Chapter 10

Experience in sustainable management of rainwater for multiple purposes: Case in ten villages, gossas district, Senegal

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10.1 CONTEXT

Senegal aims to become an emerging market by 2035. The Senegalese Emerging Market Plan (*Plan Sénégal Emergent; PSE*) has guided this ambition since its inception in 2014. The PSE is the main socio-economic reference document for the country's medium- and long-term development. The plan's 'Human Capital: Social Security and Sustainable Development' section identifies access to drinking water as being integral to achieving Senegal's socio-political development goals.

Since 2015, efforts to provide these basic social services have accelerated, in conjunction with the programme outlined in the Plan for Urgent Community Development (*Plan d'urgence pour le development communautaire;* PUDC), in which water infrastructure plays a key role.

Programmes including Pepam Aqua, a Senegalese-Belgian collaboration, have enabled Senegal to explore different avenues for creating potable water supplies, from brackish water extracted from boreholes, and by harvesting rainwater. The rainwater purification project at Walalane results from Pepam Aqua's collaboration with Caritas Kaolack.

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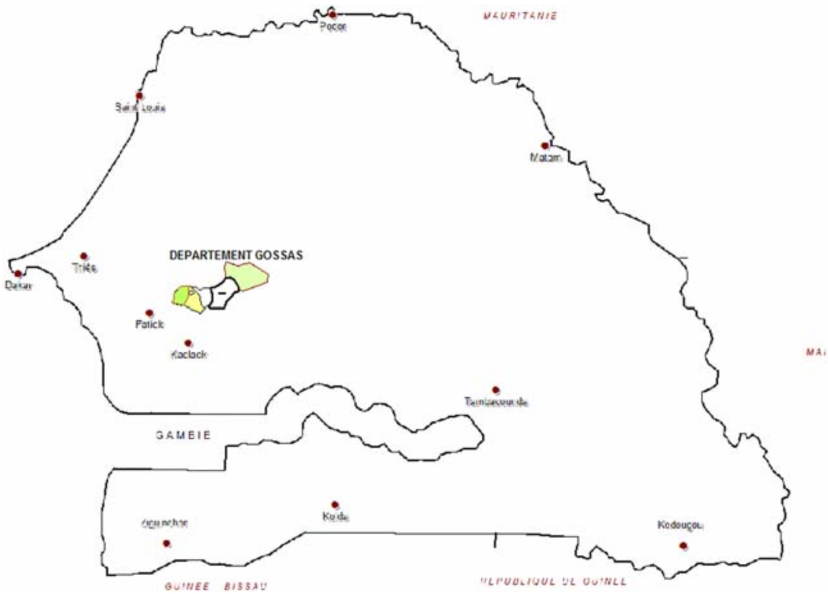

Figure 10.1 Project zone situation in Gossas. (S.Sene, 2018).

Since 2006, Caritas Kaolak have instigated multiple projects, with the support of the Dutch NGO, Rain Foundation, to harvest rainwater as a drinking water supply for communities living in regions where surface and groundwater freshwater supplies are scarce. In such locations, it is sometimes necessary to canoe for tens of kilometres to access a drinking water supply, which might be prohibitively priced. For inhabitants of the Saloum Islands, acquiring a 20 l barrel of drinking water costs 0.3 euros (15 euros/m^3).

Setting up rain-harvested water supplies for school children in Senegal's Gossas district (Figure 10.1), with project funding from Horizont3000 (Meerman et al., 2015), aligned with Senegal's national development policy: to make drinking water supplies available to its populace, irrespective of where they live. Children are the future of Senegal, and providing this vulnerable sector of the population with water through such projects is of vital importance.

10.2 HYDRO-GEOGRAPHY AND HYDRO-CHEMISTRY IN GOSSAS

Gossas, located in the extreme north of the Fatick region, experiences a semi-arid, Sahel-Soudanian type climate, with annual precipitation levels rarely exceeding 500 mm. Vegetation in the area is characterised by spiny shrubs and members of the *combretaceae* family.

Most water resources in the district derive from deep groundwater reserves. Wells supplying freshwater are dug to minimum depths of 70 m below ground. However, a Maastrichtian-age aquifer, located between 200–400 m below ground, contains the best water reserves. Boreholes used to access this drinking water resource typically supply 50 m^3/hour.

A key priority of the Senegalese government is to supply drinking water to all its inhabitants. Given that 45% of Gossas district's rural population lacks access to drinking water, developing a range of water supply options for this demographic clearly contributes to meeting their water needs (CONGAD, 2014). Provision of sanitation facilities in rural regions such as this one is, similarly, of great importance: on average, only 49.1% of the population could access such amenities in 2013. In the rural district of Mbar, access to sanitation was only available to 7% of the local population (PEPAM: *Projet Eau Potable et Assainissement pour le Millénaire*).

Survey work was conducted before boreholes were drilled by PEPAM – Bassin Arachider (Project Drinking Water and Sanitation for the Millennium – Groundnut Basin). Results from this survey demonstrate that out of 53 boreholes surveyed in the districts of Diourbel, Fatick, Kaolack and Kaffrine, 32 supplied water whose quality did not meet with the standards defined by the World Health Organisation (WHO). These waters had excessively high concentrations of fluoride, salts and, in some locations, iron (Initial Field Survey; PEPAM-Aqua (2011a)). For instance, fluoride levels of 4–5 mg/l were sometimes measured in the field; these levels far exceed the 1.5 mg/l stipulated by the WHO. Similarly, salt levels in excess of 1.5 g/l were measured; WHO recommends that salt levels be less than 250 mg/l in drinking water (National Hydraulic's Direction, 2015).

Water analyses conducted by Caritas, deriving from three boreholes drilled in the Gossas district, where the PEPAM–BA project is located, find comparable levels of chloride and fluoride.

Water samples systematically contain double or triple the concentrations recommended by the WHO for drinking water, human consumption of such water sources is harmful (Table 10.1). Public health surveys in the Patar Lia and Ouadiour local communities within the Gossas district report cases of arterial hypertension, stomach pains, diarrhoea, and skeletal fluorosis in pregnant women, children and old people that regularly consume water from boreholes.

Table 10.1 Physico-chemical analyses of some boreholes in gossas.

	Soumbel Keur Latyr Borehole	Gossas Village Borehole	Sakhmack Borehole	WHO Recommended Concentrations
Chloride (mg/l)	475.2	550	404.2	250
Fluoride (mg/l)	4.5	3	5	1.5

Given the high levels of mineral salts in this water source, local communities increasingly reject it, choosing to walk long distances to obtain safe drinking water, or using water stored in traditional wells that are restocked with rainwater, which is often of poor quality.

Groundwater supplies might appear limited, over-exploited or difficult to access in Senegal. However, in the rainy season, millions of cubic metres of rain are recorded as falling. Much of this precipitation is lost as runoff that enters the sea. Harvesting rainwater is increasingly relevant in Senegal, given the decreasing groundwater resources and groundwater quality in many areas, and the cost of drilling boreholes that yield water that is often not of a potable standard.

Furthermore, water access in school contexts is often particularly problematic, given the difficulty of connecting these institutions to a supply that can be drunk, used to maintain hygiene and sanitation facilities, and thirdly employed to improve the quality of school learning environments by irrigating vegetation that can provide shade and beauty. While precipitation is not abundant in the Gossas region, it is of sufficient volume to satisfy the drinking water needs of local communities, and to improve the learning environments of school children.

10.3 METHODOLOGY

This project was developed in collaboration with farming organisations in the Gossas District, including the *Association régionale des Agriculteurs de Fatick* (ARAF). Fatick's regional association of farmers is well represented in the Gossas District, and local members have a good understanding of the needs of each village, particularly with regard to their potable water supply requirements.

Collaborations were developed with the local mayors in villages in the Gossas district, to guide their decision making with regard to the following issues: the existence of primary schools lacking a supply of freshwater; the acceptance of rainwater harvesting as an alternative potable water source in this context; a willingness to experiment with school gardens on campus; an openness to local authorities offering in-kind support of projects by supplying local materials for building projects and local labour; and teaching local masons how to construct rainwater harvesting systems.

In all of the target sites, field visits and meetings were conducted to ensure the project's sociological and technical feasibility. The schools involved in the project were visited to gather data about the school populations and to study how rainwater could be collected from each school's roof; to consider what size of the rainwater harvesting tank would be needed, the quality of the roofing materials, and how to store drinking water reserves, while distancing them from the toilet facilities.

In each village, a kick-off workshop was organised at the beginning of the project, and before the village councils developed a strategy for implementing it. These workshops helped participants identify collaborators' roles and responsibilities, how they would participate in the project, and project deadlines.

The volume of water needed to supply the drinking water requirements of each school for a year, assuming 1.5 litres per person, per day, was calculated. The number of school children and staff in the project's 10 villages totalled 1368. The combined population of the 10 villages involved in the project was 5365. Accordingly, it was decided that 100 m^3 of rainwater (stored in two 50 m^3 systems) would meet the water requirements of each school, and give the communities associated with these schools punctual access to this water resource as well, to test its quality with a view to scaling up rainwater harvesting in the villages.

Since one of the project aims was to create green zones in these village schools, by planting trees for shade and growing vegetables for four months of the year, an additional 60 m^3 cistern was constructed specifically for irrigation purposes. It was estimated that 24 litres per day would be required to irrigate eight raised beds that were each 1 m^2; 200 litres per day were also allocated for the other watering purposes. To calculate the required surface area of the rainwater cisterns, the following formula was used:

$$\text{Cistern surface area} = \text{total volume of estimated rainwater}\,(\text{m}^3)/\text{precipitation}\,(\text{m})$$

The area calculated was increased by 10%, to compensate for possible water losses.

The reservoirs constructed for this project (Figure 10.2) were partially buried, with 2 m of the structure located below-ground and 0.5 m protruding above ground. These tanks collected water from the roofs, using corrugated iron or aluminium gutters, at the end of which a funnel covered with a metal mesh was attached. This semi-permeable barrier performed a initial filtering of the rainwaters before they ran, via a PVC pipe, into the rainwater reservoir or cistern.

Figure 10.2 Rainwater harvesting system in Dekhaye School. (S.Sene, 2018).

Rainwater is collected once the season's first rainfall has occurred, which flushes dust from the roofs and piping. From the second rainfall event, (equivalent to or greater than 20 mm), all rain falling onsite is collected in a partially submerged tank, for use as a potable water resource. Once a management committee is put in place for the rainwater harvesting system, its role includes ensuring that the roofs that collect the rainwater are kept clean of debris.

10.4 RESULTS

30 rain cisterns were constructed. 20 cisterns were 50 m^3, nine were 60 m^3 and one was 40 m^3, enabling 1000 m^3 of rainwater to be collected for drinking water purposes, and 580 m^3 to be collected for gardening purposes, in total.

In one village involved in the project (Walalane), Caritas had built a large (1400 m^3) rainwater harvesting tank in the 1980s, enabling the local village women to continue market-gardening during the dry season for 3–4 months. This water tank had begun to leak. It was re-sealed and returned to its original use, enabling market gardening in Walalane to be restarted.

In each of the ten schools involved in the project, eight raised beds were built and installed. Responding to the wishes of each school and its neighbouring village regarding what vegetables they would like to farm, on-site nurseries were established, using honeycomb-shaped planters. To enhance the longevity of this gardening strand of the project, school children and staff responsible for maintaining the schools' outdoor environments were actively involved.

Two types of agricultural substrate were adopted for these raised beds: a mix of well-washed gravel, peanut shells, and rice grain husks; and hydroponics, using 80 litres of water containing macro- and micro-nutrients.

In total, eighty 1.2 m^2 raised beds were planted. 39 of these beds used a solid substrate and 41 used specially constructed hydroponic systems.

Ultraviolet light was used to purify the water in each school, thereby removing live bacteria. A small, solar-powered pump enabled water to be pumped from the reservoirs through this system.

Laboratory analyses were undertaken to compare water samples obtained directly from the rainwater harvesting reservoirs and samples of water that had been exposed to UV light.

10.5 DISCUSSION

The results of the bacteriological analyses (Table 10.2) show that water obtained from the different rainwater harvesting systems does not present any major risks for consumption (with the exception of the Tchingué site), if adequate treatment with UV light is adopted. Ultra-violet light is effective in eliminating coliform and *enterococcus* bacteria, which provoke gastroenteritis, if basic hygiene measures are undertaken in parallel with this water treatment measure. Regarding

Table 10.2 Bacteriological analyses from rainwater harvesting tanks in different villages (Sene, 2018).

Parameters Measured	Water in the Cistern	Water Exiting the UV Lamp	Treated Water Exiting the Reservoir	Drinking Water Norms (WHO)	Water in the Cistern	Water Exiting the UV Lamp	Treated Water Exiting the Reservoir	Drinking Water Norms (WHO)
		Mbar Bawane				**Boustane Diaw**		
Germs: Total (UFC)	202	22	648	20/1 ml	162	50	58	20/1 ml
Coliform bacteria (UFC)	310	0	0	0/100 ml	0	0	0	0/100 ml
Enterococcus bacteria (UFC)	460	0	0	0/100 ml	920	0	0	0/100 ml
		Tchingué				**Dékhaye**		
Germs: Total (UFC)	520	>**880***	680	20/1 ml	90	34	976	20/1 ml
Coliform bacteria (UFC)	60	**58**	**50**	0/100 ml	0	0	0	0/100 ml
Enterococcus bacteria (UFC)	1130	**312**	**80**	0/100 ml	140	0	0	0/100 ml
		Bill Mbacké				**Loumbel Kelly**		
Germs: Total (UFC)	815	–	174	20/1 ml	184	–	120	20/1 ml
Coliform bacteria (UFC)	0	–	0	0/100 ml	10	–	0	0/100 ml
Enterococcus bacteria (UFC)	150	–	0	0/100 ml	10	–	0	0/100 ml

the Tchingué site, this location had a water cistern that was always open for drinking water consumption. The water it stored was unpotable, even after it had been treated with UV light, due to the continued presence of *enterococcus* bacteria. Consequently, this rainwater harvesting tank was only used, subsequently, for irrigation purposes.

Even if water becomes potable after it has been treated with UV radiation, appropriate hygiene protocols need to be put in place, to prevent the water from being re-contaminated. The laboratory analyses show that when dust falls on the water reservoir barrel, if they are not well sealed around the entry point of the rainwater pipe, further contamination of the water source can occur. Accordingly, the vigilance of those managing and using harvested rainwater resources is paramount to maintaining water quality. A user's guide was made to teach project participants what precautionary measures to take when consuming water that might be contaminated. This included using chlorine to treat the water, or adding bleach at 8°C.

Using water from the cisterns, the schools were able to irrigate their mini-gardens and harvest produce including lettuce, tomatoes, turnips, aubergines, carrots and mint (Figures 10.3 & 10.4). This herb is much used locally in tea, and in drinks such as *bissap* (*Hibiscus sabdariffa L.*) or red Guinean sorrel.

Additionally, as a result of the variety of vegetables that were harvested (salads, carrots, turnips, okra, sweet and bitter aubergines, and tomatoes) the project beneficiaries were able to improve the nutritional value and diversity of their meals during at least three months. The beneficiaries' households had never previously been able to grow or consume these vegetables out of season, and, with regard to carrots and turnips in particular, certainly never in the volumes produced by the project.

Figure 10.3 Development state of tomato and eggplants. (S.Sene, 2018).

Figure 10.4 Eggplant harvest after 2.5 months. (S.Sene, 2018).

Growing crops such as tomatoes considerably increased the revenue of project beneficiaries. As an example, in the village of Walalane, where market gardening was conducted in fields, and irrigated using the above-mentioned restored water tank, 604 kg of tomatoes were harvested from a 100 m^2 parcel of land and sold for 22,500 Fcfa (343 euros). This money was used by the five, female project beneficiaries, to improve the quality of the food they bought for their families, by buying seasonings and spices and additional food stuffs.

Rainwater harvested at Walalane was sold, generating a revenue of 1,125,000 Fcfa (1715 euros) over a period of nine months, in a year when rainfall was abundant. It is estimated that wages for the manager of the tank cost 225,000 Fcfa (343 euros), representing a net gain of 900,000 Fcfa (1371 euros). Given that constructing a rainwater harvesting reservoir and water purifying system of the type used in this project costs 5,000,000 Fcfa (7622 euros), the money gained through water sales would enable a new rain cistern to be built every six years.

The initial purpose of the Walalane rainwater harvesting initiative was to meet the water needs of this village's school and community, in part if not completely. However, water was sold to people traveling from the towns of Gossas and Diourbel, and also neighbouring villages on a punctual basis, when water canisters were available. These consumers considered that this rainwater was of a better quality than the groundwater available to them in their towns and villages.

Improving school environments was a final, important element of this project. Planting trees to provide shade is valuable in a context where the dry, hot

Harmattan wind, which blows between February and May, makes it uncomfortable for students to spend time outside. Students are invariably obliged to remain in class during their breaks, even in the intense heat of the afternoon, because it is even more uncomfortably hot outside. Harvesting rainwater allows plants to be watered during the rainy season and through the whole of the dry season. In less than two years, trees cultivated in this manner can grow from 50 cm high saplings to 2 m high tree species. This vegetation transforms the environment of school playgrounds, giving school children shady outdoor spaces in which to play.

10.6 DIFFICULTIES AND LIMITS OF THE PROJECT

In the project's first year (2017), implementation of the rainwater harvesting infrastructure coincided with a period of very little rainfall. The little rain that did fall between July and August was not able to be collected, as the cisterns were not yet completed. Consequently, the volume of rainwater that was harvested did not meet the local demand for water.

Additionally, some gutters did not function well, either as they had been damaged due to winds and rain, or because the management and maintenance committees in charge of the rainwater harvesting infrastructure had not sufficiently taken care of them.

It is normal for households with a reasonable revenue to pay 150 F for 20 litres of water. However, for other households, buying 40–60 litres per day to meet the water needs of a large family proves to be a costly expenditure, constituting a large portion of the household budget. By identifying which groups were most in need of free access to harvested rainwater, in this context, specifically pregnant women, children and old people, the harvested rainwater was used most effectively within local communities. This is not to deny the relationship between health and water, but rather to make sure that at-risk groups had their minimum requirements for water met.

Water cisterns and tanks were built in locations exposed to the easterly Harmattan wind were observed to become rapidly re-contaminated, even as the water was purified, due to dust and pollution becoming deposited in holes and crevices on the rainwater harvesting cisterns and associated structures.

10.7 LESSONS LEARNED

Rainwater is a useful alternative water source that can be used to provide potable water and water for irrigation in arid regions with low precipitation. Thus, while rainwater does not conform to the norms of water collection, harvesting and consumption, it is a good quality drinking water resource. Harvesting rainwater for these purposes can resolve problems of water access, experienced by populations trying to access more traditional drinking water resources. However, this approach requires that the appropriate infrastructure and equipment is put in place, and that hygiene measures are scrupulously respected.

The quality of water coming from rainwater harvesting systems was appreciated by all project beneficiaries in our endeavour, as it improved their health, particularly with regard to illnesses such as arterial hypertension and bone pain, which pregnant women and the geriatric population are particularly prone to suffering, if they consume brackish waters or waters highly concentrated in fluoride. That said, it is paramount that the water quality is regularly assessed in rainwater harvesting systems; testing should be conducted on rainwater as it is harvested, stored and distributed.

Poor drinking water quality can often be traced back to a water's source. But it is also important to assess the quality of water as it is stored and distributed, as water can be re-contaminated in both these phases. Those using rainwater as a drinking resource should always be careful in storing rainwater, and they should take appropriate measures in treating water and in handling it hygienically.

The collection and use of rainwater in agricultural settings can favour the diversification of farming practices in regions where climate change poses challenges to production. This is a wise use of a resource that is often lost, as it runs off into the sea, without having been utilised.

Harvesting rainwater in school contexts can significantly improve the quality of life of students. This resource can be used to cultivate trees and clean toilets. Consequently, the school environment evolves rapidly, improving the learning conditions of school children and their teachers, thereby allowing young scholars to blossom.

Creating micro-gardens using harvested rainwater can also extend the range of fresh vegetables available to a community. Many of the vegetables grown as part of this project were never previously available to beneficiaries. Additionally, the creation of these micro-gardens had a non-negligible effect on the quality of practical teaching methodologies. Previously, home economics classes had been predominantly theoretical; with the implementation of the micro-gardens, practical classes are now also offered by teachers.

Micro gardens provide the best solution for cultivating vegetables in school grounds, where water resources are often limited. As they consume little water, it is possible to irrigate them throughout the dry season. Micro garden cultivation gives schools a way of earning money through selling produce. However, it is important that the practical requirements associated with tending a micro garden are met on a daily basis. Their management requires the commitment of school children and their parents, who provide invaluable help in maintaining school gardens, particularly during school holidays.

For rainwater harvesting systems to function optimally, it is necessary for them to be regularly maintained. Therefore, a management committee needs to be established, who can pay particular attention to preparing the systems before the first rains of the season. This is the only means of ensuring that rainwater cisterns are filled effectively, and with water that is of potable quality.

This project has demonstrated the pertinence of rainwater harvesting in Senegal, and in the Sahel region more generally. Rainwater harvesting has accordingly been adopted by the FAO, who, in 2018, inspired by this project, launched the initiative '*un million de citernes pour le Sahel*' (a million of cisterns for the Sahel). This project was supported by Caritas, who made personnel and resources available during the pilot phase of this initiative in Senegal and Niger.

10.8 CONCLUSIONS

This project is a new initiative in this region; accordingly, its results could not be anticipated at the outset. Drinking water is not a common activity in this region, not is the consumption of fresh vegetables in the dry season. Accordingly, our project now presents us with the challenge of presenting a new image for rainwater harvesting. This resource is no longer only pertinent to irrigating large areas of winter crop. Today, harvested rainwater can be used to meet other needs, thereby modifying the daily activities of project beneficiaries.

After two years of project implementation, the local population of the Gossas district understands the value of rainwater harvesting for multiple uses. Seven to nine months after the rainy season ends, the project's cisterns still contain rainwater, which can be employed in a diverse manner, and often in applications that are innovative.

What are our governments waiting for, in order to integrate rainwater harvesting into rural and urban hydrological development projects? This is a legitimate question in a context where we know that water resources costing billions of euros are presently being developed to improve millions of people's access to freshwater resources; for instance, through desalinisation projects. We know, however, that this type of solution will privatise freshwater resources, and make them increasingly inaccessible for those with low incomes. In contrast, rainwater, manna from heaven, could ensure the democratisation of access to drinking water resources. Rainwater cisterns are easily reproducible, particularly for low-income communities, whose low revenues often preclude their being able to prioritise the purchase of this vital resource. They prioritise the purchase of basic food stuffs, and tend to utilise water resources that are of poorer quality than rainwater; the adverse consequences of consuming such waters will indirectly increase the cost of public health care for this demographic.

Projects such as this one merit more governmental and private sector investment, as well as the financial support of international bodies. They assist populations that might consider themselves as being overlooked by the political system.

10.9 BENEFICIARIES' TESTIMONIALS

> 'When I was still drinking water from the borehole, during my pregnancies, I had troubles with my legs. My feet swelled up to the extent that I had trouble walking,

and I had to go to the toilet a lot to urinate. The nurse told me these symptoms were related to the poor quality of my drinking water, and gave me a tablet to dissolve in the water coming from the borehole before drinking it. Since the rainwater harvesting system has been installed in my village, this is the water that I drink. I have not suffered from the same symptoms during my pregnancies once I made this change. My last child, who I'm carrying on my back, was an example of an easier pregnancy. This water has become really important for us'.

Ndiague Faye, mother, Walalane.

'I live with my mother, who is old. When she drank water from the borehole, she often suffered from hypertension and rheumatism. I took her to the hospital in Gossas, located 7 km from our home, for her to be cared for there, and this cost me lots of time and money. Since our rainwater harvesting system has been installed, and she has begun to drink this water, she is in better health. This is why, even if we have run out of harvested rainwater at home, she doesn't attempt to drink water from the borehole, and rather prefers to go and ask for rainwater from one of our neighbours'.

Bathie Faye, son, Walalane.

'We never thought we'd have fresh vegetables in the dry season, certainly not on our tables, and in such great quantities; it's incredible! Today, in our school canteen, we have different vegetables, which improve the quality of our meals'.

Teaching staff member, Tchingué

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REFERENCES

Caritas Sénégal (2009). Impact of fluoride ingested via drinking water on the health of populations. Case of five rural communes, May 2009. Multidisciplinary Research Team, Synthetic Document, Caritas, Senegal, 6p.

CONGAD. (2014). Document de plaidoyer des ONG du Sénégal. UNDEF, Senegal.

Meerman R., Sène S. and Nitzsche M. (2015). Towards an Integrated Rain Water Harvesting Approach in Senegal, Concept Note Project, October 2015, 13p. Horizont3000, internal

document National Hydraulic's Plan (2015) Note on Senegal's water resources, October 2015. National Hydraulics, Senegal.
National Hydraulic's Plan. (2015). Note on Senegal's water resources, October 2015. National Hydraulics, Senegal.
PEPAM-Aqua. (2011a). Initial Field Survey, December 2011. PEPAM-Aqua, Kaolack, Senegal.
PEPAM-Aqua. (2011a). Start-Up Study of the Project to Support the Improvement of Water Quality in the Kaolack, Kaffrine, Fatick and Diourbel Regions, Final report, December 2011, PEPAM-Aqua, Kaolack, Senegal, 66p.
Sene S. (2016). Integrated Project of Sustainable Management of Rain Water with Multiple uses, Final report, March 2016, 12p. Horizont3000, internal document.
Sene S. (January 2019). Sustainable management of rainwater for multiple uses in rural areas, Final report, January 2019, 28p. Horizont3000, internal document.
Sene S. (2018). Integrated Project of Sustainable Management of Rain Water with Multiple uses, Semi annual report, July 2018, 14p. Horizont3000, internal document.