UWR Rainwater Offset Unit Standard

(UWR RoU Standard)

Concept & Design: Universal Water Registry

www.uwaterregistry.io

Project Concept Note & Monitoring Report

(PCNMR)

Project Name: Rainwater Harvesting Project by ACAATINGA

UWR RoU Scope: 02

Monitoring Period: 01/01/2014-31/12/2023

Crediting Period 1: 2014-2023

UNDP Human Development Indicator: 0.786[1]

[1] https://hdr.undp.org/data-center/country-insights#/ranks

A.1 Location of Project Activity

State	Ceará and Piauí
District	Crateús and Buriti dos Montes municipality
Block Basin/Sub Basin/Watershed	Parnaíba Hydrographic Region
Lat. & Longitude	Crateús: 5°10'41.14"S, 40°40'10.64"W Buriti dos Montes: 5°18'46.50"S, 41° 5'46.67"W
Area Extent	Average catchment area: $32m^2$
No. of Villages/Towns	30 communities

Figure 1: Country of Brazil

Figure 2: Location of Project

A.2. Project owner information, key roles and responsibilities

Project Proponent (PP):	Associação Caatinga (ACAATINGA)
Project Aggregator	Kosher Climate India Private Limited
Dated PCNMR prepared (Version 2.0)	22/07/2025

Acaatinga is the Implementor of the Rainwater Harvesting (RWH) project, responsible for providing the necessary materials and constructing of cisterns. The local communities of Crateús and Buriti dos Montes are the End Users and are responsible for maintaining the systems that capture rainwater during the monsoon season. An agreement has been signed between Acaatinga and the local communities (End Users) stating that any environmental benefits, such as the Rainwater Offset units (RoU) associated with the project, will be retained by Acaatinga.

These communities have also undergone training, which includes two days focused on water management for human consumption, enabling them to effectively manage the harvested rainwater and ensure its safe use for drinking and other essential needs.

A.2.1 Project RoU Scope

PROJECT NAME	Acaatinga Project
UWR Scope:	RoU Scope 2
Date PCNMR Prepared	22/07/2025
Average Catchment Area	32 m^2
Type of Tank	Cisterns
Tank Capacity	16,000 liters
Diameter/Size of Tank (m)	3.46 m
Height of tank (m)	2.4 m
Type of Construction	Cisterns made of cement mortar, reinforced with wire.
Average Rainfall (mm)	589.35 mm (Avg. of 559.4 & 619.3)
RoU Crediting Period	01/01/2014 to 31/12/2023
Total RoU generated for the crediting period	**19,056** RoUs (1 RoU = 1000 liters)

Year	RoUs
2014	781
2015	1,119
2016	1,229
2017	842
2018	2,855
2019	811
2020	3,809
2021	2,102
2022	1,212
2023	4,296
Total	**19,056**

The project activity involves the installation of Rainwater Harvesting (RWH) cisterns constructed near the homes of local community members. The Project Proponent, Acaatinga, adheres to all required rules and regulations by the Brazilian ministry of Development and Social assistance, Family and fight against Hunger[2]. Each household is allotted its own distinct cistern, ensuring that the water user rights remain with the local communities.

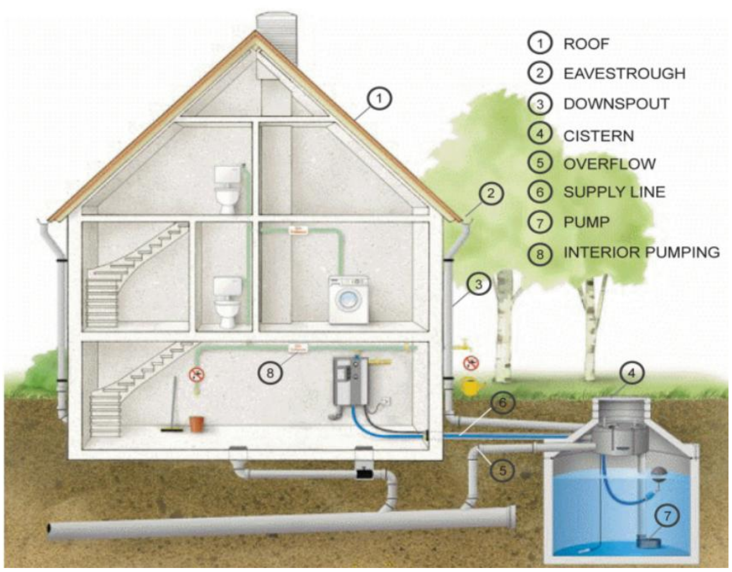
[2] https://www.gov.br/mds/pt-br/acoes-e-programas/acesso-a-alimentos-e-a-agua/programa-cisternas

The installed Rainwater Harvesting System is man-made constructed cisterns that conserve and stores rainwater for future use in the rural area of the Crateús and Buriti dos Montes municipality. The plate cistern is a type of cylindrical, covered and semi-buried water reservoir, which allows the capture and storage of rainwater from its runoff on the roofs of houses, through the use of PVC gutters. The closed reservoir is protected from evaporation and contamination caused by animals and waste brought by floodwaters.

The program focuses on establishing a standardized approach to ensure quality construction and minimize potential failures. The training on water management for human consumption and cistern construction has been provided to the beneficiaries of individual households. Attendance is documented through signed lists, capturing participant details and community identification, with records maintained.

Construction teams consist of one farmer paid R$ 60.00 per day for five days and one helper at R$ 30.00 per day. Additionally, food costs for workers are R$ 17.00 per day during construction. This program enhances community resilience by promoting sustainable water management practices through high-quality cistern construction.

Rainwater harvesting (RWH) is the process of collecting, conveying, and storing rainfall for future use. It involves capturing rainwater from rooftops (roof water) which can then be reused for irrigation or other domestic purposes. The collected rainwater is directed into storage facilities, which can vary in size small for residential use and large for commercial and institutional applications.



The Project aims to improve living conditions for low-income families in rural areas by installing 16,000-liter plate cisterns for rainwater collection and storage. Alongside this infrastructure, capacity-building and training in water management are provided. By maintaining these systems, families can access quality water more easily, reducing the need for long walks to find water and avoiding reliance on low-quality sources. Ultimately, these efforts not only enhance water access for human consumption but also contribute to food and nutritional security, fostering resilience in Brazil's semi-arid regions.

The training program for constructing cisterns aims to equip farmers with essential skills for building plate cisterns. Teams of up to ten farmers participate in hands-on training, guided by an experienced instructor who demonstrates construction techniques and procedures.

Cistern Characterization and Average consumption	
Parameter	**Description**
Project	Cisterns for collecting rainwater
Construction type	Cement motor system reinforced with wire
Capacity	16,000 Liters- Exclusively for domestic use (cooking, washing & drinking)
Daily consumption/person	13 Liters
Monthly consumption/person	390 Liters
Consumption per person during 8 months of Drought	3,120 Liters
Consumption for a family of 5 people on an average for a period of 8 months	15,600 Liters

List of communities involved in the project activity:

S.No	**Community**	**City**
1	Aldeia Nazário	Crateus - CE
2	Barro Vermelho	Crateus – CE
3	Bebedouro	Buriti dos Montes - PI
4	Boqueirão dos Galdinos	Crateus – CE
5	Cabaças	Crateus – CE
6	Cabeça da Onça	Crateus – CE
7	Cana Brava	Buriti dos Montes - PI
8	Jatobá Medonho	Buriti dos Montes - PI
9	Jurema	Buriti dos Montes - PI
10	Lagoas	Crateus – CE
11	Monte Nebo	Crateus – CE

12	Patos	Crateus – CE
13	Pau de Óleo	Crateus - CE
14	Pendência	Crateus – CE
15	Queimadas	Crateus – CE
16	Realejo	Crateus – CE
17	Santa Luzia	Crateus – CE
18	Santana	Crateus - CE
19	Santo Antonio	Buriti dos Montes - PI
20	Saquinho	Buriti dos Montes - PI
21	Tabuleiro	Crateus – CE
22	Tapuio	Crateus – CE
23	Xavier	Crateus – CE
24	Boa Esperança	Crateus – CE
25	Caldeirão	Buriti dos Montes - PI
26	Camará	Buriti dos Montes - PI
27	Marins	Crateus – CE
28	Ponta do Poço	Buriti dos Montes – PI
29	Salgado	Crateus – CE
30	Taboa	Buriti dos Montes – PI

Baseline scenario:

In the baseline scenario, prior to the installation of rainwater harvesting cisterns, the primary source of water for domestic use was rainwater during periods of rainfall. Households relied on the rainwater to meet their daily consumption needs such as drinking, cooking, and cleaning. However, during dry spells or periods with no rainfall, the stored rainwater would deplete, compelling households to purchase water from nearby supermarkets or vendors to meet their domestic requirements. This practice of buying water added a financial burden on the families, particularly during extended dry periods. These patterns of water usage and dependency were clearly identified and confirmed through the baseline survey conducted in the region, which captured the prevailing water access challenges faced by the local community.

Benefits of Rainwater Harvesting:

Sustainable Management: Rainwater harvesting contributes to sustainable water use by reducing the reliance on groundwater and municipal water systems. By collecting rainwater for non-potable purposes like irrigation, landscaping, and cleaning, or even for potable use with proper treatment, communities can reduce their consumption of treated water, which often requires a significant amount of energy to process and transport. The stored water will be used for the consumption during the drought period.

Reduces Runoff: In urban areas, rainwater that falls on impervious surfaces like roads, rooftops, and parking lots can create significant runoff, leading to flooding, erosion, and the transportation of pollutants into rivers, lakes, and oceans. Rainwater harvesting mitigates this by capturing rainwater before it becomes runoff. This not only reduces the risk of flooding but also prevents the transport of pollutants such as oil, heavy metals, and debris that often contaminate surface water.

Drought Resilience: One of the most pressing concerns related to water resources is the increasing frequency and severity of droughts. Rainwater harvesting serves as a supplementary water source, providing an alternative when regular water supplies are low. By storing rainwater during wet seasons, communities can have a reliable reserve to use during periods of drought or water scarcity. This reduces dependence on groundwater and municipal systems, making regions more resilient to water shortages and ensuring a more consistent water supply throughout the year

Groundwater Recharge: Groundwater is a critical source of drinking water and irrigation for many regions around the world. Over-extraction of groundwater, especially during dry spells, can lead to depletion of aquifers and lower water quality. Rainwater harvesting can play a key role in replenishing groundwater supplies. When rainwater is harvested and infiltrated into the ground, it helps recharge aquifers by promoting natural groundwater replenishment. This not only increases the quantity of groundwater available but also improves its quality, as rainwater is typically free from many of the contaminants that affect surface water sources. Additionally, rainwater harvesting can prevent the salinization of groundwater in coastal areas by reducing the demand on over-exploited freshwater aquifers.

Treatment of water prior to its consumption:

In line with the instruction booklet provided to the beneficiaries, the water must be filtered and treated with chlorine before the consumption to ensure the water is free of organisms that transmit the diseases. Two drops of Sodium Hypochlorite shall be applied for one liter of water. Then, mix well and wait half an hour before using the water for consumption. The sodium hypochlorite will be provided by the Brazilian Public Health system for free of cost.

The project activity fulfills the UWR RoU requirements for “measures undertaken for conservation and storage of excess surface water for future requirements.”

A.3. Land use and Drainage Pattern

Brazil's climate is notably diverse, with significant semi-arid regions, particularly in the northeast states, such as Piauí and Ceará. These areas grapple with irregular rainfall and recurrent droughts, which have intensified over recent decades. The resulting water scarcity poses serious challenges for agriculture and local communities that depend on consistent water supplies. In response to these challenges, sustainable practices such as rainwater harvesting systems have emerged as vital solutions. These systems capture and store rainfall, providing much-needed water during dry periods and helping communities adapt to the impacts of climate change. Effectively managing the relationship between rainfall variability and water availability is essential for promoting resilience and ensuring sustainable livelihoods in Brazil's semi-arid regions.

Buriti dos Montes

A.3.1: Geology Aspect:

Approximately 98% of the area of the **Buriti dos Montes municipality** is covered by lithologies belonging to sedimentary rock formations, as detailed below. The Cabeças Formation consists of sandstone, conglomerate, and siltstone, which is at the top of the sequence. Directly below it lies the Pimenteiras Formation, composed of sandstone, siltstone, and shale. The Serra Grande Group, which includes conglomerate, sandstone, and intercalations of siltstone and shale, rests upon the crystalline basement.

About 2% of the remaining area of the municipality features outcrops of rocks from the crystalline basement, specifically the Ceará Complex, which includes gneiss, marble, quartzite, and schist.

Land use: As of 2020, 83% of the land cover in the region was natural forests and 0% was non natural tree cover.

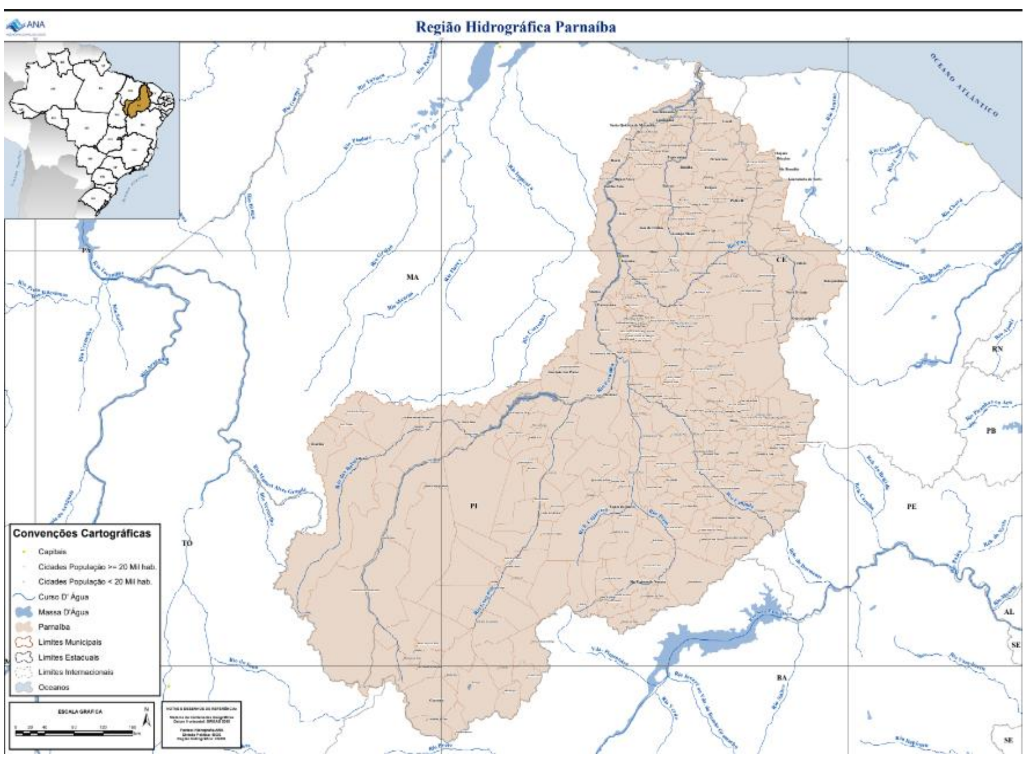
A.3.2: Hydrogeology:

A.3.2.1 Ground Water:

In the municipality of Buriti dos Montes, there are two distinct hydrogeological domains: crystalline rocks and sedimentary rocks. The crystalline rocks are commonly referred to as "fractured aquifers." They consist of a variety of Precambrian rocks from the crystalline basement, including gneiss, marble, quartzite, and schist. Since there is essentially no primary porosity in these rocks, the occurrence of groundwater is dependent on secondary porosity represented by fractures and fissures, resulting in sporadic, discontinuous, and small reservoirs. Consequently, the flow rates produced by wells are generally low, and the water is often saline due to limited circulation, the effects of the semi-arid climate, and the type of rock. These conditions define a low hydrogeological potential for the crystalline rocks; however, they remain significant as an alternative water supply for small communities or as a strategic reserve during prolonged droughts.

River Basin:

The Parnaíba Basin (Bacia do Parnaíba) is a large cratonic sedimentary basin located in the North and Northeast portion of Brazil. About 50% of its areal distribution occurs in the state of Maranhão, and the other 50% occurring in the state of Pará, Piauí, Tocantins, and Ceará.



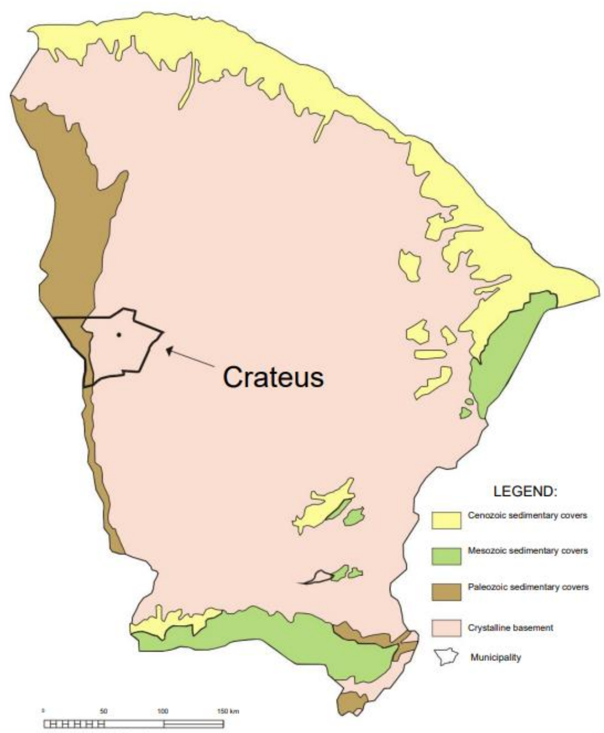
The basin has a roughly ellipsoidal shape, occupies over 600,000 km2, and is composed of 3.4 km of mainly Paleozoic sedimentary rock that overlies localized rifts. The basin as named after the Parnaíba River, which is approximately 1,400 km (870 mi) long, and runs relatively parallel to the major axis of the basin.

CRATEÚS

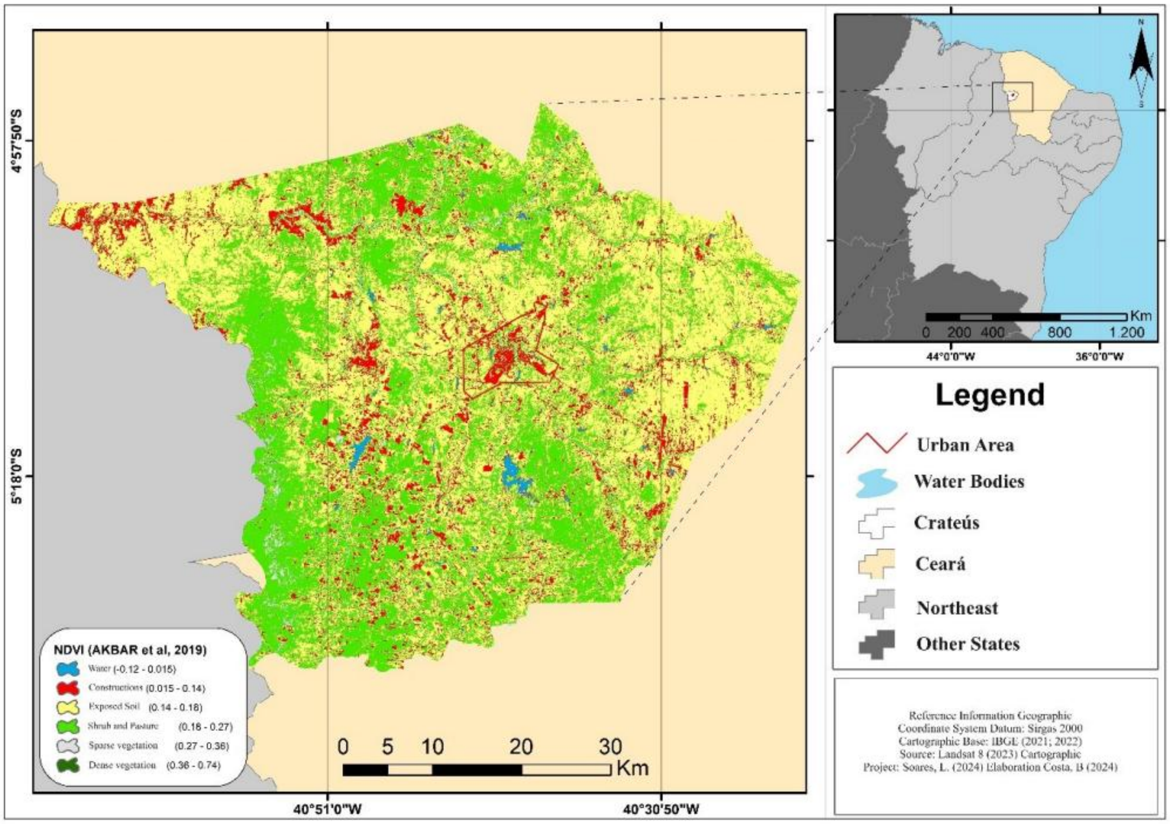
A.3.3: Geology Aspect:

The state of **Ceará** is located in the **Northeast region** of Brazil, covering an area of approximately **148,000 km²**. It lies entirely within the **Drought Polygon**, a region characterized by highly irregular rainfall patterns.

The municipality of **Crateús** is situated in the central-western part of Ceará, bordering the municipalities of **Ipaporanga**, **Tamboril**, **Novo Oriente**, **Independência**, and the state of **Piauí** to the north. Crateús covers an area of **2,770 km²**. The climate in Crateús is typical of the semi-arid region, with temperatures ranging from **20°C** in the winter to **35°C** in the summer. The average annual rainfall is around **700 mm**, reflecting the region's dry conditions.



Land use: As of 2020, 71% of the land cover in the Crateus region was natural forests and <0.1% was non natural tree cover.

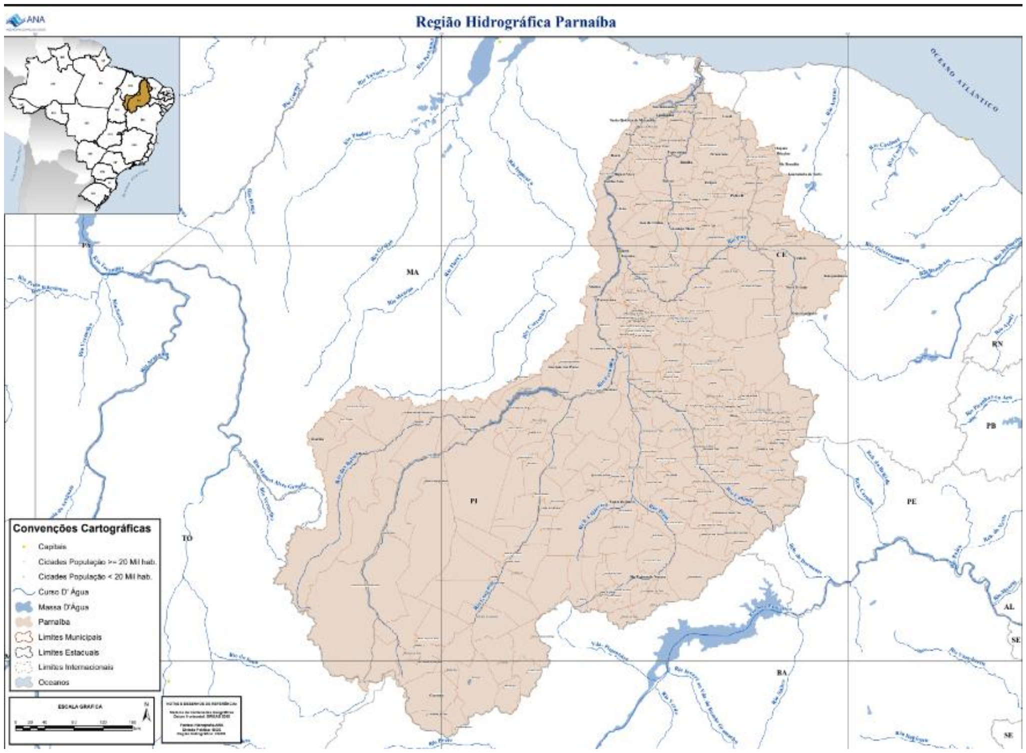


A.3.4: Hydrogeology:

The hydrological conditions of the **Crateús region** in **Ceará** are influenced by its semi-arid climate, characterized by irregular and low rainfall. The region depends heavily on both surface water and groundwater to meet the water demands of its population and agriculture.

A.3.4.1 Ground Water:

The Crateús region relies heavily on groundwater from fractured crystalline aquifers found in gneisses, granites, and schists, which yield low to moderate water quantities depending on the degree of fracturing. Shallow wells typically tap into groundwater at depths of 10 to 30 meters, while deeper wells can reach 100 to 150 meters to access more substantial aquifers. Over 70% of the rural population depends on private wells for drinking, irrigation, and livestock. Agriculture is the primary consumer of groundwater, especially for irrigation, and water levels in wells can fluctuate by 1 to 3 meters during dry spells. Deep wells yield between 5 and 15 m^3/h, depending on aquifer permeability.



A.4. Climate

The Brazilian Semi-Arid region extends across the nine states of the Northeast region and also the north of Minas Gerais. In total, it occupies 12% of the national territory and is home to around 28 million inhabitants divided between urban (62%) and rural (38%) areas, making it one of the most populated semi-arid regions in the world.

The semi-arid climate regions are characterized primarily by irregular rainfall and high evapotranspiration rates, elements that together contribute to the constant risk of water shortages. However, just as drought is an inseparable part of the semiarid region, so too is the phenomenon of torrential monsoons, which occasionally fall in short periods and cause floods, reviving thousands of intermittent rivers and lakes, restoring vegetation and helping to recover reservoirs. Thus, this climatic dichotomy makes the Brazilian semiarid region both one of the most habitable in the world and a region particularly susceptible to climate change, which is why its climatology relies on several scientific monitoring methods and the popular wisdom of the people of the backlands. The annual average rainfall is less than 800mm, dryness Index is up to 0.5 and Drought Risk is greater than 60%.

Semi-arid: The region is characterized by a climate divided into two types: the megathermal rainy climate (variety AW'[3] - hot and humid with summer and autumn rains, relatively lower temperatures in

[3] Tropical savanna climate

March or April and occurring in the coastal region and in the lower Parnaíba) and the semi-arid climate (BS[4] - characterized by high and stable temperatures, above 18°C, low average annual rainfall with poor rainfall distribution and corresponding to areas of hyperxerophytic caatinga). A variety of the AW' climate - the BSwh', is of the semi-arid type with a short rainy season in the summer and with activity in the southeast of the basin.

A.5. Rainfall

The project activity area experiences a hot to semi-arid climate. In Crateús, the summer season continues for about three and half months between September and December and the temperature rises as higher as 100°F in the month of November and during winter it falls up to 87°F during April.

Buriti dos Montes, experiences a hot climate typical of the Brazilian Northeast. The summer season lasts from October to January, with temperatures often exceeding 100°F (38°C), especially in November and December. During the winter months, from May to August, temperatures remain relatively warm, averaging around 86-88°F (30-31°C).

Both the municipalities area faces acute shortage of water due to frequent failure of monsoon creating drought like situation. The overall annual average rainfall for Cratéus is 559.4 mm and for Buriti dos Montes is 619.3 mm.

The annual rainfall data for the study area is summarized in the tables below. For **Crateús**, the highest recorded rainfall was 1,080.4 mm in 2020, while the lowest was 137.6 mm in 2019. The 15-year average annual rainfall for Crateús is 559.4 mm. In **Buriti dos Montes**, the maximum rainfall recorded was 1,111.4 mm in 2023, and the minimum was 124 mm in 2017. The 14-year average annual rainfall for Buriti dos Montes is 619.3 mm. The overall Annual average rainfall for the entire project area is 589.35 mm.

Year wise Annual Rainfall for the last 15 years (2009 to 2023) in the city of Crateús, Ceará - Brazil[5]	
Year	**Observed rainfall (mm)**
2009	904.4
2010	350.0
2011	941.8
2012	244.0
2013	402.2
2014	276.6

[4] Semi-arid

[5] Instituto Nacional de Meteorologia - INMET

2015	600.0
2016	595.2
2017	444.8
2018	897.4
2019	137.6
2020	1080.4
2021	596.8
2022	275.0
2023	644.8

Table: Annual Rainfall for last 21 years for Cratéus

Year wise Annual Rainfall for the last 14 years (2010 to 2023) in the city of Castelo do Piauí, Piauí - Brazil[6]	
Year	**Observed rainfall (mm)**
2010	903.8
2011	1109.2
2012	308.6
2013	434.0
2014	619.8
2015	501.6
2016	346.2
2017	124.0
2018	1030.0
2019	323.4
2020	no data
2021	no data
2022	no data
2023	1111.4

Table: Annual Rainfall for last 21 years for Buriti dos Montes

A.6. Ground Water

Ground water status of Crateús region: The Crateús region in northeastern Brazil heavily relies on groundwater from fractured crystalline aquifers found in gneisses, granites, and schists. These aquifers yield low to moderate water quantities depending on the degree of fracturing and rock permeability. Shallow wells typically access groundwater at depths of 10 to 30 meters, while deeper wells, reaching

[6] https://portal.inmet.gov.br/

100 to 150 meters, tap into more substantial aquifers. Over 70% of the rural population depends on private wells for drinking, irrigation, and livestock needs, with agriculture being the primary consumer of groundwater, especially for irrigation.

During dry periods, water levels in wells can fluctuate by 1 to 3 meters, highlighting the vulnerability of groundwater resources in the region. Deep wells typically yield between 5 and 15 cubic meters per hour (m^3/h), depending on the aquifer's permeability. The variability in water yields emphasizes the need for sustainable groundwater management, particularly in a region where the population and agriculture are heavily dependent on these resources. Proper management is essential to ensure long-term water availability, especially during droughts or periods of reduced rainfall.

Surface Water:

The Poti River is the primary river draining the Crateús region, with its flow varying seasonally and often reduced during dry periods. Other seasonal rivers, such as the Feijão and Cangati Rivers, also contribute surface water but may dry up in the dry season. The Crateús Reservoir (Crateús Dam), with a storage capacity of 27 million m^3, is a key water source, although it can experience significant water level reductions during prolonged droughts. Several smaller reservoirs and dams also support the region’s water supply, but they can be depleted by the end of the dry season if rainfall is insufficient. The average annual rainfall is 700 mm, and the region’s irregular rainfall patterns create challenges in managing and storing surface water.

Unconfined aquifers: The unconfined aquifers are located along the streambeds i.e., small alluvial valleys of creeks. These shallow and porous deposits offer moderate storage and recharge potential but are highly sensitive to seasonal droughts and over extraction. Public monitoring of piezometric levels in alluvial aquifers from the 2010s drought (2012–2016) shows sustained drawdown during drought, with partial recovery starting around 2017—but recharge remains unstable.

Confined aquifers: In the Crateus region, the crystalline aquifers have a salinity higher than expected in this type of environment. The aquifers are dominated by Precambrian gneiss and migmatite basement rock (> 96 % of area) with limited porosity. Groundwater occurs in fractures and weathered zones. The recharge of these aquifers is slow.

Ground water status of Buriti dos Monte’s region: The Buriti dos Montes region, located in the state of Piauí, Brazil, also relies significantly on groundwater resources, primarily sourced from fractured crystalline aquifers. These aquifers, found in rock formations such as gneisses, granites, and schists, typically provide low to moderate yields, depending on the degree of fracturing and permeability of the rocks. Shallow wells in the region usually tap into groundwater at depths ranging from 10 to 40 meters, while deeper wells, reaching up to 150 meters, access more substantial aquifers. The region's rural population, especially in areas with limited surface water, depends heavily on private wells for drinking, irrigation, and livestock needs.

Groundwater extraction in Buriti dos Montes is particularly critical for irrigation, with agriculture being the primary consumer of water. The water levels in wells can experience fluctuations during dry spells, with reductions of up to 2-4 meters in some cases. Deeper wells in the region typically yield between 5 to 12 cubic meters per hour (m^3/h), depending on the local aquifer's characteristics. Given the semi-arid climate of the region and its dependence on groundwater for both domestic and agricultural purposes, sustainable water management practices are essential to prevent over-extraction and ensure a continuous water supply, particularly during extended periods of drought.

Surface Water:

The surface water resources in the state of Piauí are represented by the Parnaíba River basin, the largest among the 25 basins in the Northeast region, covering an area of 330,285 km², which is approximately 3.9% of the national territory. The Parnaíba River stretches for 1,400 kilometers, and most of its tributaries located downstream of Teresina are perennial, fed by rainfall and groundwater. After the São Francisco River, it is the most important river in the Northeast.

Among the sub-basins, notable rivers include: Balsas, located in Maranhão; Potí and Portinho, with sources in Ceará; and Canindé, Uruçuí-Preto, Gurguéia, and Longá, all in Piauí. It is important to highlight that the Canindé River sub-basin, despite representing 26.2% of the total area of the Parnaíba basin, drains a large semi-arid region. Although Piauí is part of the "Drought Polygon," it does not have a significant number of reservoirs.

Unconfined aquifers: In the Buriti dos Monte's region of northeastern Brazil, the shallow sedimentary formations and weathered profiles often form unconfined aquifers, especially within sandy alluvial deposits. These aquifers do not contain an impermeable layer above them and contains water table that responds to local recharge due to seasonal rainfall.

confined aquifers: The confined aquifers are formed at deeper depths lie beneath the less permeable strata. The aquifers are associated with the silicified layers and fine-grained sandstones.

A.7. Alternate methods

The topography of Crateús and Buriti dos Montes, with its uneven terrain of hills and valleys, makes large-scale water infrastructure like dams and reservoirs difficult to implement. In contrast, rainwater harvesting (RWH) is well-suited to this landscape, as it can be deployed at the household or community level without significant alterations to the natural terrain. The region's rainfall pattern, characterized by concentrated wet months and prolonged dry spells, further underscores the benefits of RWH, enabling the collection and storage of water during the rainy season for use in the dry months.

Additionally, limited groundwater resources, due to low aquifer recharge and contamination risks, make RWH an attractive alternative that alleviates pressure on fragile aquifers. Furthermore, the scarcity and seasonality of surface water sources like rivers and lakes make them unreliable, while

RWH offers a localized, consistent supply by capturing rainwater directly from rooftops and other surfaces, circumventing the need for extensive water transport or reliance on surface water bodies.

Alternate Water Management Methods available:

- **Boreholes/Well Drilling**: While drilling boreholes or wells can provide groundwater, it's often not a sustainable solution in semi-arid regions like Crateús and Buriti dos Montes, where aquifers are limited and over-extraction can lead to depletion. Additionally, the high cost and maintenance requirements make this method less viable in the long term.

- **Surface Water Storage (Dams or Ponds)**: Creating large-scale surface water storage, such as dams or ponds, can be expensive and impractical in areas with seasonal or unreliable water sources. The uneven topography in the region makes such infrastructure difficult to implement, and it may not provide a consistent water supply during dry periods.

- **Desalination or Water Treatment**: Desalination, while an option for coastal areas, is not feasible in Crateús and Buriti dos Montes due to their inland location. Furthermore, the energy-intensive nature and high cost of desalination make it an impractical solution for these communities.

- **Water Importation**: Importing water through pipelines or tanker trucks is costly, logistically complex, and not sustainable in the long term, especially in rural or isolated areas. It also adds environmental concerns related to transportation and fuel consumption.

Advantages of RWH over other Water Management Methods:

- **Local Suitability**: The region's seasonal rainfall pattern makes rainwater harvesting a highly suitable method. By capturing rainwater during the rainy season and storing it for use during the dry months, rainwater harvesting ensures a steady water supply without over-relying on local aquifers or surface water.

- **Cost-Effective**: Compared to drilling boreholes, building dams, or importing water, rainwater harvesting is cost-effective, especially for rural households and communities. The infrastructure required for rainwater harvesting (e.g., gutters, storage tanks, filtration systems) is relatively simple and inexpensive.

- **Environmental Sustainability**: Rainwater harvesting is an environmentally friendly method that avoids over-exploiting local water resources, which is a critical concern given the fragile state of groundwater and surface water in the region.

- **Scalability and Flexibility**: Rainwater harvesting systems can be implemented at various scales, from individual households to large community-level systems. This flexibility makes it suitable for both urban and rural areas, adapting to local needs and capacities.

A.8. Design Specifications

Construction of Cistern:

The construction of the cistern at the beneficiary's home should only begin after confirmation of the beneficiary's participation or that of a person representing him/her in the training on water management for human consumption.

The plate cistern is a type of cylindrical, covered and semi-underground water reservoir that allows the collection and storage of rainwater from its runoff on the roofs of houses, through the use of zinc or PVC gutters. The closed reservoir is protected from evaporation and contamination caused by animals and waste brought by floods.

The cistern is buried in the ground up to about two-thirds of its height. It consists entirely of concrete slabs measuring 50 by 60 cm and 3 cm thick, which are curved according to the projected radius of the cistern wall, varying according to the expected capacity. There are variants where, for example, the concrete slabs are smaller and thicker, and made of a finer mix of cement. These slabs are manufactured on site in wooden molds. The cistern wall is raised with these slabs.

After this, a galvanized steel wire No. 12 is wound around the outside of the wall, then a crimp is made in each wire that surrounds the plates for better fixation and then the external plastering is done. In a second stage, the roof is built with other pre-molded plates in a triangular shape, placed on top of reinforced concrete beams, and the external plastering of the roof is done.

The process of constructing a cistern involves seven key steps. Below are the steps, along with relevant information and technical recommendations for each stage of the construction process:

- **<u>Digging the Hole:</u>**

  The cistern should be located near the house for convenience, while considering the type of terrain, which will affect both the depth of excavation and the stability of the tank. It's important to avoid constructing the cistern too close to trees, corrals, or pits, maintaining a minimum distance of 10 to 15 meters to ensure proper structural integrity and prevent potential hazards.

- **<u>Manufacturing of Plates:</u>**

  Use medium sand that is washed and sieved, with a particle size between coarse and fine. The recommended mix ratio is 4 cans of sand for every 1 can of cement.

- **<u>Manufacturing of rafters:</u>**

  The rafters are made using a concrete mix with twisted rebar. The materials required include 2 cans of sand, 2 cans of gravel, and 1 can of coarse cement. Additionally, 4 boards measuring 1.30m in length, 6cm in width, and 2 to 3cm in thickness are needed, along with 17 rods of ¼ inch rebar. Each rebar rod should have a hook at the end, formed in the final 10cm of the rod.

- **<u>Raising the walls:</u>**

  I. **Manufacturing of bottom slab:** The concrete mix consists of 4 cans of coarse sand, 3 cans of gravel, and 1 can of cement, with a thickness of 3 to 4 cm. The radius is measured as 1.73 meters from the centre to the edges.

  II. **Placing the plates:** The material mix consists of 2 cans of sand for every 1 can of cement, with a 2 cm gap between each plate.

  III. **Wall binding:** Galvanized wire No. 12 is used for tying, which can be done 1 hour after lifting the plates. The process begins at the base, ensuring that all wire turns are evenly distributed along the cistern wall.

  IV. **Plastering the walls:** For plastering, the fine sand-to-cement ratio is 3 cans of sand to 1 can of cement for internal plastering, and 5 cans of sand to 1 can of cement for external plastering. External plastering should be started first, followed by internal plastering.

  V. **Plastering the bottom of the cistern:** The same mass as the internal plaster of the wall.

VI. Application of waterproofing: Waterproofing should be applied 1 or 2 days after the cistern is built. The waterproofing agent is mixed with cement and applied in up to three coats. It is important to add water to the cistern once it's ready to prevent it from drying out.


- <u>**Coverage:**</u>

  The construction process includes the placement of the central pillar, positioning of rafters, and installation of ceiling tiles. Ceiling plastering is done with a mix of 5 cans of sand to 1 can of cement, followed by finishing and painting as needed.

- <u>**Installation of the Collection System:**</u>

  Rainwater collection is achieved through downspout gutters attached to the rafters of the house roof, with pipes connecting the gutters to the cistern. A strainer must be placed at the cistern's entrance to prevent dirt from entering the interior.


- <u>**Final Touch-ups and finishing:**</u>

This phase involves creating a mortar belt to join the rafters to the cistern wall using a mix of 5 cans of fine sand to 1 can of cement. It also includes fixing the identification plate according to the standard model and whitewashing the cistern wall.

- **<u>Manual pump (with free water outlet from the cylinder):</u>**

This type of pump is distinct from others because it features a "free" water outlet from the cylinder, meaning there is a dedicated pipe that directs water out of the system. This design provides two key hydraulic benefits: (1) when the piston is pushed, the available hydraulic load is higher; and (2) the load loss at the water outlet is minimized, as the water flows almost freely, with only the check valve (marble) offering resistance.

Check valves are used to control the flow of water during the piston's "push-pull" movement in the cylinder. Water enters through one valve (V1) and exits through the other (V2), ensuring a unidirectional flow (see figure below). When the piston is pulled, Valve V1 opens, allowing water to enter and fill the cylinder, while Valve V2 remains closed. Upon pushing the piston, Valve V2 opens to release the water from the system, while Valve V1 closes to prevent backflow.

The pump model presented is not only more efficient but also offers several advantages that make it particularly well-suited for use in cisterns located in the Brazilian semi-arid region. These advantages include: larger diameters for the cylinder and piston, which allow for higher pumping flows; ease of acquiring materials and simple assembly; minimal maintenance requirements, with any needed repairs being straightforward; and a reduced cost that aligns with the budget proposed by the program. In contrast, cast iron hand-operated pumps and PVC hydraulic pumps (with movable water outlets) are not suitable for the program. For further details, refer to the MDS publication on the subject.

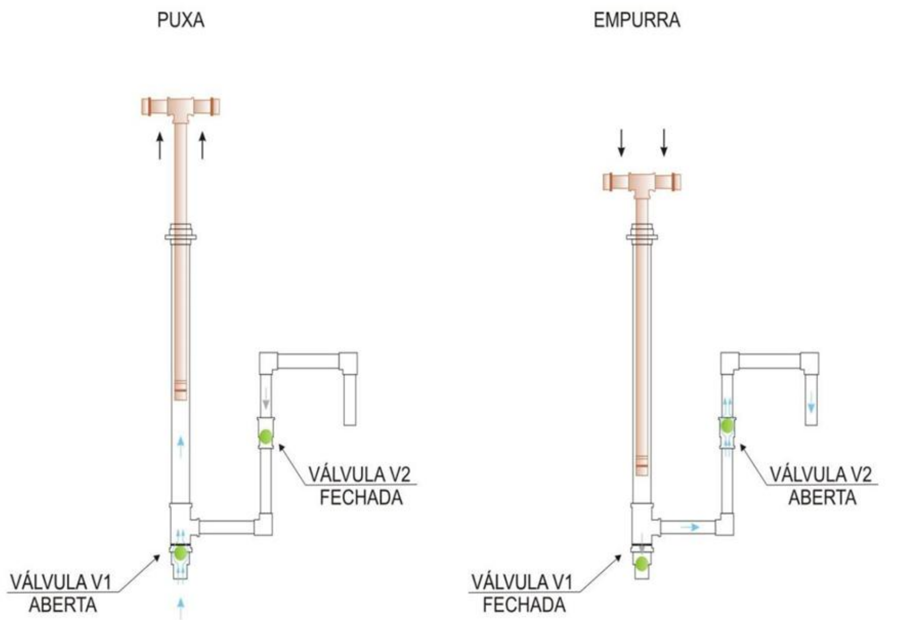


Fig: Operation of the manual water pump models MOC and PATAC

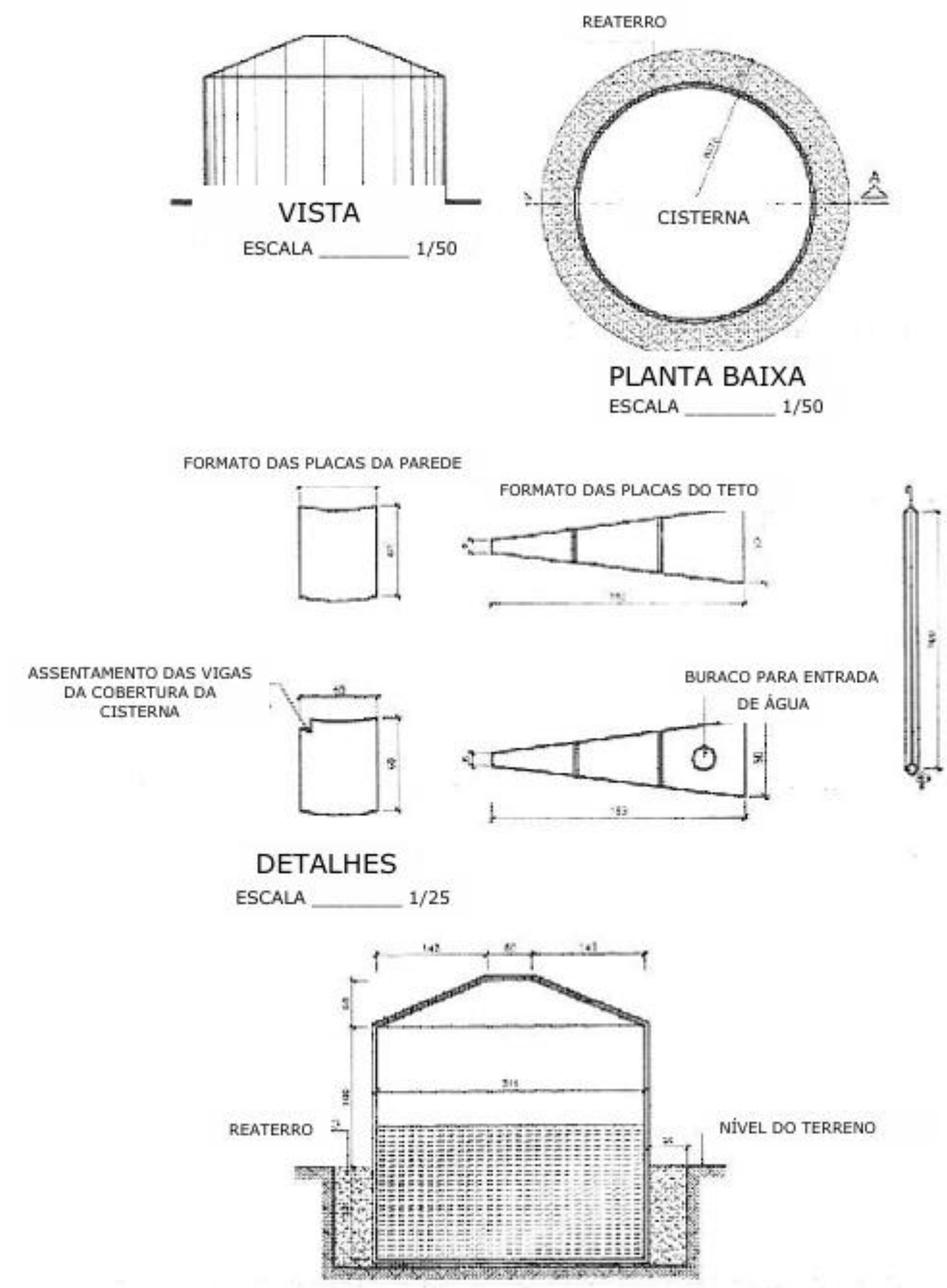
Photos 1,2,3, and 4: Cistern Construction Sequence in communities

Photos 5, 6, 7 and 8: Cistern Construction Sequence in communities

<u>Design Specification of Cistern:</u>

Summary Table **Cistern Characterization and Average Consumption**
Project: Cisterns for collecting rainwater.
Type of Construction: Cement mortar cisterns, reinforced with wire.
Capacity: approximately 16,000 liters of water.
Daily consumption per person: 13 liters of water – exclusively for drinking, cooking, brushing teeth and washing hands and household items for immediate use.
Monthly consumption, per person: 390 liters of water.
Consumption, per person, during 8 months of drought: 3,120 liters of water.
Consumption per family of 5 people, on average, during 8 months of drought: 15,600 liters of water.
Basic composition of the kit: sheet metal formwork; wooden forms; wooden ladder; plastic tarpaulin and tools.

Measurements for a cistern-16,000 Liters		
Type	**Measure**	
Ray	1.73 m	
Hole Depth	1.20 m	
Ground Height	1.20 m	
Total Height	2.40 m	
Part Type	**Number of Pieces**	**Measures**
Wall Plates (4 rows)	88	Curve 1.60cm / Thickness: 4 cm / Width: 0.4 m / Height: 0.50m
Cover Plates (set)	21	Length: 1.63m / Width at edge: 0.50m / Width at tip 0.08m
Beams (rafters)	21	Length: 1.66m / Width: 6cm / Iron 1.71m



A.9. Implementation Benefits to Water Security

In Brazil's semi-arid regions, where harsh climatic conditions, erratic rainfall, and frequent droughts create significant challenges for water access, the implementation of Rainwater Harvesting Systems (RWHS) with water storage tanks is proving to be a transformative solution. In areas such as Crateús and

Buriti dos Montes, around 202 RWH units, each with a storage capacity of 16,000 liters, have been installed across 30 communities.

Rainwater Harvesting Systems (RWHS) allow communities to capture and store rainwater during the wet season, ensuring a reliable water supply throughout the year, even during prolonged dry periods. By reducing dependence on increasingly unreliable groundwater and distant sources, these systems help mitigate the impacts of climate variability and improve water security. RWHS provides clean, safe water to residents while strengthening local water management. This approach not only boosts resilience to droughts but also empowers communities to better control their water resources and improve their quality of life.

- **Enhanced Water Availability in Drought-Prone Areas:** In Brazil’s semi-arid regions, where droughts are frequent and rainfall is unpredictable, the RWHS project ensures a reliable water supply by capturing and storing rainwater during the rainy season. This stored water is then available year-round, especially during extended dry periods, when other water sources are scarce or dried up.

- **Reduced Reliance on Depleting Groundwater:** With groundwater resources under strain due to over-extraction and prolonged droughts in Brazil’s semi-arid regions, RWHS helps reduce the dependency on these dwindling sources. By storing rainwater, the system allows aquifers to recharge, easing pressure on underground water reserves and preventing further depletion.

- **Increased Resilience to Climate Variability:** As Brazil’s semi-arid regions face increasing climate variability, with more frequent and intense droughts, RWHS provides a sustainable, localized water source. This helps communities adapt to climate change, ensuring water availability even as weather patterns become more erratic and extreme.

- **Mitigation of Flooding and Erosion:** Although rainfall in Brazil’s semi-arid areas is generally low, heavy rain bursts can still lead to flash flooding and soil erosion. RWHS systems capture and store excess rainwater, reducing runoff and helping prevent flooding, while also protecting soil and agricultural land from erosion.

- **Lower Water Costs:** In rural semi-arid areas of Brazil, water is often expensive due to the need for long-distance transportation or groundwater pumping. By providing a locally sourced water supply, RWHS helps reduce water costs for households and farms, making water more affordable and accessible.

- **Sustainability and Local Self-Sufficiency:** RWHS encourages sustainability by reducing reliance on external water sources, such as distant municipalities or unsustainable groundwater pumping. By harvesting rainwater locally, communities become more self-sufficient, ensuring long-term water security and resilience.

- **Improved Water Quality:** In many rural areas of Brazil, water quality can be compromised due to inadequate sanitation and infrastructure. When properly collected and stored in clean tanks, rainwater provides a safer, higher-quality water source, benefiting both domestic use and agriculture.
- **Community Empowerment and Capacity Building:** The RWHS project fosters community involvement by engaging locals in the design, installation, and maintenance of the systems. This not only builds local capacity for managing water resources but also creates jobs and instills a sense of ownership, empowering communities to take control of their water security.
- **Support for Public Health:** By providing clean, reliable water for drinking, cooking, and sanitation, RWHS helps improve public health in Brazil's semi-arid regions. In areas where access to safe water is limited, rainwater harvesting reduces the risk of waterborne diseases, ensuring better health outcomes for local populations.

A9.1 Objectives vs Outcomes

Project Objective: The objective of the Rainwater Harvesting System (RWHS) project in Brazil's semi-arid regions of Crateús and Buriti dos Montes is to enhance water security and resilience for local communities impacted by irregular rainfall, prolonged droughts, and increasing water scarcity. By installing 202 rainwater harvesting systems with a 16,000-liter storage capacity across 30 communities, the project aims to provide a sustainable, reliable water source that can be used year-round, especially during dry spells. The primary goal is to reduce communities' dependence on depleting groundwater resources, allowing aquifers to recharge and preventing over-extraction.

Additionally, the project seeks to mitigate flooding, soil erosion, and waterlogging by capturing excess rainwater during heavy rains and storing it for future use. This will help improve agricultural productivity, enhance food security, and contribute to better public health by providing access to clean, safe water. In doing so, the project aims to empower local communities, particularly women, by involving them in the installation, maintenance, and management of these systems, thereby fostering sustainable water management practices and creating opportunities for capacity building and economic empowerment.

Project Outcomes: The Rainwater Harvesting System (RWHS) project in Crateús and Buriti dos Montes has successfully improved water security, agricultural productivity, and public health across 30 communities. The installation of 202 RWHS units, each with a 16,000-liter capacity, has provided year-round access to water, reducing dependence on unreliable groundwater sources. This has enabled better water management, especially during dry seasons. The project has strengthened community resilience, ensuring a sustainable water supply in these semi-arid regions.

- **Environmental Outcomes:** The RWHS systems have mitigated the risk of flooding and soil erosion. By capturing excess rainwater during intense rainfall events. The stored rainwater has been crucial for irrigation, allowing farmers to continue growing crops during dry spells, which has boosted agricultural yields and helped increase food security. Furthermore, by reducing the reliance on external water sources, the project has contributed to greater sustainability and self-sufficiency in water management.

- **Social Outcomes:** The project has improved public health by providing communities with clean, safe water for drinking and daily activities, thereby reducing the incidence of waterborne diseases. The involvement of local women in the project has empowered them by offering opportunities for skills development and leadership roles, fostering gender equality within the communities. The training provided has helped build local capacity for system maintenance, ensuring the long-term sustainability of the project. As a result, the project has strengthened community resilience to climate variability and drought, fostering greater economic and social stability in these historically water-scarce regions.

A9.2 Interventions by Project Owner / Proponent / Seller

Pre-Project Scenario: The Brazil's semi-arid regions, local communities have long faced significant challenges due to irregular rainfall patterns, prolonged droughts, and increasing water scarcity. The harsh environmental conditions, including unpredictable rainfall and prolonged dry spells, have resulted in severe water shortages, putting immense pressure on the daily lives of these communities.

Interventions by Project Owner: The project proponent (PP) recognized these pressing issues and took proactive steps to address them. Understanding the severity of the water crisis, the PP identified rainwater harvesting as a sustainable solution to help mitigate the impact of the region's harsh climate. By installing 202 rainwater harvesting systems (RWHS) across 30 communities, with each system having a 16,000-liter storage capacity, the project aimed to provide a reliable, year-round water source. These systems offer an alternative to depleting groundwater, enabling communities to rely on harvested rainwater during dry periods while allowing aquifers to recover and preventing over-extraction of groundwater resources.

To ensure the long-term success and sustainability of the intervention, the PP emphasized the importance of community involvement and capacity building. Recognizing that proper training is essential for the effective use and maintenance of the rainwater harvesting systems, the PP planned a comprehensive training program for beneficiaries. The training, tailored to the specific economic and cultural realities of each family, would provide essential knowledge on how to properly maintain the cisterns, manage water use efficiently, and prioritize its use for drinking and cooking. Each training session would involve groups of up to 30 participants and would be conducted over two days, totaling at least 16 hours of instruction.

This dual approach—installing the rainwater harvesting systems and providing critical training—was designed to not only provide immediate relief but also to empower communities with the skills necessary to manage their water resources sustainably. By addressing both the environmental challenges and the need for local capacity building, the project aimed to significantly improve the water security of these communities and enhance their resilience to future environmental challenges.

A.10. Feasibility Evaluation

As explained in the section A.7 among the other alternatives available for increasing the availability of water, Rain Water Harvesting System (RWHS) is the most feasible option in the identified communities where the RWHS are installed.

A.11. Ecological Aspects & Sustainable Development Goals (SDGs):

- **Inundation of inhabited Land:** The project activity does not lead to the inundation of inhabited land.

- **Creation of Waterlogging and Vector Disease Prevention:** By storing rainwater in tanks rather than allowing it to accumulate in open areas or poorly drained fields, the RWHS project prevents the creation of waterlogged conditions. This reduces the potential for vector-borne diseases by eliminating standing water that could serve as mosquito breeding sites. Additionally, by managing rainwater locally and efficiently, the project helps to improve the overall sanitation and hygiene conditions in these communities.

- **Deterioration of Quality of Groundwater:** The RWHS project directly addresses this issue by reducing the community's reliance on groundwater, thus allowing aquifers to recharge and improving the sustainability of groundwater resources. By providing an alternative water source through the capture and storage of rainwater, the project reduces the strain on groundwater reserves, helping to preserve both the quantity and quality of underground water resources. This contributes to the long-term health of the local water table and prevents the negative environmental impacts of groundwater degradation.

Sustainable Development Goals Targeted	Most relevant target/ SDG Impact	Indicator (SDG indicator)
 **Goal 01:** End poverty in all its	**<u>Target 1.4</u>**: By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other	**<u>Indicator 1.4.1:</u>** Proportion of population living in households with access to basic services

forms everywhere	forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	
 **<u>Goal 03:</u>** Ensure healthy lives and promote well-being for all at all ages.	**<u>Target 3.9:</u>** By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.	**<u>Indicator 3.9.2:</u>** Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services).
 **<u>Goal 06:</u>** Ensure availability andsustainable management of water and sanitation for all.	**<u>Target 6.1:</u>** By 2030, achieve universal and equitable access to safe and affordable drinking water for all. **<u>Target 6.4:</u>** By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.	**<u>Indicator 6.1.1:</u>** Proportion of population using safely managed drinking water services. **<u>Indicator 6.4.2:</u>** Level of water stress: freshwater withdrawal as a proportion of available freshwater resources

A.12. Recharge Aspects:

The ground water recharge is not involved in the installed harvesting systems. The harvested rainwater will be used by the households for their domestic needs.

A.12.1 Solving for Recharge

The ground water recharge is not involved in the installed harvesting systems. The harvested rainwater will be used by the households for their domestic needs.

A.13. Quantification Tools

Water Harvesting Potential

The formula for calculation for harvesting potential or volume of water received or runoff produced or harvesting capacity is given as:

Option 01:

Harvesting potential or Volume of water utilized (liters) =	**Area of Catchment/Roof/Collection Zone (m^2) X Amount of rainfall (mm) X Runoff coefficient**

Parameters	Value
Annual Avg. Rainfall in mm (I)	589
Average Catchment Area in m^2 (A)	60
Catchment Terrain coefficient	0.85
Run-off coefficient (K)	**0.40375**
Residential-(0.3 to 0.5)	0.5[7]
Uncertainty Factor (2014 to 2021)	**0.8**
Roof inclined or Sloping-(0.85 to 0.95)	0.95

Option 1 is being considered to calculate the rainwater harvesting potential, the parameter analyzed are as follows:

Annual Rainwater harvesting Potential

Annual rainwater harvesting potential is given by $V = K \times I \times A$

Where, V=Volume of water that can be harvested annually in liters.

K = Runoff coefficient

[7] As per UWR standard, version 7.0

I = Annual rainfall in (mm)

A = Catchment area in (m^2)

1. **Annual average rainfall (I):** The year wise (2014-2023) annual average rainfall for both locations are sourced from INMET[8] and calculated accordingly.

Year	Observed rainfall (mm) for Crateús, Ceará - Brazil	Observed rainfall (mm) for Castelo do Piauí, Piauí -Brazil	Annual Average Rainfall in (mm)
2009	904.4	no data	904
2010	350	903.8	626
2011	941.8	1109.2	1025
2012	244	308.6	276
2013	402.2	434	418
2014	276.6	619.8	448
2015	600	501.6	550
2016	595.2	346.2	470
2017	444.8	124	284
2018	897.4	1030	963
2019	137.6	323.4	230
2020	1080.4	no data	1080
2021	596.8	no data	596
2022	275	no data	275
2023	644.8	1111.4	878

2. **Average catchment area (A):** The catchment area for House holds varies in between 50 to 70 m^2, Thus the average catchment area is considered for the calculation i.e., **A= 60 m^2.**

3. **Run-off Coefficient (K):** Based on type of area, Type of surface and terrain type of the catchment area, which considers all the types of losses losses due to spillage, leakage, infiltration, catchment surface wetting and evaporation, which will all contribute to reducing the amount of runoff.

Parameters	**Type of Area (A)**	**Different Surfaces (B)**	**Terrain type (C)**	**Run-off Coefficient (K) = A*B*C**
	Residential	Roof inclined (Sloping)	concrete works	**0.40375**
	0.3 to 0.5	0.85 to 0.95	0.85	

8 https://portal.inmet.gov.br/

Value considered	0.5	0.95	0.85	

4. **Uncertainty Factor:** For conservative approach as mentioned in option 1, The uncertainty factor of 0.8 (1-0.2) is considered from 2014 to 2021.

Water budget component	**Typical estimated uncertainty (%)**	**Description**
Surface inflow	2%	Typical range of accuracy from meters to minimum delivery accuracy requirements of delivery and diversion measurement devices
Precipitation	10%	Typical range of accuracy from field-level rain gauges to extrapolation of local weather station data
Surface outflow	3%	Typical range of accuracy from meters to estimated outflow relationships
Evapotranspiration	NA	Evapotranspiration will not occur as the surface of the water harvesting unit is closed.
Change in storage	NA	The actual amount of water collected by the units is not considered for the RoU calculation. Hence, not applicable.
Deep percolation	5%	Typical range of accuracy
Total	**20%**	

Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**

Cumulative Systems	90	105	135	153	153	182	182	182	182	202
Avg. Rainfall (mm)	448	550	470	284	963	230	1080	596	275	878
Avg. Rainfall (m)	0.448	0.55	0.47	0.284	0.963	0.23	1.08	0.596	0.275	0.878
RoU	976	1398	1537	1052	3569	1014	4761	2627	1212	4296
Uncertainty factor	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	NA	NA
Conservative RoU	781	1,119	1,229	842	2,855	811	3,809	2,102	1,212	4,296
Total RoU's	**19,056**									

Quantification

Year (January 01, 2014 onwards)	RoUs (1 RoU = 1000 litres)/yr *
2014	781
2015	1,119
2016	1,229
2017	842
2018	2,855
2019	811
2020	3,809

2021	2,102
2022	1,212
2023	4,296
Total	**19,056**

A.14. UWR Rainwater Offset Do No Net Harm Principles

1. Increase the Sustainable Water Yield in Areas Where Over-Development Has Depleted the Aquifer

Brazil's semi-arid regions, such as Crateús and Buriti dos Montes, face significant groundwater depletion due to over-extraction, especially during prolonged dry spells. The implementation of RWHS systems helps reduce reliance on depleting aquifers by providing an alternative, locally sourced water supply. By harvesting rainwater, the project contributes to increased water availability without putting further stress on groundwater reserves. This helps recharge aquifers and promotes sustainable water management, ensuring long-term water availability without exacerbating resource depletion.

2. Collect Unutilized Water or Rainwater from Going into Storm Drains or Sewers

The RWHS systems in **Crateús** and **Buriti dos Montes** captures the unutilized rainwater, preventing it from being lost to runoff and sewage systems. By directing rainwater into storage tanks, the project ensures that valuable water is preserved for use during drier periods. This reduces environmental waste and enhances water conservation, turning what would otherwise be a lost resource into a beneficial, stored supply.

3. Conserve and Store Excess Water for Future Use

The primary function of the RWHS project is to conserve and store excess rainwater for use during dry periods, making water available when other sources are depleted. Each system in the project can store 16,000 Liters of water, ensuring that communities have a reliable supply even in the face of climate variability. This water storage capacity helps buffer against future water scarcity and creates a long-term solution to the challenges posed by seasonal fluctuations in rainfall, without causing harm to existing water systems or ecosystems.

4. Enhance Local Women's Participation and Professional Development

The RWHS project in Brazil is committed to promoting gender equality and empowering local women by actively involving them in the planning, implementation, and maintenance of the systems. Women, who are often responsible for water collection and management in rural areas, are given leadership roles in training, system maintenance, and local water management. This approach not only enhances women's participation but also provides opportunities for professional development, thereby improving their economic and social standing within the community. The involvement of women in this project helps strengthen community resilience and promotes gender equity, contributing to overall social well-being without causing harm to community dynamics.

A.15. Scaling Projects-Lessons Learned-Restarting Projects

The Rainwater Harvesting System (RWHS) project in Brazil's semi-arid regions of Crateús and Buriti dos Montes has demonstrated a successful approach to enhancing water security and resilience for local communities, but it also offers potential for scaling further. As the project has shown, integrating rainwater harvesting with sustainable groundwater management practices can significantly reduce dependency on depleting aquifers, allowing for their recharge and preventing over-extraction. Given the growing challenges of irregular rainfall and water scarcity in other parts of Brazil's semi-arid regions, scaling this project to additional communities could provide a broader solution. This scaling effort can take advantage of existing integrated practices such as community participation and capacity-building programs, ensuring that the systems are not only installed but also maintained and managed by locals. In particular, the empowerment of women through training and involvement in the maintenance of the systems has been a key social benefit, and this model could be expanded to other regions to enhance gender equality while addressing water scarcity.

Furthermore, while the initial project focused on providing year-round water access and mitigating environmental impacts like flooding and soil erosion, areas of potential duplication and integration could further improve both water and urban management. For example, incorporating the RWHS with urban water infrastructure systems could enhance water distribution efficiency in towns that are currently dependent on unreliable groundwater sources. Additionally, stormwater management could be integrated into the rainwater harvesting systems, capturing excess water from urban runoff to augment the rainwater storage and reduce urban flooding. Such integrated practices would ensure that both rural and urban areas benefit from sustainable water use while fostering resilience to climate variability.

The project's positive outcomes—ranging from improved public health to agricultural productivity—demonstrate that with targeted communication, local involvement, and proper training, further adoption of rainwater harvesting systems can significantly contribute to sustainable water and urban management practices in other drought-prone areas.