proportion of the population knows about their principles. Creating trust for financial schemes within these communities is complex.

Local banking and micro-credit/financing systems are only available in the towns of Bricakville, Vatomandry and Mahanoro. This will involve consequent logistics and administration procedures. However, the mobile phone network has developed very rapidly in the region, and has now reached many more communities including Andovoranto, Tsivangiana, Ambodivaro, Marosiky, Sondrara, Vavony, Andavakimena, Ivato, and Manakambahiny. All mobile phone operators have payment and account holding services that are largely used throughout the country. The accounts are also publicly consultable. Creation of water committee accounts could be established in order to move toward a greater recognition of their status and, and the transparency of finance movement. For instance, people could participate according to the following estimates: 400 MGA per month per household, with an average of 150 inhabitants, the monthly participation average 15$ per month. This amount can be recharged by adding credits from any local shops. The mobile accounts could firstly be held (centralised) by MWP. This implies one account held by a water committee that can be recharged, withdrawn from and consultable at distance. Mobile phone payment systems are largely used in Africa and Madagascar with at least three service operators delivering the services throughout the country. These services are under the name of Orange Money, Airtel Money and M'vola and are now well-known by both urban and rural communities.

The support to communities for finance management suggests a precise awareness and knowledge of the different costs involved in service continuity. The water committees must be able to show and explain to users a list of the costs of repair or/and spare parts, being able to produce their own budget analysis and give their authorisation for the disbursement from their account. This can be done progressively as majority of communities will not be able to provide the total cost of a Batimax handpump body if one breaks. However this will give to communities more visibility on the value of their infrastructure, and will develop the vision of independence for decisions. Communities should be able to decide if they prefer to undertake the tasks themselves or contract a maintenance service. MWP could start progressively by requesting payment for leather cups that could be stocked within the different maintenance teams, or within municipalities. Of course all of this is supported by a common monitoring and book keeping from communities, water committees, municipalities and MWP.

Institutional

The MWP strategy on giving support to the Municipalities reflects their intention to develop a WASH Technical Service or STEAH within the municipalities. This increases national policy dissemination.

However, the flow of information on water services is clearly slowing. A network contributing to tconnecting different *fokotany* presidents of could be developed, as well as the water committees and the Municipalities. Each body should be provided mobile phone contacts for consultation with each other, or gather information on certain water service principles that would have not been thoroughly understood. This will also help to develop an atmosphere of common support between the different communities and increase the feeling of independence of decisions by an enabling environment and good communication.

In addition to health care services, MWP should also engage its support to other sectors such as Education by contacting the different national public schools. They could provide them (and children) some maintenance task training, and implement a hygienic behaviour change programme by explaining and disseminating the F diagram. They should also be regularly informed about the potential risks of pollution through the consequences of massive open defecation, deforestation and uncontrolled massive exploitation. They also should be encouraged with potential benefits through the creation of employments such as mechanics, services managers, environment protection projects and eco-tourism.

One of the most important stages that MWP must achieve is the sharing of information with the central authorities. This step will allow MWP to be introduced into the national database, NPREAH. This necessitates a formal request from MWP to the Regional Directorate of WASH services based in Toamasina , the capital of the Atsinanana region. This last one will proceed to a control in the field and validate the work undertook by MWP. The report will be transmitted to central government (Ministry of WASH in Antananarivo) which then will proceed to the registration of the infrastructure into database. The national database is available online at: www.bdeah-sesam.mg or by sending email requests to the dedicated service of the Ministry (see Annex 16 for contacts).

This procedure will have to be done on a regular basis in order to keep up a systematic updating process of the national database.

This will increase the official recognisance of the infrastructure that will develop the sense of ownership within the communities.

Health

Hygienic behaviour change will be durable only if it is inculcated since the earlier age. As it has been noticed, girls and boys participate actively at a very young age to the daily household tasks such as carrying jerrycans of water for boys, washing utensils in the canals for girls. The different generations need to be reached at regular basis but essentially through different sources of information and methods of communication. Even if school enrolment seems to be low with a low coverage of school infrastructure, educators and pupils are still an important layer of population that can have an important influence on the dissemination of hygienic behaviour change. Visuals tools such as advertisements or posters regularly updated are easier to remember with a more pronounced psychological effect. Some training programme of maintenance tasks could be arranged with educators and students as well as accounting and management support. In addition governmental health agents (A.C), a partnership with healthcare NGOs should also be considered within network.

Few NGOs such as Armada (see at: http://www.ar-mada.fr/) and Sahambala (see at: https://www.sahambala28.fr/) are working in regular basis in the same coastal eastern areas.

Armada organisation is regularly providing free healthcare services by following the canal of Pangalanes to reach very remote communities where health agents and health centres are cruelly lacking. The team has been approached during one of their visit in proximity of Andovona. They say to regularly having cases of diarrhoeal diseases with major part on infants. Generally people do not make the link between poor quality water and illnesses as people in this area have always used surface water as drinking water sources.

Firstly as a volunteer doctor for the Health Base Centre of Brickaville, the doctor Fournier is now providing periodic healthcare services for Sahambala in Vavony, Andavakimena, Ambila-Lemaitso…). He has expressed his will to collaborate in any manners that will support hygiene sensitization. He has also underlined the lack of communication between the different organisations resulting too often to redundancies in actions. He said:

"Even if diarrhoeal diseases cases are frequent in rural remote communities, the rate of these illnesses is more than alarming in small town such as Brickaville."

Unfortunately, this is also confirmed by MWP team.

Environmental

Chemical and E.Coli presence tests should be done on a regular basis, at least one or two times per year. They should also made public and provided to water committees, health agents and the Municipalities.

Furthermore even if land or property accessibility means limited space, the MWP apron slabs should be built in a way which allows adequate evacuation of waste water. For the majority of water points, a lot of water has been noted to stagnate in the vicinity of the handpumps, leading to unhygienic conditions and increasing the risk of contaminated water infiltration or insect breeding in the area.

Fencing should also have doors not allowing the eventual access of animals.

Environmental data should be accessible and monitored in a regular basis. For instance, wells should be constructed in a way that thewater table could be measured when necessary as is in Ivato, with handpumps installed on concrete wells on the community request.

Technical

The restoration and improvement of existing traditional water sources should be considered and discuss with the communities. These include covering hand dug wells, encouraging different water treatments, developing adequate rain catchment systems…The example of Ivato shows that if handpump would come to break down people could still have access to an improved water source. This suggests the importance of giving the choice of technology to community members. Indeed convenient solutions seem restricted. For instance several non-functioning canzee pumps were notified in the areas. Thanks to Bushproof advices, the President Patrick Behra of “Homme et Environment” has given his approbation for the restoration of the old canzee pumps installed by the NGO. Discussion between Bushproof, Homme et Environment and MWP are in progress.

The concern of spare parts availability does not give much alternative than importation of goods from abroad. Fortunately, even if they are limited, some transfers of technology has been made from abroad (Nicaragua) to Madagascar. However, the rope pump technology has not yet reached the eastern regions which are already leader in manufacture of the local Pitcher pumps (or pump “Tany”). More researches could be done in this subject area.

Still in a concern of durability, borehole development should be improved with cement casing in order to allow eventual corroded pipes replacement and letting the access of borehole for environmental data recording with minimum damages. Indeed we know that the flux of relevant information in regular basis is fundamental for obtaining sustainable services.

Conclusion

Since 2012, The MWP has taken the challenge of providing durable and improved water supply services in remote areas of Madagascar. Between the towns of Brickaville and Mahanoro (east Madagascar), they are now implemented within more than 30 localities. Access to clean water is unconditional for reducing diarrhoeal diseases and child mortality. They are not the first having tried such challenge and unfortunately not the last. Indeed we have seen throughout this research study these factors need to be treated in the same time: Institutional, Economic and Social, Environmental and finally Technical. Even if there will always be something to improve, in some aspects MWP is doing really good such in thedemand approach and social reflexions. However, financial sustainability is at risk. Furthermore, the consequent lack of spare parts availability increase the reliability of communities on perpetual external support. It is why, MWP should also consider the rehabilitation of traditional water sources as they have done in one community. Also proposing to different choices of technology is based on the same insight of letting people choosing their financial participation. However, as any core factor involved in water supply project, community members should also be provided with the right information. They must know the different costs involve in their services in order to give them the choice. This research aim is far away of will of giving lessons anybody as MWP members are the one on the field since almost six years. Also it is sure that many other WASH actors have acquired much knowledge than somebody could take. Indeed, this research study tries to bring on the table what all these people have experienced and permit to give the choice of different low cost and potentially durable alternatives. With limited resources and difficult environment (Institutional and Natural), the MWP service coverage is more than impressive. Henceforth the requests for handpumps installation seem to not stop to fall. Is it more judicious replying to a maximum of communities in cruel need of fresh water or to focus in fewareasto see what could be working sustainably without external support in the long term and then try to replicate this system? Time will tell.

Discussion with Bushproof
RANAIVOJAONA, Serge (Directeur General)

As a private company, we work according to the clients' requests. We sell our Canzee pumps, but as we also specialise in drilling, for many missions we frequently only drill and install other types of pumps chosen by customers.

Among the homologated hand pumps in M/car (Rope pump, Canzee, Indian Mark, Vergnier), the Canzee pump is suitable for coastal regions. It is manufactured locally, with a minimum of metallic parts (apart from a stainless rod), meaning that there is no corrosion problem in comparison to other types of pumps. This pump can easily last seven years, and its maintenance cost is low (about 5 US$ per year or 20,000 MGA).

The price of an apron slab is about 900.000 MGA, and the pump is sold at 1.800 000 MGA (the pump body is 1.500.000 MGA, plus a stainless rod 300.000 MGA).

For the east coast regions, hand augering drilling is the appropriate method. We do maintenance tasks on request. We work in the long term with companies and others ask only for punctuality. A private manager, in a semi-urban locality close to the capital, we provide water supply services with a Canzee pump installed in 50 waterpoints. The water tariff is 2,000 MAG per month. Similar projects may not be financially viable with less than 50 waterpoints.

Discussion with the Malagasy NGO Frère de Saint-Gabriel (21/06/2018)

We are an NGO, financed by external donors such as WaterAid, who was our major financier -but also from American funds such as CRMF. They call us for implementation and WASH sensitisation. We decide which community to approach through demand by mayors and the population. We put in place a committee; according tothe place it may have one committee for several water points. We install committees before infrastructure installation. It is important to collaborate with private entities, for the formation of committees, and for the support of management. Local Privateare influentional actors within communities, as they know how to get money, (they are very efficient within poor populations).

Municipality are the *maitre d'oeuvre*(they own the infrastructure), and often mayors are more self-interested rather than concerned with their constituency. We do have the duty to train Municipality staff, and to remember the other collaborators such as *mayor delegate*, *chef fokontany*, *chef sectors*or *chef carreau*. It is important to consider gender parity: sometimes it is better to include more women than men in water committees.

For the construction of gravity-flow systems, we call for bids from private companies. In general, it is the villagers who give land for water points, and when the communal taps are delivered, the community do not call us any more for support. They own the system, and are supposed to be able to collect funds themselves for eventual repairs. In general they contribute monthly, with amounts decided commonly.

We do occasional field visits. There is major concern about open defecation in the countryside due to the lack of sanitation infrastructure: this leads to increased pollution of groundwater.

We provide one water filter and one latrine per household in order to contribute to the diminution of respiratory diseases. We provide jobs by selling locally made water filters for 65.000 MAG, concrete wells for 45.000 MGA, sections of 1m diameter and 1m of lengths, and provide installation of Ecosan toilets for 4 million MGA. We also promote reforestation and teach techniques of rain catchment methods and water reduction methods within households.

In 2010, we ordered and installed -in Fenerive-Est (north-east Madagascar) -15 canzee pumps from Bushproof, that cost 1.300.000 MGA/unit. They are very interesting pumps with no metallic parts. They are not working any more due to lack of maintenance.

One of the major issues for sustainable services is adequate drilling methods and choice of technology. Some wells if well-constructed can last more than 30 years. In Fenerive East one has lasted almost 50 years. It is obligatory to drill during *etillage* period (i.e September-October-November, the driest seasons) in order to always reach groundwater. Even gravity flow system projects should respect the *etillage* period rule. We have a technician team specialising in manual drilling. This technique is essential, especially for reaching and working in remote rural areas, where motorised drilling techniques would not be possible. At present our drilling team is in south Madagascar, in Orombe region, where we are also implanted. Canzee pumps are adequate for 15 meters depth. India Marks go deeper and are more solid, but are the most expensive pumps (+ 2 millions MGA), essentially because of their long pipe.

Discussion with SMEF

We sell India MARK III (VLOM) but we do not do drilling.

Discussion with SOMECA

We sell Vergnet pumps that have been used by many international NGOs for several decades for different WASH projects. We also ensure maintenance services. Our pumps cost between 10 and 11 millions MGA.

Discussion with BATIMAXX

We sell India Mark II and Chinese imported stainless handpump (*fonte*). We do not install the pump, and do not have leather cups in stock.

Discussion with FIKRIFAMA
(HANDRIANARIJAONA, Bruno –Quantitative Researcher Coordinator, and
RAKOTONJAINIARIVO, Oelinandrasana Herizo –Technical Coordinator)

We are a Malagasy NGO that installs handpumps for semi-urban to rural communities. We have preferences for the India Mark II and II that are sold by SMEF and SMTP. We think they are the most suitable because of their durability (resistance), spare parts are accessible, frequency of repairs is low and span life can last between 5 to 10 years. The problem with Canzee pumps is due to their plastic (PVC) components: they are fragile, and are too placed too low because of their dimensions. Their mechanism of pulling and pushing (“T” handling) is not convenient for the women who collect water in our society.

However, the leather cups in India Marks need to be replaced quite often, and is the weakest part of the system. They are often replaced by local leather cups that are of worse quality. The pump also needs regular maintenance as oiling. The rod can break if it is not properly installed. We do not do hydrological studies, but work in partnership with specialists, such as “Arc-en-ciel”, “Artelia”, or universities. The bodies able to do physico-chemical analysis are JIRAMA and the Institute Pasteur in Antananarivo.

We do first approaches to communities, and support sustainability. We put in place the connection between all these actors (donors, municipalities that are *maitre d'ouvrage* or owners of infrastructure, and the local authorities, traditional leaders or tangalamena and *fokonolona* (Community Council). When everything is reunited with all authorisations, we put in place the project cell that will collect local material for future infrastructures. This is to build ownership within the communities. The *fokonolona*must elect eight people to form the Water Committee. We support projects generally for a period of two years before leaving the infrastructure to the community. We often provide computers to municipalities in order to support them in STEAH services.

In addition to the lack of resources, the major issue is the lack of connection or relationships between municipalities (STEAH) and the Regional Directorate of water, and between Municipalities and Water Committees. We support Water Committees called (*Comité de Point d'Eau*) for their legal status and duty, and to implement directives (such as scheduling, maintenance tasks etc…), and decide water tariffs in accordance with investment costs. Generally it is monthly participation and per households. We also form one technical responsible for each water point. Funds are placed in microfinance organisms in order to validate frugal spending. We help committees with book keeping for their accounts. We promote community management and ownership, and do not work with private organisations. We work according to the Regional Directorate of Water database, or in direct relationship with Healthcare Base Centres. There are examples of “exploiting managers” (g*estionnaire exploitant*), such as Sandandrano, who take the management of existing infrastructure, and “investor managers” (*investisseur gestionnaire*) such as GRET, who invest 10% of capital cost of infrastructure and before to undertake management duty.

<u>Discussion with Rano Wash (17/07/2018)</u>
(RANDRIAMAHERISOA, Dr Alain –Chief of Party, RANO WASH Project)

Rano WASH is a consortium of USAID, CARE, Catholic Relief, Bushproof, WaterAid and Sandandrano. The project is financed by USAID.

In 2018 we are starting to work in Atsiranana region (eastern region), and five other regions. We have chosen these regions because of their low rate of water access, low numbers of WASH projects and malnutrition rates. The three objectives of the Rano WASH project are:

- Reinforce governance and monitoring of WASH sector
- Increase private sector involvement in WASH supply
- Accelerate hygienic behaviour sensitisation

1) The Ministers have created a database (BPOR and SESAM or BDEA) which are complementary. The Diarano WASH platform has just been stopped by the minister of Water, because it was firstly created as a service of water in the Ministry of Energy and Mines. When the first ministry of water was created in 2008, overlapping started to occur as the Diorano WASH office started to take the leadership and do the job of a ministry. In exchange for the Diarano WASH platform, the new Minister has created the PNPEAH (*Plateforme Nationale de Promotion de L'Eau Assainissement Hygiene*).

CARE has the lead for governance (policy and strategy) and monitoring (thanks to the SESAM database). We are here to reinforce the Ministry of Water by building capacity and enabling an environment with appropriate strategy and policies, and to make it the central leadership of coordination of WASH programme at the national scale. Every stakeholder can therefore contribute through the platform.

2) Now we want to increase the private sector by professionalising (or privatising) the water sector. We want toget private bodies to manage water infrastructure (pumping, gravity, dams etc). So we need to control the procedures and management of these private companies. 15-year contracts are drawn up, and they bring 10-20 % of infrastructure budget (they have to ensure, maintain, extension etc).

They need to make a profit. These private companies have to produce different business plan scenarios, and propose them to the Municipality, as it is the Municipality and Users Committee that would decide the price of water. Our role is to create these new private jobs and to professionalise them in 4 categories (study and analysis, construction, management and the builder / manager / investor). This is 10-20% of the capital cost of infrastructure. The appropriation of infrastructure is for the Municipality, private companies just sign a contract with Municipalities for management rights: this is why the governance part is important. There are 600 municipalities in these 6 regions, but we have only targeted 250 municipalities.

3) Behaviour change through communication: we have created a sharing centre, Learning Hub, in partnership with the London School of Hygiene and Tropical Medicine (LSHTM), to bridge the gap between the WASH sector and healthcare, nutrition and environment. We work with schools and health base centres, but also directly with communities through AC (Agent of Ministry of Health), and in addition have Rano WASH agents, called TA (*Technician Accompagnateur*), two per Municipality formed for CLTS methods.

We have regional teams who work with implementing partners (local NGO and associations) who work in the field with AC and TA. We are also in partnership with universities, and all international NGOs like UN, WWF, Civil Society Organisation…

We do not have a handpump project as they serve few people: we are focused on piped schemes. However, we are interested to enter into a relationship with MWP, because it is difficult to bring private companies into small communities as they are not interested in working for small communities adopting community management. Small scale water supply needs local technicians, as maintenance is a major issue. It is important to support Municipalities to create STEAH. Mayors are elected people, so they may promise something for being elected and when they are elected they are free to not respect their promises. The goal of the STEAH is to not be associated with politics.

<u>Discussion with WaterAid (06/07/2018)</u>
Interviewee: RAMIFEHIARIVO, Jacob –Project Officer

"We have three departments: Programme (with technician), Advocacy (social and governance), and Administration and Finance.

We do not work with unique technology: we choose the technology according local conditions. Projects can be based around pumping, well drilling, or gravity flow water supplies.

We choose from the poorest communities, with the most urgent water and sanitation needs. We have worked throughout the country since 1999. We work in urban / semi-urban and rural communities, either Municipality or *fokontany*. In the past we have worked in Eastern region in the north of Toamasina In Fenerive-Est, running motorised pumping projects.

Participative approach:
Our goal is to delegate the water point to the community by implementing management mechanisms, creating ownership. The community through its committee (CPE committee de Point d'Eau) decide the location of the waterpoint, such as a communal water tap. We work on demand from the commune or *Fokontany*. We require contributions from users. There are no applied tarrifs, but they contribute with local material such as sand, stones etc…

We instigate one CPE per waterpoint. They need to collect funds for each water tap or water point. All the CPE are grouped in the AUE network (Association des Usagers, or Committee de Gestion du System), which is the system management committee.

For example, one reservoir is built to deliver water to ten *fokontany*(with one water point per *fokotany*, thus one CPE per *fokontany*). If a pipe is broken between the reservoir andthe waterpoint, it is the AUE's responsibility to pay and repair the pipe. However, if problems occur at the waterpoint, it is the CPE's responsibility to pay or fix it. The communities have to decide on their contribution (for instance 500 MGA per houshold, per month). 300 MGA is alloacted to AUE, and 200 MGA to the CPE.

The Municipality or Commune is supposed to have a STEAH (Service Technique de l'Eau Assainissement Hygiene). This is not automatically carried out, so we install at least two local technicians per Fokontany (for cleaning reservoirs, repairing filters etc) This is during the work of installation (they are paid by the community).

We work with NGO recipients: some associations for "soft" projects to install AUE and CPE, and to give them legal status, and with private institutions, known as "hard" for infrastructure. We work in collaboration with the Education ministry, and we produce guides for WASH sensitisation to different actors, doctors, and leaders. We work with the Ministry of Health, as well as the Ministry of Communications. We used to work in collaboration with the platform Diarano Wash, installed by the previous minister: it is the platform used by all WASH sector actors. We talk to communities (Fokonolona) to ask if they are willing to participate in a project, then we open projects to tender by private companies.

We respect the international norm for drainage, as we cannot promote hygiene if dirty water is stagnating in the vicinity of a pump! We support governance building capacity, so we give our database to ministries such as:
BPOR (Budget Programme par Objectif Regional)
SESAM (suivi evaluation assenissement Mada)
When we undertake a project in a region we report it to the *Direction Regional:* they enter the data in the national database (we often provide computers to local authorities). A Commune should work with *Direction Regional*to report if a tap is broken.

With other partners such as Wateraid and UNICEF we are still trying to install a spare parts network. Networking in general is necessary, and needs to be reinforced in order to disseminate information effectively. We do monitoring, and produce a PIMS (Post Intervention Monitoring Survey) every one, three, five and ten years.

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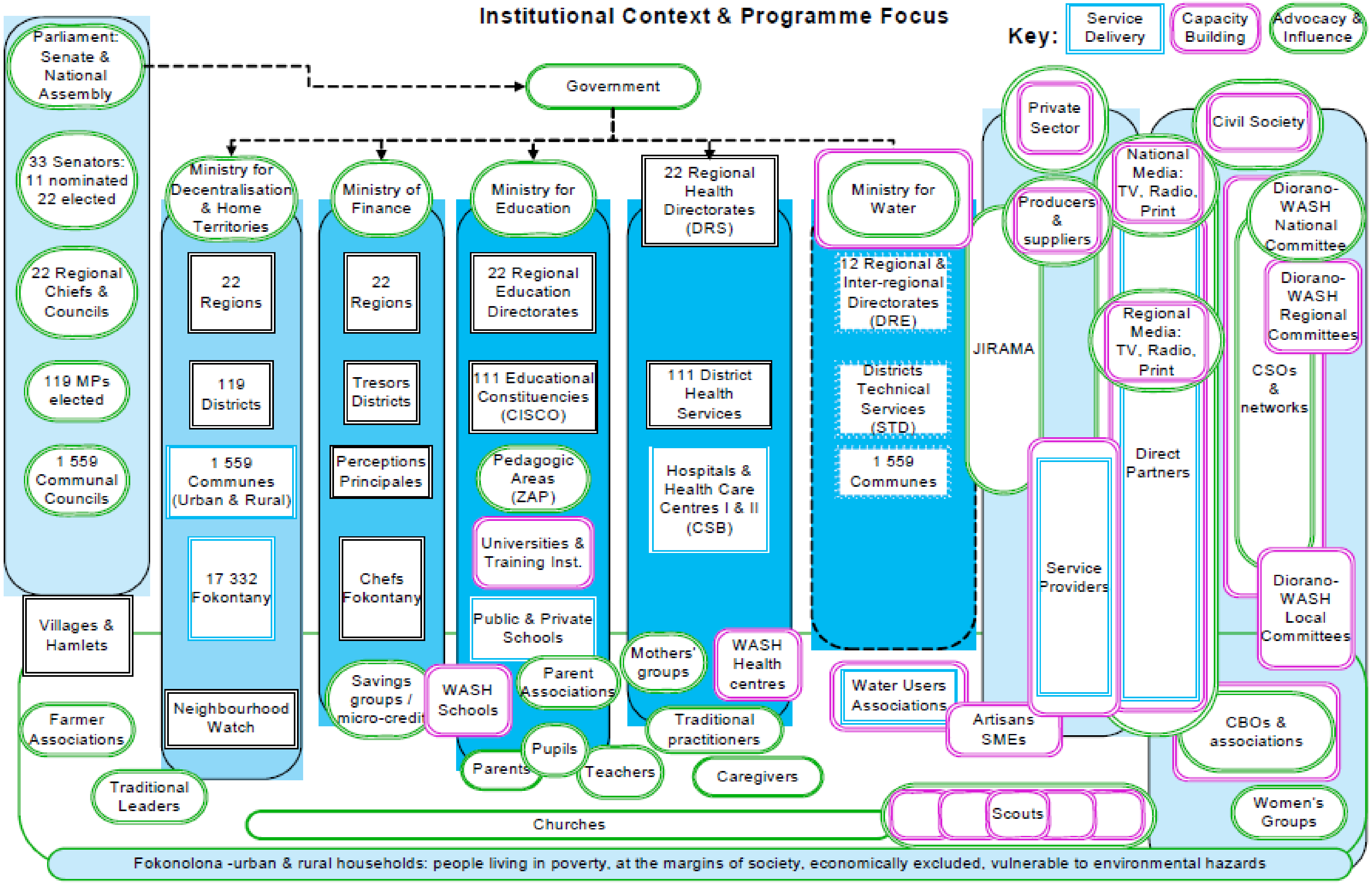
Annex 1

Related UNICEF Strategic Plan 2014–2017 outcomes: 1: Health; 3: WASH; 4: Nutrition; 5: Education; 6: Child protection; 7: Social inclusion							
UNICEF outcomes	**Key progress indicators, baselines and targets**	**Means of verification**	**Indicative country programme outputs**	**Major partners, partnership frameworks**	**Indicative resources by country programme outcome** (in millions of United States dollars)		
Outcome 2. WASH By the end of 2019, households and communities have access to safe drinking water, sanitation, and healthy environments and good hygiene practices are equitably improved in target regions.	Percentage of population in rural areas using an improved source of drinking water *Baseline:* 35% (JMP 2014) *Target:* 50% Percentage of population in rural areas practising open defecation *Baseline:* 48% (JMP 2014) *Target:* <1% (in 2018)	Ministry of Water, UNICEF records House Hold Survey (HHS), Census, JMP report	**Policy and capacity development:** By the end of 2019, Government demonstrates increased political commitment and capacity to legislate, plan, budget, coordinate, deliver, monitor and evaluate WASH interventions at scale at national and subnational levels. **WASH in health, nutrition and education centres:** Community-level institutions have strengthened capacity to promote the use of safe water and latrines, and hand-washing with soap by children and families. **Sustainable access to safe water:** Community demand for sustainable safe drinking water sources is increased and met. **Sanitation and hygiene:** All communities eradicate open defecation and use improved sanitation facilities in combination with appropriate hygiene practices.	Ministry of Water Ministry of Health Ministry of Education (MoE) Ministry of Finance Ministry of Decentralization Ministry of Communication Regional Directorates ADB EU JICA USAID Civil society	**6.2**	**17**	**23.2**

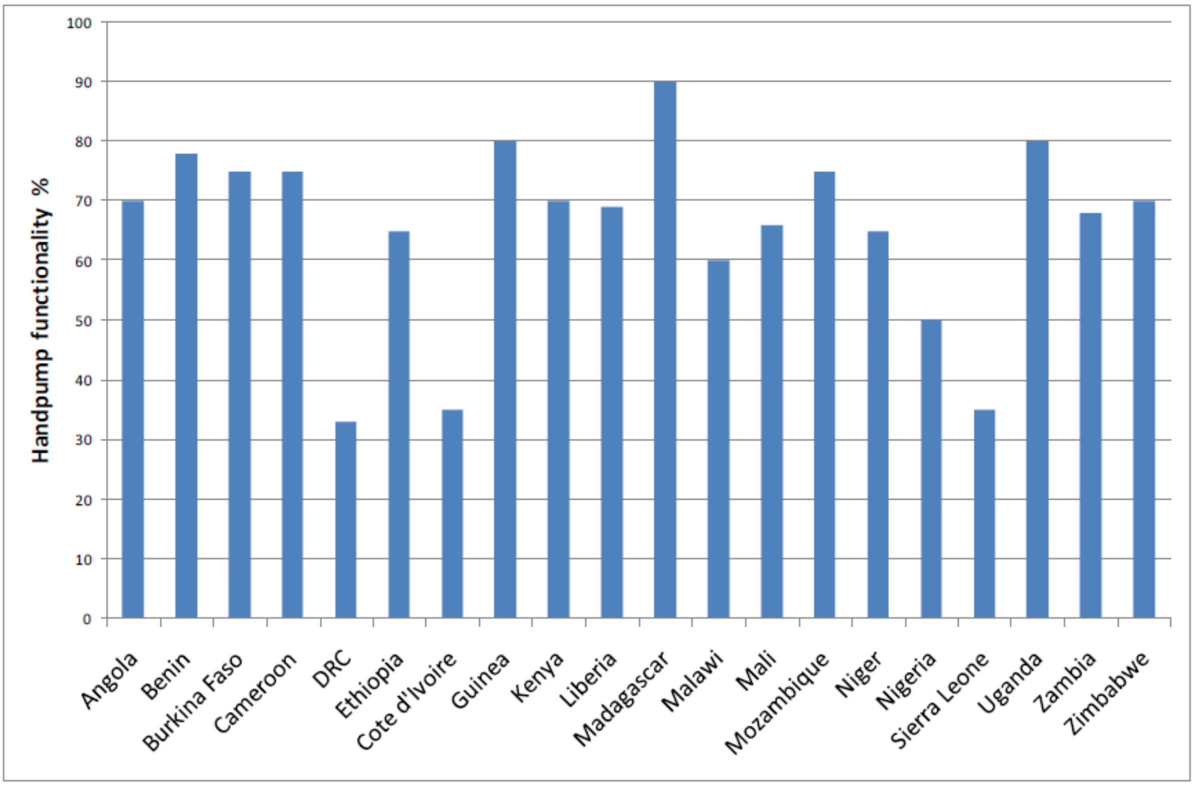
(UNICEF, country programme document 2015-2019)(p.13-14).

Annex-2

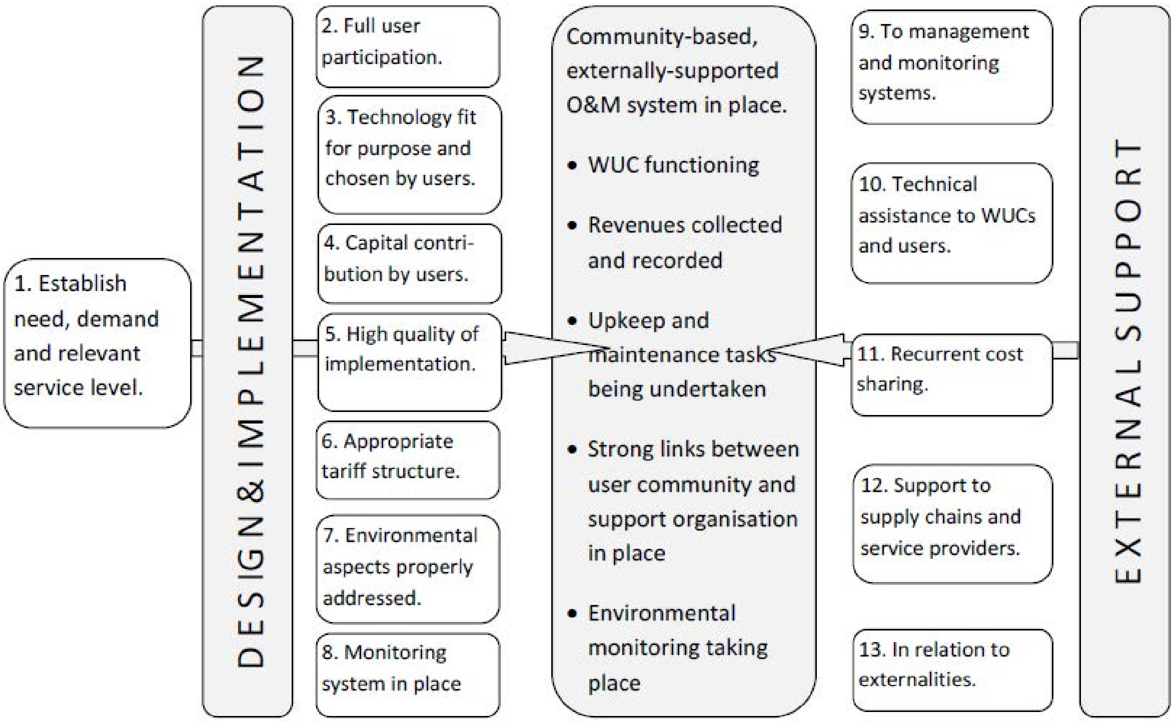


Institutional Context & Programme Focus
Key:
Service Delivery
Capacity Building
Advocacy & Influence
Parliament: Senate & National Assembly
33 Senators: 11 nominated 22 elected
22 Regional Chiefs & Councils
119 MPs elected
1 559 Communal Councils
Villages & Hamlets
Farmer Associations
Traditional Leaders
Government
Ministry for Decentralisation & Home Territories
22 Regions
119 Districts
1 559 Communes (Urban & Rural)
17 332 Fokontany
Neighbourhood Watch
Ministry of Finance
22 Regions
Tresors Districts
Perceptions Principales
Chefs Fokontany
Savings groups / micro-credit
Ministry for Education
22 Regional Education Directorates
111 Educational Constituencies (CISCO)
Pedagogic Areas (ZAP)
Universities & Training Inst.
Public & Private Schools
WASH Schools
Parent Associations
Pupils
Parents
Teachers
22 Regional Health Directorates (DRS)
111 District Health Services
Hospitals & Health Care Centres I & II (CSB)
Mothers' groups
WASH Health centres
Traditional practitioners
Caregivers
Ministry for Water
12 Regional & Inter-regional Directorates (DRE)
Districts Technical Services (STD)
1 559 Communes
Water Users Associations
JIRAMA
Private Sector
Producers & suppliers
Service Providers
Artisans SMEs
National Media: TV, Radio, Print
Regional Media: TV, Radio, Print
Direct Partners
Civil Society
Diorano-WASH National Committee
Diorano-WASH Regional Committees
CSOs & networks
Diorano-WASH Local Committees
CBOs & associations
Women's Groups
Scouts
Churches
Fokonolona -urban & rural households: people living in poverty, at the margins of society, economically excluded, vulnerable to environmental hazards

Annex 3

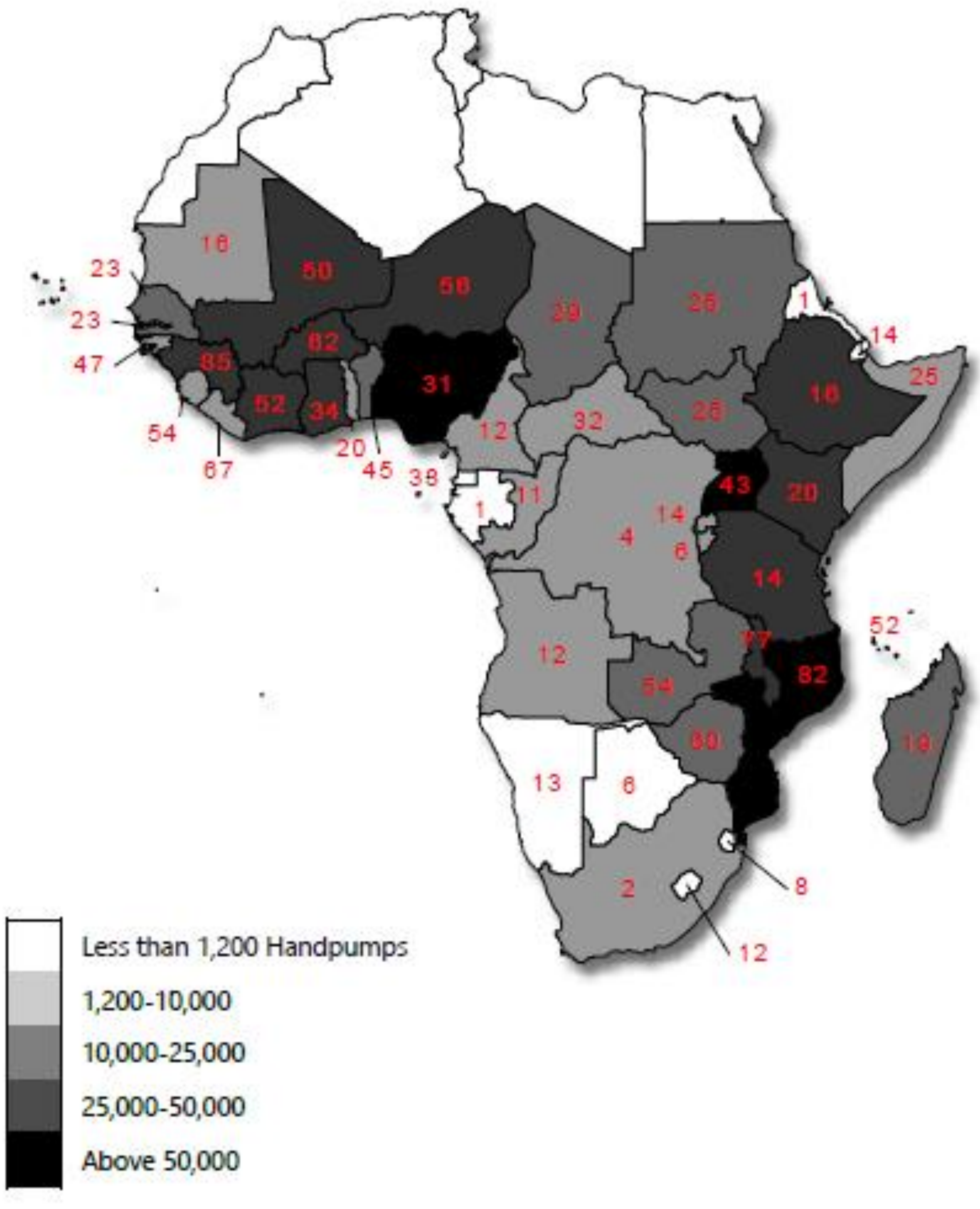


Estimated functionality of handpumps in 20 African countries. (RWSN, 2009)(Carter et al., 2010)(p.11)



(W.U.C: Water User Committee)

Figure 2.2: Conceptual framework for effective externally supported community based management of water supply services (Carter et al. 2010)(p.6)



Estimated quantity of installed handpumps and the percentage of the population reliant on handpumps (%) (Abstract from *Handpump standardisation in Sub-Saharan Africa*, MacArthur, 2015)(p.3)

Annex 4

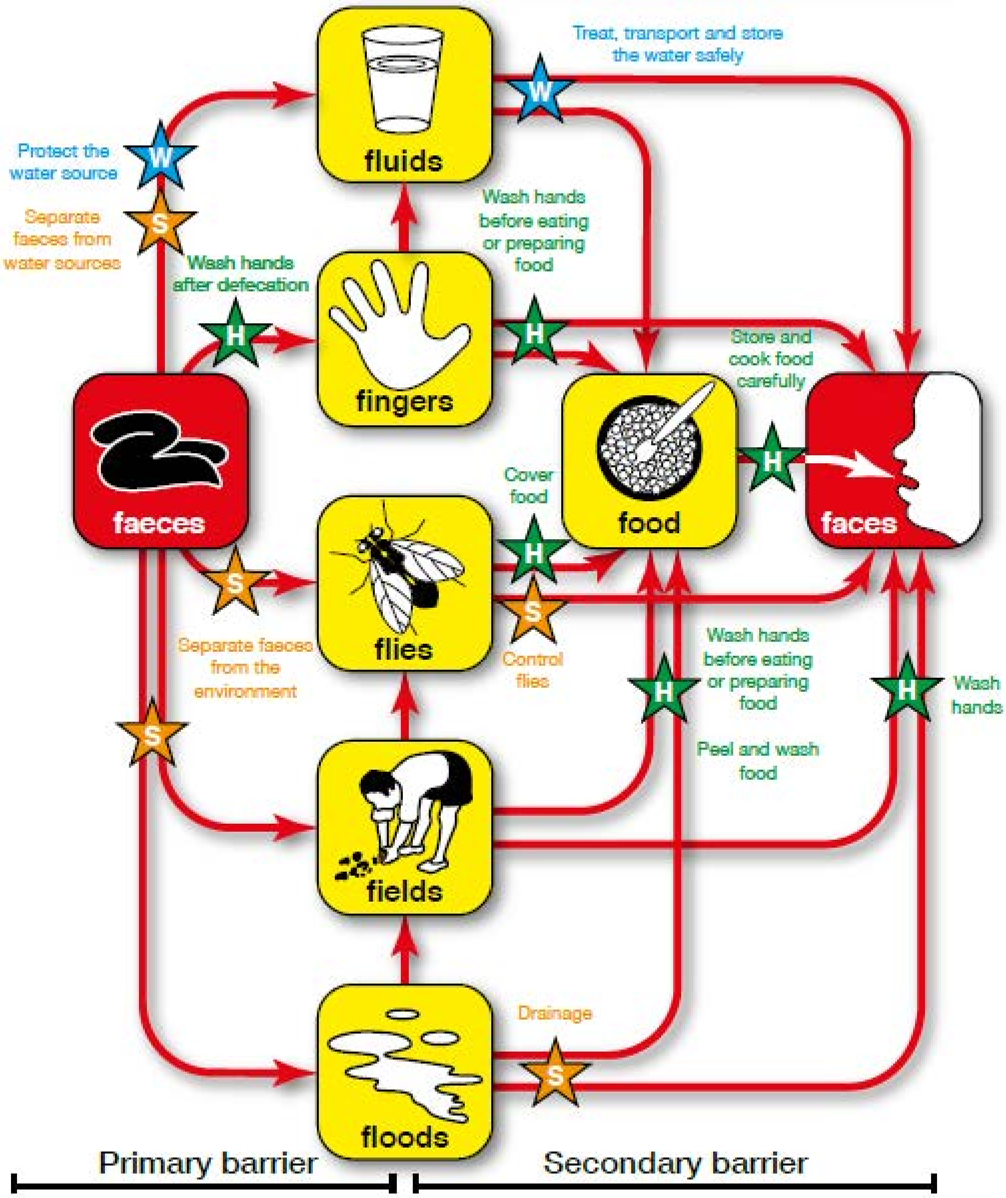
County	Areas of High Potential for Manual Drilling
Benin	Sediments of the coastal basin in the south. Sediments in the north-west and north east. Alluvium river deposits (UNICEF et al, nd-a).
Central African Republic	Sediments and alluvium in the north of the country (UNICEF et al, nd-b).
Chad	Large parts of western and south-western Chad. Parts of the east on the sediments surrounding seasonal water courses (MEERH, nd & Danert, 2014).
Guinea	West coast and eastern and southern regions (GRAIA, 2012).
Ivory Coast	Sediments of the south –eastern coastal fringe and pockets within central and western Ivory Coast. However, there are concerns about groundwater pollution by nitrates and phosphates in the Abijan Basin. (UNICEF et al, 2009a).
Liberia	Sediments within the north and central Liberia and along the coastline near Monrovia (UNICEF et al, nd-c).
Madagascar	Along the east coast and within the western sedimentary areas (Abric, 2014b; MINEAU, nd).
Mali	Sediments and alluvium of the Inner Niger Delta and along the Niger, and Bani rivers (UNICEF et al, nd-d).
Niger	Alluvial deposits close to major rivers in Maradi, Tahoua and Tillabéry; sediments around Lake Chad; sediments towards the north-east of Zinder; sediments in north and north-east Niger (MEELCD, nd).
Senegal	Mid to north west coast (UNICEF et al, nd-f), Kane et al (2013).

	Good Quality	Poor Quality	Implications of poor quality
Siting	At least 30 meters from contamination source	Close to latrine, septic tank or soakaway	Borehole contamination; aquifer contamination. Risk of cholera!
Depth	No inflow of surface water	Tapping very shallow water levels	Borehole contamination; aquifer contamination. Risk of cholera!
Casing	Grade 3 uPVC pipe	Waste disposal pipes	Borehole collapse & slots cannot be properly cut.
Screen	Factory slotted screen	Poor hand slotting on site	Lower yield due to clogging
Gravel Pack	Sieved and washed sand of appropriate particle size	Unwashed, un-sieved river or beach sand	Fine materials flow into well and water is turbid and takes long to develop
Sanitary Seal	Cement grout to 5 or 6 meters below ground level	No grout, or less than 5 meters of grout	Borehole contamination; aquifer contamination. Risk of cholera!
Borehole Development	Develop until water is clear and sand free	None or inadequate	Turbid water, sandy water, reduced lifespan of pump.

Country	Estimated Number[1]	Where drilled?	Who drills?	Clients	Methods/*Kits*	Claimed Costs	Pump types	When[2]
Madagascar (driven wells)	~10,000	East coast and some along the west coast[12]	Private enterprises	Households	Driven wells,	$ 35 to $50	Pompes Tany/ Pitcher pump[13]	1960's – date
Madagascar (Jetting, rota-sludge & Mad Drill)	~2,000	Throughout the country	Private enterprises BushProof, MEDAIR	Households, projects	Jetting, rota-sludge & *MaDrill*	~$ 1,000 to $3,000 (<30m depth	Rope pump, Canzee & various hand pumps	Early 2000's - date

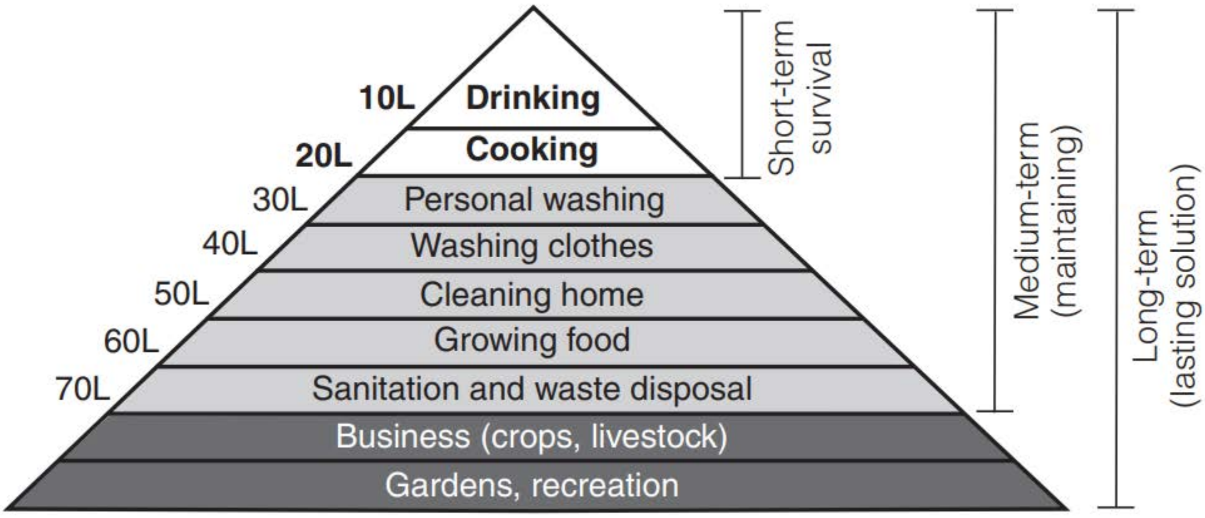
(Abstracts from Manual drilling compendium 2015 by Danert, 2015)(p.6-9-27)

Annex 5



"F" Diagram

Annex 6



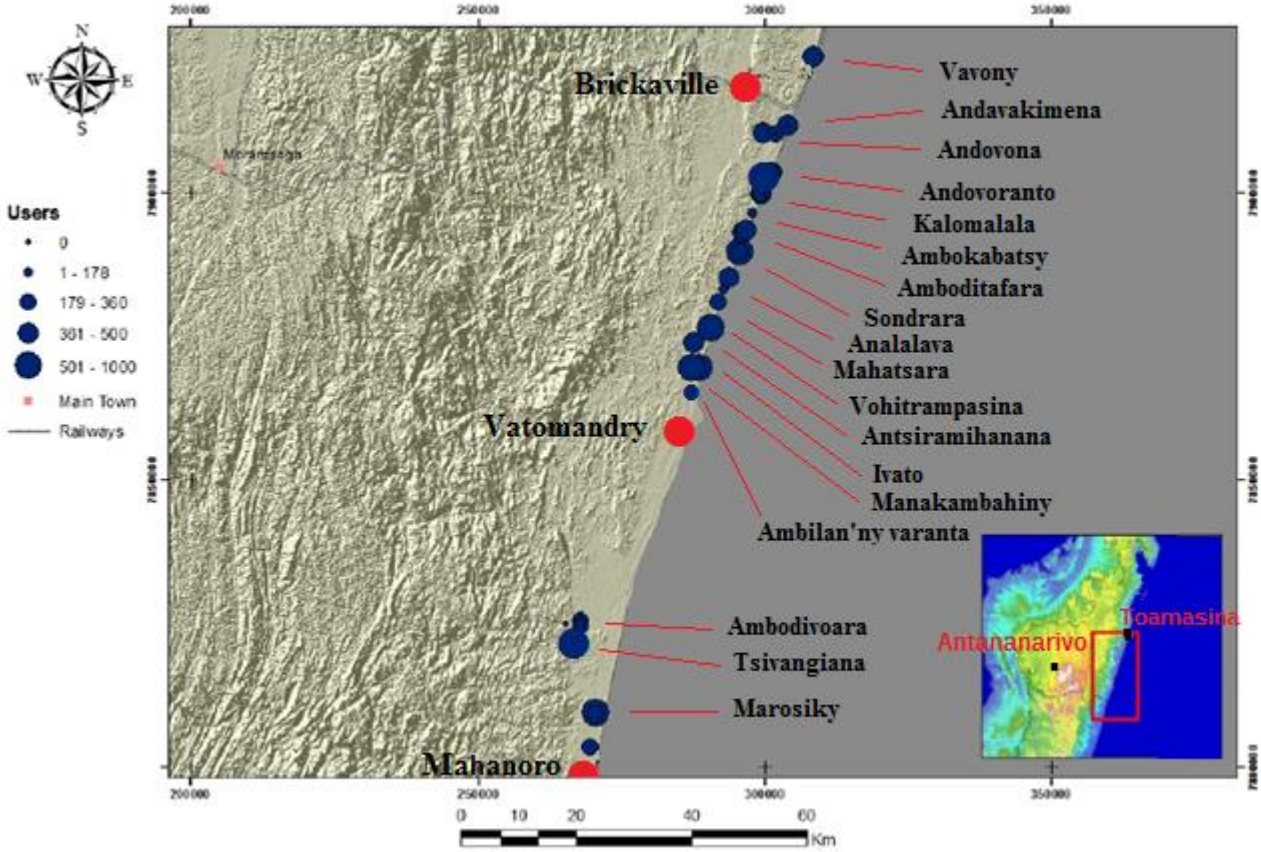
(Figure 2.2.1: Hierarchy of water requirements, inspired by Maslow's hierarchy of need) (B. Reed, 2013)

Table 2.2.1: Summary of requirement for water services level to promote health

Service level	Access measure	Needs met	Level of health concern
No access (quantity collected often below 5 l/c/d)	More than 1000m or 30 minutes total collection time	Consumption – cannot be assured Hygiene – not possible (unless practised at source)	Very high
Basic access (average quantity unlikely to exceed 20 l/c/d)	Between 100 and 1000m or 5 to 30 minutes total collection time	Consumption – should be assured Hygiene – handwashing and basic food hygiene possible; laundry/ bathing difficult to assure unless carried out at source	High
Intermediate access (average quantity about 50 l/c/d)	Water delivered through one tap on plot (or within 100m or 5 minutes total collection time	Consumption – assured Hygiene – all basic personal and food hygiene assured; laundry and bathing should also be assured	Low
Optimal access (average quantity 100 l/c/d and above)	Water supplied through multiple taps continuously	Consumption – all needs met Hygiene – all needs should be met	Very low

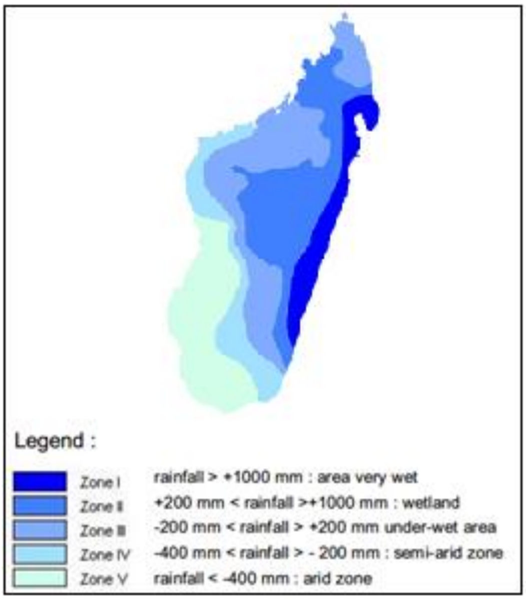
(Howard, 2003, WHO.) (p. Executive Summary Table S1)

Annex 7

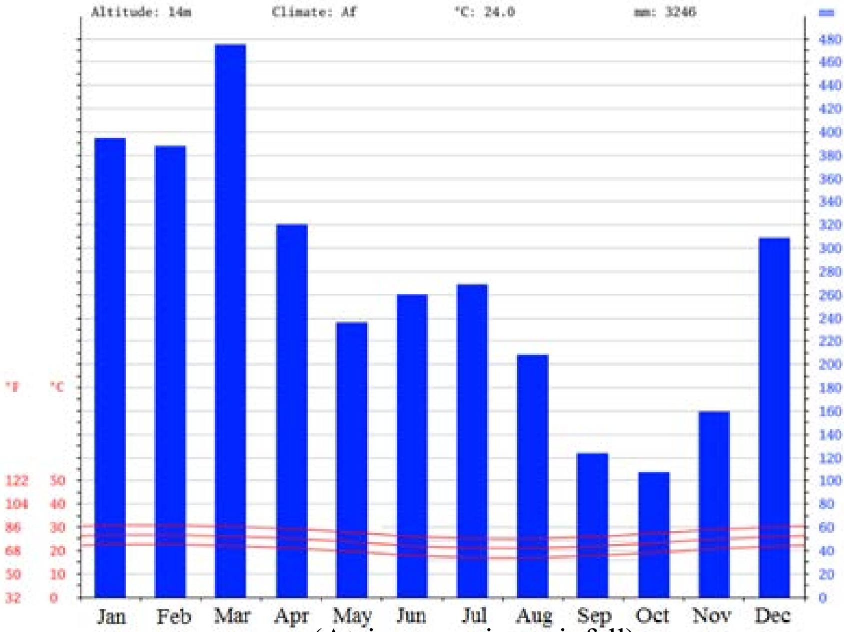


(The Madagascar Water Projects handpumps users)

Climat and rainfall



(Madagascar rainfall)



(Atsinana region rainfall)

National rainfall average is estimated to be 1 632 mm per year, whereas the Atsinanana (Eastern) region has a rainfall average of 3,267.8 mm / year so 250 days of rainfall per year.

Atsinanana region temperatures throughout the year:

1971-2000	Janv.	Fév.	Mars	Avril	Mai	Juin	Juil.	Août	Sept.	Oct.	Nov.	Déc.
T° average	26,5	26,6	26,1	25,2	23,6	21,9	21	21	21,5	22,9	42,4	25,8
T° max	30,2	30,4	29,8	28,9	27,5	25,9	24,9	25,1	25,9	27	28,4	29,8
T° min	22,7	22,8	22,5	21,5	19,7	17,9	17,1	17,9	17,2	18,8	20,3	21,9

(Source ONE, Atsinanana region, Service Meteo Toamasina, 2009) (p 145)

In Atsinanana region, the amount of water is well distributed throughout the year and the number of rainy days per year is high. The month of March remains the rainiest and the driest, October. The strongest temperatures are in January and the weakest in July, but the gaps remain low between December and March.

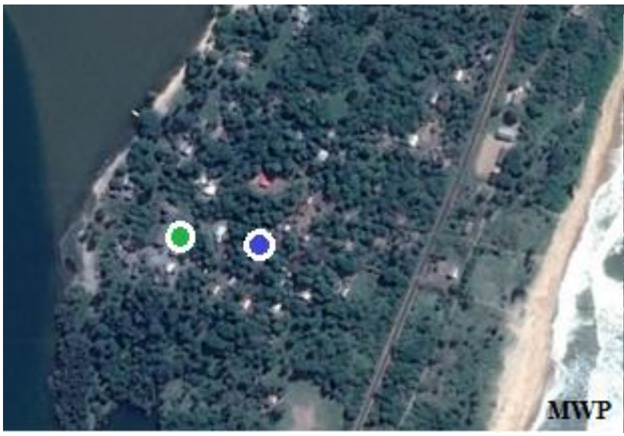
Annex 8

Table 2	
Items to Consider When Selecting a Handpump	**How Each Consideration Influences Decision**
Lift Height and Yield - How much water does the community need? - At what depth is the water table? - How high must the water be lifted? - Will the water table fall due to overuse? - What is the maximum flow? Does it meet the community demand?	- The suction pump provides the highest yield but is limited to shallow depths - The deep well pump can reach depths up to 100 m, but the yield is limited
Water Collection -Which group is tasked with water collection?	- A pump with a lever may be easier for women and children to use compared to a "T" bar which depends on user strength
Operation and Maintenance - Does the community have funds for capital and O&M costs? -What are the costs of the parts to replace? -Are spare parts available and affordable? -How often is maintenance or repair required?	- If the community has limited funds for O&M, it is best to choose a handpump with as few wearing parts as possible and one with parts that are affordable and available
Can the pump parts be manufactured using local skills and materials?	- This helps to support the local economy and helps ensure the availability of parts
What is the life expectancy of the pump?	- To improve life expectancy, use durable and robust materials
Is the community capable of overseeing operation and maintenance?	- O&M is simpler for suction pumps as all parts are above ground - O&M is more complex for deep well pumps which have many parts located below ground - Does the community have the technical expertise for the O&M of a deep well pump?

Different Handpumps and criteria selection (adapted from Jenna Martin)

Annex 9

Locality : Vavony District: Brickaville, Commune: Andovoranto, Fokontany: Vavony Hand pump n°29 (Type: 9 m depth)	Population : 650 inhabitants (70 Households) Date of installation: Sep. 2017 (Phase V)



Technical	
Characteristics State of repair Pipe / Filter Wooden support Apron slab	Well depth: 5.7m BGL Addition of washers, fittings tighten Galvanised / PVC filter screen Good condition Good condition

Community	
Water Committee Water sources	Not well organised (6 members / 2 women) + 1 open bucket well

Environmental	
Characteristics Yield Pollution risk(s) Protection	Water table: 4.5m BGL + 25 Litres/minute Water stagnation around apron slab No fencing

Health	
Healthcare services	No health services

Comments:

- Handling have been replaced the community with a wooden one
- Very remote community - Distance 20 km from Andovoranto (need to take the ferry and cross the canal of Pangalanes), 1h15 by car
- Cement slab repaired during previous maintenance trip

Locality : Andovona District: Brickaville, Commune: Andovoranto, Fokontany: Andavakimena Hand pump n°28 (Type: 9 m pump)	Population : 400 inhabitants (45 Houses) Date of installation: March 2017 (Phase V)

Technical	
Characteristics State of repair Pipe / Filter Wooden support Apron slab	Well depth: 7m BGL Good condition Galvanised / steel screen filter Good condition Broken

Community	
Water Committee Water sources	Not well organised (8 members / 1 woman) No other

Environmental	
Characteristics Yield Pollution risk(s) Protection	Water table: 5m BGL - red water + odour + 25 Litres/minute Water stagnation around apron slab, priming Good fencing condition

Health	
Healthcare services	No health services

Comments:

- The team has noticed smelly water with red coloration. People still collect and drink it. Need more analysis.
- 9 km in North of Andovoranto, 20 min by car from Andovoranto
- Replacement of handpump n°24

Locality : Antsiramihanana District: Vatomandry Commune: Sahamatevina Fokontany: Manakambahiny Hand pump n°41 (Type: 7 m pump)	Population : 700 inhabitants (84 Houses) Date of installation: Sep. 2017 (Phase V)

Technical	
Characteristics State of repair Pipe / Filter Wooden support Apron slab	Well depth: 5.3m BGL Broken handpump fixed by local technician Galvanised / PVC screen Good condition Broken

Community	
Water Committee Water sources	No committee / Presence of local technicians No other (one canzee pump broken)

Environmental	
Characteristics Yield Pollution risk(s) Protection	Water table: 4m BGL - 25 Litres/minute Water stagnation, priming No fencing

Health	
Healthcare services	No health services

Comments:

- Even if there was no committee in place, some local technicians have undertaken repairs but with considerable loss of pressure. Repairs made: Replacement of leather cup, replacement of rod and fittings tighten.

Locality : Kalomalala District: Brickaville Commune: Andovoranto Fokontany: Sondrara Hand pump n°31 (North)(Type: 7m depth) Handpump n°19 (South)(Type: 7m depth)	Population : 500 inhabitants (70 Houses) Date of installation: Sep. 2017 (Phase III) Date of installation: Sep. 2016 (Phase V)

Technical	
Characteristics	Well depth: 4m BGL (n°19)/7m BGL (n°31)
State of repair	Pipe broken, pressure loss (n°19)/used rubber cup (n°31)
Pipe / Filter	Galvanised (both)/Stainless steel screens (both)
Wooden support	Good condition for both handpumps
Apron slab	Good condition (n°31)/Broken(n°19)

Community	
Water Committees	In place (n°19)/ Not in place (n°31)
Water sources	No others apart two MWP handpumps

Environmental	
Characteristics	Water table: 4m BGL(n°19)/5m BGL (n°31)
Yield	+ 25 L/min (n°19) / - 15 L/min (n°31)
Pollution risk(s)	Water stagnation and priming (n°19)
Protection	Good fencing condition (both)

Health	
Healthcare services	No health services

Comment:

- The handpump n°31 is the replacement of previous handpump n°18 which went dry seasonally. The depth of the new borehole reaches 7m BGL, the previous was 6m BGL
- The committee of the handpump n°31 is not in place.
- Villagers have tried to fix the broken pipe (handpump n°19) with local material but did not succeed to avoid leaks and loss of pressure. People still used the handpump with a considerable loss of yield. Need of priming.

Locality : Manakambahiny District: Vatomandry Commune: Sahamatevina Fokontany: Manakambahiny Hand pump n°39 (type 7 m depth)	Population : 1000 inhabitants (140 Houses) Date of installation: Sep. 2017 (Phase V)

Technical	
Characteristics State of repair Pipe / Filter Wooden support Apron slab	Well depth: 4.8m BGL Good condition Galvanised / Stainless steel screen Good condition Good condition

Community	
Water Committee Water sources	Not well organised +2 open wells (and 1 broken canzee pump)

Environmental	
Characteristics Yield Pollution risk(s) Protection	Water table: 2.5m BGL + 25 Litres/minute Water stagnation around slab apron Good fencing condition

Health	
Healthcare services Case(s) of diarrhoeal diseases	Presence of Community Agent 2016 / 2017 / 2018 9 4 0

Comments:

- Other unprotected bucket wells still largely used.

Locality : Vohitrampasina District : Brickaville Fokontany : Mahatsara Commune : Andovoranto Hand pump n°37 (Type: 7 m depth)	Population : 360 inhabitants (33 houses) Date of installation: Sep. 2017 (Phase V)

Technical	
Characteristics State of repair Pipe / Filter Wooden support Apron slab	Well depth: 7m BGL Rubber cup used and changed Galvanised / Stainless steel screen Good condition Good condition

Community	
Water Committee Water sources	Not in place No others (1 broken canzee pump)

Environmental	
Characteristics Yield Pollution risk(s) Protection	Water table: 5.8m BGL + 25 Litres/minute Fence not in good condition

Health	
Healthcare services	No health services / No information

Locality : Sondrara District: Brickaville Commune: Andovoranto Fokontany: Sondrara Handpump n°23 (North)(Type: 7m depth) Handpump n°35(South)(Type: 7m depth)	Population : 950 inhabitants (250 houses) Date of installation: Feb. 2017 (Phase IV) Date of installation: Sep. 2017 (Phase V)

Technical	
Characteristics State of repair Pipe / Filter Wooden support Apron slab	Well depth: 6.3m BGL / 5.7m BGL (n°35) Used rubber cup (n°23) / Not in function (n°35) Galva / PVC screen Good condition Good condition

Community	
Water Committee Water sources	In place (Presence of local technician) No others (1 not functional MWP pump)

Environmental	
Characteristics Yield Pollution risk(s) Protection	Water table: 3.5m BGL / 4.9m BGL (Salty) + 25 Litres/minute Water stagnation around apron slab Good condition

Health	
Healthcare services	No health services / No information

Comments:

- Salty water at pump n°35, community requests its transposition since its installation
- High demand from communities with queueing time exceeding 30 minutes especially in the afternoon
- Ground formation: Sand (white coarse grain at 4m down hole)
- Distance: 1h30 by boat from Andovoranto (the only way to access the locality)

Prdt of Well Committee: Mr Doudou (+261 34 81 425 44), Prdt of fokontany (+ 261 34 37 631 18)

Locality : Mahatsara District : Brickaville Commune : Andovoranto Fokontany : Mahatsara Hand pump n°36 (Type : 9m depth)	Population : 178 inhabitants (52 Houses) Date of installation: Sep. 2017(Phase V)

Technical	
Characteristics	Well depth: 7m BGL
State of repair	Good condition
Pipe / Filter	Galva / Stainless steel screen
Wooden support	Good condition
Apron slab	Good condition

Community	
Water Committee	Not in place
Water sources	No others (1 broken down canzee pump)

Environmental	
Characteristics	Water table: 5.3m BGL
Yield	+ 25 Litres/minute
Pollution risk(s)	Water stagnation around apron slab
Protection	Good condition

Health	
Healthcare services	No health services / No information

Comment:

- The MWP team has previously repaired the wooden support as it was broken due to forcing on the handling of the 9m depth Handpump type.
- Replacement of handpump n°10 installed in March 2016 during Phase II

Locality : Analalava District: Brickaville Commune: Andovoranto Fokontany: Mahatsara Hand pump n°34 (type: 9 m depth)	Population : 215 inhabitants (50 Houses) Date of installation: Sep. 2017 (Phase V)

Technical	
Characteristics	Well depth: 7.3m BGL
State of repair	Good condition
Pipe / Filter	Galva / Steel (screen) well point
Wooden support	Good condition
Apron slab	Good condition

Community	
Water Committee	Not in place
Water sources	No others

Environmental	
Characteristics	Water table: 5.5m BGL
Yield	+ 25 Litres/minute
Pollution risk(s)	Water stagnation around apron slab
Protection	Good fencing condition

Health	
Healthcare services	No health services / No information

Comments:

- Pipe fixed during the last maintenance mission and no problem reported since then
- No President of fokontany in function. The locality is under Mahatsara jurisdiction

Locality : Tsivangiana Type 7m depth	Population : inhabitants (Houses) Date of installation: March 2016 (Phase II)

Technical	
Characteristics State of repair Pipe / Filter Wooden support Apron slab	Well depth: BGL / Broken down Good condition Good condition

Community	
Water Committee Water sources	Not in place 1 open well

Environmental	
Characteristics Yield Pollution risk(s) Protection	Water table: BGL 0 Litres/minute Water stagnation and rubbish No fencing

Health	
Healthcare services Case(s) of diarrhoeal diseases 0-5 years 5-12 years and adults	Presence of Community Agent & Healthcare Base Centre 2015 / 2016 / 2017 / 2018 49 36 - 59 34 - 3

Comments:

- Policy conflicts within community, committee and other organisation team have been previously reported by MWP team. However, the Water committee was back in charge in October 2017 but was found not functioning once again at the maintenance visit of March 2018.

Locality : Ambilan'ny varanta District: Vatomandry Commune: Sahamatevina Fokontany: Manakambahiny Hand pump n°42 (Type 9 m depth)	Population : 400 inhabitants (45 Houses) Date of installation: Sep. 2017 (Phase V)

Technical	
Characteristics	Well depth: 6.5m BGL
State of repair	Screw stolen as the handpump is not in function
Pipe / Filter	Galvanised
Wooden support	Good condition
Apron slab	Good condition

Community	
Water Committee	Not in place
Water sources	No others (1 broken down canzee pump)

Environmental	
Characteristics	Water table: 4m BGL (cloudy and smelly water-not potable)
Yield	- 25 Litres/minute
Pollution risk(s)	
Protection	No fencing

Health	
Healthcare services	No health services / No information

Comments:

- Very remote community, 1hour by boat from Manakambahiny
- The community does not have any improved water source. Villagers have to rely on surface water sources including the Canal of Pangalanes for drinking water
- Parts of the handpumps had been stolen (handling, nuts and bolts)

Locality : Ambodivaro District: Vatomandry Commune: Tsivangiana Fokontany: Ambodivaro Hand pump n°16 (Type 7m depth)	Population : 250 inhabitants Date of installation: Sep. 2016 (Phase III)

Technical	
Characteristics State of repair Pipe / Filter Wooden support Apron slab	Well depth: 7.1m BGL/ Broken down Pipe broken Broken Good condition

Community	
Water Committee Water sources	Not in place + 2 open wells

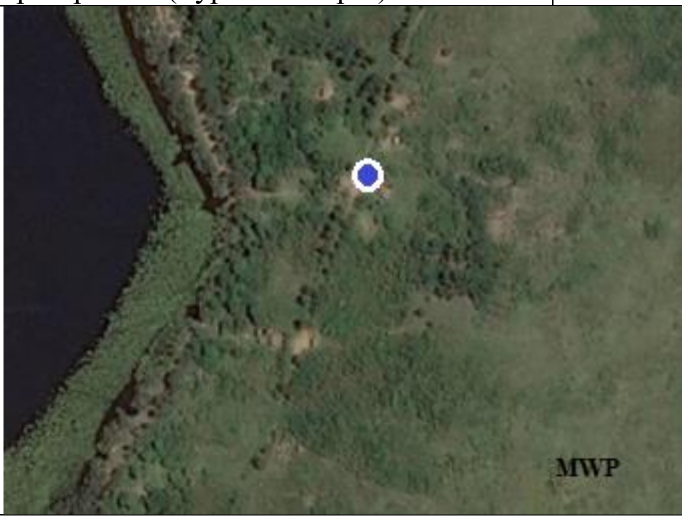
Environmental	
Characteristics Yield Pollution risk(s) Protection	Water table: 5.2m BGL 0 Litres/minute Water stagnation and rubbish No fencing

Health	
Healthcare services Case(s) of diarrhoeal diseases 0-5 years 5-12 years and adults	Community Agent & Healthcare Base Centre 2014 / 2015 / 2016 / 2017 / 2018 18 - 1 - - 12 - - - -

Comments:

- Prdt of fokontany (A.C): (+261 34 51 100 04)
- Lithology: brown clay-rich siltstone with no sand nor weathered basement red beds
- Enlarged borehole diameter to 6 inches and protection of the well from 5m to 8m (BGL) depth with sand pack screening.

Locality : Ambokabatsy District: Brickaville Commune: Andovoranto Fokontany: Kalomalala Handpump n°32 (Type: 7m depth)	Population : 72 inhabitants (15 households) Date of installation: Sep. 2017 (Phase V)



Technical	
Characteristics State of repair Pipe Wooden support Apron slab	Well depth: 7m BGL Used rubber cup, bolt needed to be tighten Galvanised / Stainless steel screen Good condition Good condition

Community	
Water Committee Water source(s)	Not in place No other water sources

Environmental	
Characteristics Yield Pollution risk(s) Protection	Water table: 5.6m BGL - 25 Litres/minute Water stagnation around apron slab No fence

Health	
Healthcare services	No health services

Comments:

- No president of fokontany in function. The locality is under Kalomalala fokontany jurisdiction
- No school within the locality
- Very remote community, 30 minutes from Kalomalala by boat

Locality : Amboditafara District: Brickaville Commune: Andovoranto Fokontany: Sondrara Handpump n°33 (Type: 7m depth)	Population : 455 inhabitants (55 households) Date of installation: Sep. 2017 (Phase V)

Technical	
Characteristics State of repair Pipe / Filter Wooden support Apron slab	Well depth: 5.8m BGL Used rubber cup Galvanised / Stainless steel screen Good condition Good condition

Community	
Water Committee Water source(s)	Not in place No other water sources

Environmental	
Characteristics Yield Pollution risk(s) Protection	Water table: 4.5m BGL + 25 Litres/minute Water stagnation around apron slab No fence

Health	
Healthcare services	No health services

Comments:

- Very remote community, 30 min by boat from Sondrara
- Replacement of MWP n°25 (Amboditafara) which went dry seasonally
- No president of fokontany in function (under Sondrara fokontany jurisdiction), no school

-

Locality : Ivato District: Vatomandry Commune: Sahamatevina Fokontany: Ivato No references -2 Handpumps (Type: 7m depth)	Population : unknown Date of installation: Sep. 2017 (Phase V)

Technical	
Characteristics State of repair Pipe Wooden support Apron slab	Well depth 7m: Used rubber cup, bolt needed to be tighten PVC Good condition Good condition

Community	
Water Committee Water source(s)	Not well organised 2 MWP handpumps installed on concrete wells

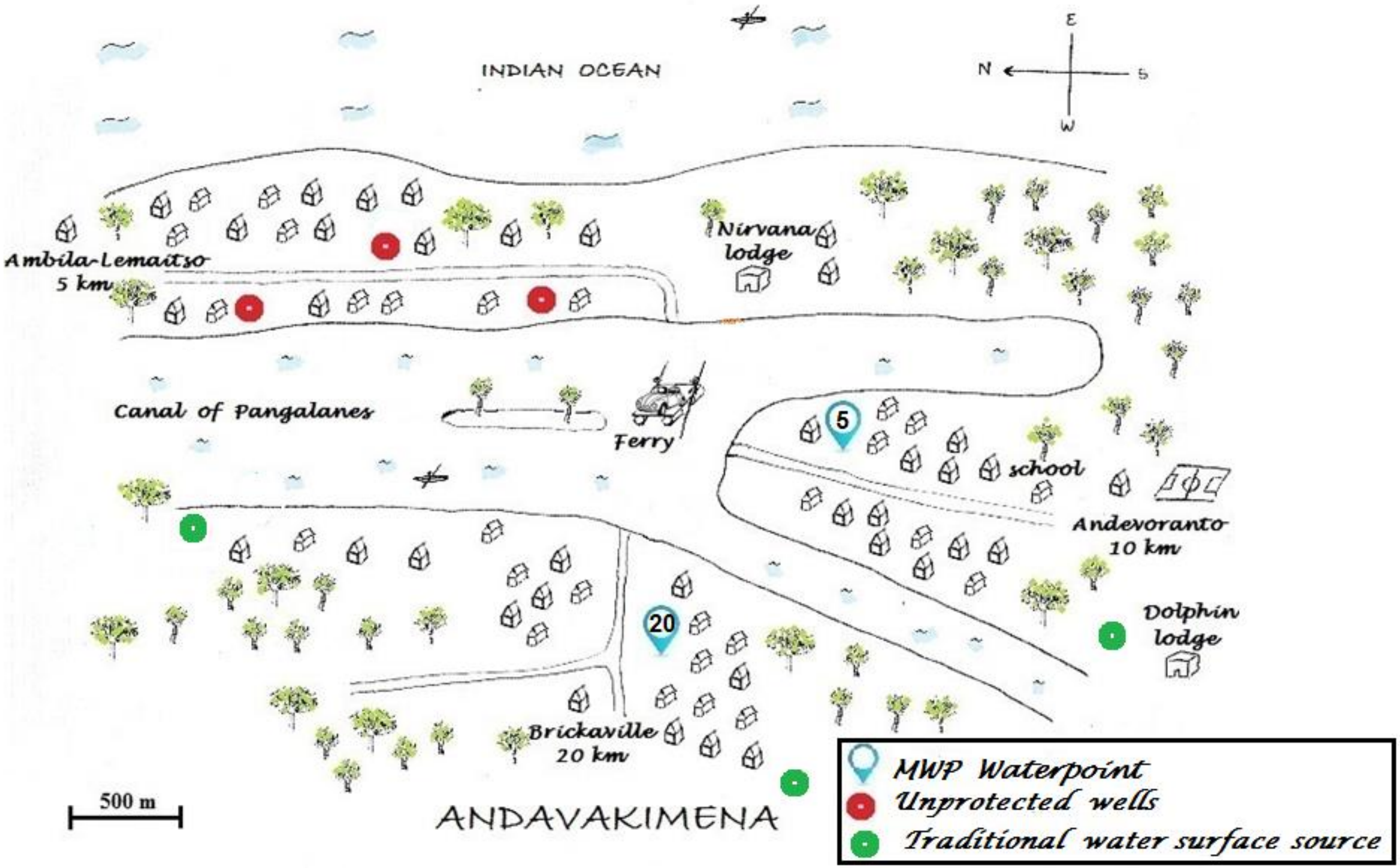
Environmental	
Characteristics Yield Pollution risk(s) Protection	Well depth 10m + 25 Litres/minute (both) Space between covers and top of wells Good condition (both)

Health	
Healthcare services	Presence of A.C

Comments:

- Two handpumps are not referenced as they have been installed on concrete wells on villagers requests. The MWP team reports having replaced former galvanised pipes by PVC pipes
- According the President of Water committee, there is consequent seasonal variation of water quality and quantity. At end of the year, the water level drop from () with red coloration

Annex 10


INDIAN OCEAN
E
N
S
W
Ambila-Lemaitso
5 km
Nirvana
lodge
Canal of Pangalanes
Ferry
5
school
Andevoranto
10 km
20
Dolphin
lodge
Brickaville
20 km
500 m
ANDAVAKIMENA
MWP Waterpoint
Unprotected wells
Traditional water surface source

Annex 11

BatiMax
La qualité au meilleur prix

POMPE A EAU MANUEL

FICHE TECHNIQUE PRODUIT

Technical note / *Note Technique*

1. Cast iron manual pump / *Pompe manuelle en fonte*

Ref. 3060201005

Ref. 3060201006

2. Main technical data / *Données techniques principales*

Ref.	3060201005	3060201006
Suction height / *Hauteur d'aspiration*	6 - 9 m	
Max. flow / *Debit maximal*	28 L/min	
Height / *Hauteur*	67 cm	40 cm
Diameter of water outlet / *Diamètre evacuation eau*	Ø4.5 cm	
Diameter of the bottom / *Diamètre base*	Ø16 cm	Ø18 cm
Net weight / *Poids*	15 kg	6.8 kg

3. Domains of usage / *Domaine d'utilisation*:

Garden, park, work site, fields, farm, etc…/ *Jardin, parc, chantier, champs, ferme, etc…*

(*) Information donnée à titre indicatif. Il appartient à l'utilisateur de vérifier si le produit convient à l'usage envisagé.

Anne 12

The MWP team discharging materials on the bank before visiting a community

A typical community along the Indian Ocean and the Canal of Pangalanes

The "Tany" pump in a shop of Toamasina

A ferry-cross (Andavakimena)

Girls fishing in the Pangalanes

A fisherman in his lakana on his way to the office

Transport of wood and water on the Pangalanes in the traditional lakana (canoe)

Annex 13

Carte 1. Cartographie de faisabilité des forages manuels

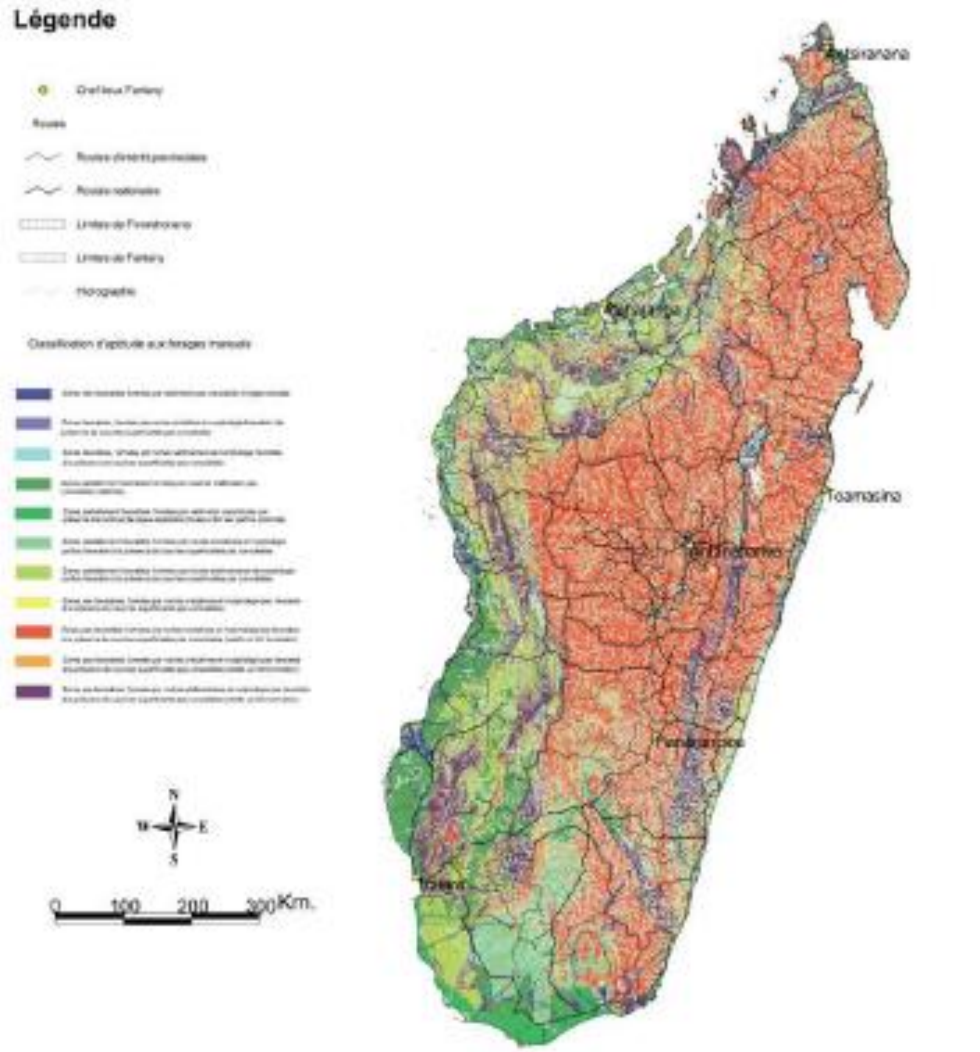
MINISTERE DE L'EAU

unicef

PRACTICA

ETUDE DE FAISABILITE DES TECHNIQUES DE FORAGES MANUELLE

APTITUDE AUX FORAGES MANUELS - REPUBLIQUE DE MADAGASCAR



Annex 14

Institut Pasteur de Madagascar

Fiche de demande d'analyse. Microbiologie Eaux

Laboratoire d'Hygiène des Aliments et de l'Environnement B.P. 1274 - 101 Antananarivo
☎ : (261 20) 22 401 64/65 ou 22 412 72/74 email : lhae@pasteur.mg
Les échantillons sont réceptionnés au laboratoire du lundi au vendredi de 08H00-12H00 et 13H30-15H30

DEMANDEUR : *(Remplissez ou apposez un cachet)*
NOM/Prénom/Société :
Adresse :
Tél/ Fax :
Référence du bon de commande :
N° de facture pro-forma ou N° de convention :
E-mail nominatif pour l'envoi des résultats d'analyses :
Date et signature du Demandeur ou son Représentant :

Personne à contacter en cas de non-conformité :

PRELEVEMENT :
Prélevés par : ❒ Vos soins ❒ IPM ❒ Autorités ministérielles
(*Précisez*) Nom/Prénom :
Date :
Visa :

NATURE ET NOMBRE DE(S) L'ECHANTILLON(S) :
❒ Eau non traitée pour consommation :
❒ Eau de surface non destinée à la consommation
❒ Eau traitée destinée à la consommation (particulier) :
❒ Eau traitée destinée à la consommation (collectivité/industrielle) :
❒ Eau embouteillées ou destinées à l'être :
❒ Eau de piscine :
❒ eau de baignade :
❒ Eau usée/eau résiduaire :
❒ Autres (précisez) :

ANALYSES DEMANDEES *(vous avez la possibilité de contacter le laboratoire pour vous aider dans votre choix)*
-Le laboratoire applique systématiquement le plan de contrôle standard dans le tableau ci-dessous sauf contre-indication du client (proforma, convention, demande manuscrite...)
-Pour des demandes particulières, veuillez mentionner les paramètres à rechercher et les critères associés

PLANS DE CONTROLE STANDARDS	TYPE D'EAU	FLACONNAGE	TEXTES REGLEMENTAIRES *
EAU NON TRAITEE POUR CONSOMMATION : *Escherichia coli* et bactéries coliformes, entérocoques intestinaux	Eaux de puits, forages, source...	500 ml stérile	*Limites de qualité selon le décret du MEM N°2004 635 du 15 Juin 2004 - (Madagascar)*
EAU DE SURFACE NON DESTINEE A LA CONSOMMATION : *Escherichia coli* et bactéries coliformes, entérocoques intestinaux	Eaux superficielles (ruisseau, rivière, lac, source ...)	500 ml stérile	*Critère selon le Code de la Santé publique, Code de l'Environnement, décret n°2011-1239 du 04 octobre 2011, République française*
EAU TRAITEE DESTINEE A LA CONSOMMATION (PARTICULIER) : *Escherichia coli* et bactéries coliformes, entérocoques intestinaux, spores de microorganismes anaérobies sulfito-réducteurs	Eaux d'adduction de la JIRAMA, eaux traitées en individuel, Glace hydrique	500 ml stérile + 10 mg de thiosulfate de Na	*Limites de qualité selon le décret du MEM N°2004-635 du 15 Juin 2004 - (Madagascar)*
EAU TRAITEE DESTINEE A LA CONSOMMATION (COLLECTIVITE/ INDUSTRIELLE) : Bactéries aérobies 22 et 36°C, *Escherichia coli* et bactéries coliformes, entérocoques intestinaux, spores de microorganismes anaérobies sulfito-réducteurs	Eaux de distribution traitées et/ou glace hydrique	500 ml stérile + 10 mg de thiosulfate de Na	*Limites et références de qualité selon l'arrêté du 11 janvier 2007, modifié par l'arrêté du 24 décembre 2015, République française*
EAU EMBOUTEILLEE OU DESTINEE A L'ETRE : *Escherichia coli* et bactéries coliformes, entérocoques intestinaux, spores de microorganismes anaérobies sulfito-réducteurs , *Pseudomonas aeruginosa*, microorganismes revivifiables à 22°C et 36°	Eaux embouteillées ou destinée à l'être	Conditionnement ou **1000 ml** stérile **X2**	*Limites et références de qualité selon l'arrêté du 14 mars 2007 modifié par l'arrêté du 14 janvier 2016*
EAU DE PISCINE : *Escherichia coli* et bactéries coliformes, Bactéries aérobies à 36°C, Staphylocoques à coagulase +	Eaux de piscine	500 ml stérile + 60 mg de thiosulfate de Na	*Critères selon l'arrêté du 18 janvier 2002 modifiant l'arrêté du 07 avril 1981 modifié, fixant les dispositions applicables aux piscines République française*
EAU DE BAIGNADE : *Escherichia coli en NPP* et bactéries coliformes, entérocoques intestinaux en NPP	Eaux superficielles douces et marines	500 ml stérile	*Critère selon le Code de la Santé publique, Code de l'Environnement, décret n°2011-1239 du 04 octobre 2011, République française*
EAU USEE/EAU RESIDUAIRE : *Escherichia coli en NPP* et bactéries coliformes, entérocoques intestinaux en NPP	Eaux usées Eaux résiduaires, eaux issues de process industriel	500 ml stérile	————

EPO1/10	Version : 1	Date d'application : 16/03/18

1/2

Microbiological analysis request at Institut Pasteur, Antananarivo