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Installation of environmental technology for water retention at the university farm of UFRPE/UAG

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Abstract

Due to the greatest drought problems in the Northeast region of Brazil, especially in the Semi-arid region of the State of Pernambuco, and the lack of sustainable water and soil conservation technologies, this work aims to apply the BAPUCOSA Methodology (Barrier with Used Tires for Containment of Soil and Water), at the University Farm of UFRPE (Federal Rural University of Pernambuco – Brazil), developed by Baracuhy (2007), which promotes the partial obstruction of the surface water flow and of the soils carried in temporary channels, promoting a greater storage of water. In addition to this, the water storage capacity of this dam was calculated, disregarding soil infiltration and recommended more in-depth studies on this subject.

Keywords: Environmental Conservation, Environmental Management, Water Resources.

1. Introduction

Water is an indispensable life resource, the most important product of Earth, but it is sadly diminishing and, day after day, it is starting to drop (FAO, 2016). The clear majority of living beings depends on this resource to develop and reproduce, making it one of the most essential products for life, without it there would be no survivals, neither humans nor nonhuman species, such as animals and plants. It is up to us, human beings, having the peculiarities and the special characteristics that differentiate us from other animals, to care about water and preserve this very rich material, which is freely given to us.

Although periods of drought and limited geographic areas, such as Arid and semi-arid ecosystems (Geroy, 2011), it is important to develop a constant awareness - in a public and private sphere - that rainwater can and should be stored in a way that favours reuse, both in reservoirs and in groundwater (Wang et al., 2013). Firstly, a higher level of evaporation of the retained water occurs; In the second place, the evaporation is much smaller and at the same time the water contained therein is naturally filtered to the point of being potable, which is, suitable for consumption. Whereas these data are expected in studies on water, we also know that in Brazil there is no adequate exploitation of water potential that is found in the underground of national lands (Bertoni, 2010).

With the aim of preserving the environment and water resources of a rural property, this paper presents and discusses a renewable technique of water containment, called BAPUCOSA (Barrier with Used Tires for Containment of Soil and Water). This technology was presented didactically to show to the academics of UFRPE (Federal Rural University of Pernambuco – Brazil) other sustainable alternatives of conservation of the environment, water and soil. According to Baracuhy (2007), these technologies are cheap and they ecologically acceptable, because in order to put the tires on the rubbish it is getting recycling.

This work aims to contribute to the development of an Experimental Farm, making it increasingly sustainable to the point of being, very soon, a model of property (Rocha, 1997), which uses technologies accessible to small and medium farm producers. In the scientific-academic field, studies will be used as database for other researches of the same area and other environmental areas. In addition to this, it fulfils the function of serving as a didactic model for students of agrarian majors and related areas, as a practical and useful lecture.

2. Materials and methods

The experiment was carried out in the city Garanhuns, State of Pernambuco - Brazil (08º53'30 "S and 36º30'00 "W, altitude of 842 m, climate: mesothermic with dry summer and warm continental, average annual temperature 22.8ºC) (Lima, 2014), more precisely in the Experimental Farm of UFRPE, located in the District of Iratama (Figure 1).

Garanhuns is in the transition of two Brazilian biomes: Atlantic Forest and Caatinga (Semi-arid area). And it has an average rainfall of 788 mm (APAC, 2012), with the highest incidences of rain in June, July and August (Figure 2).

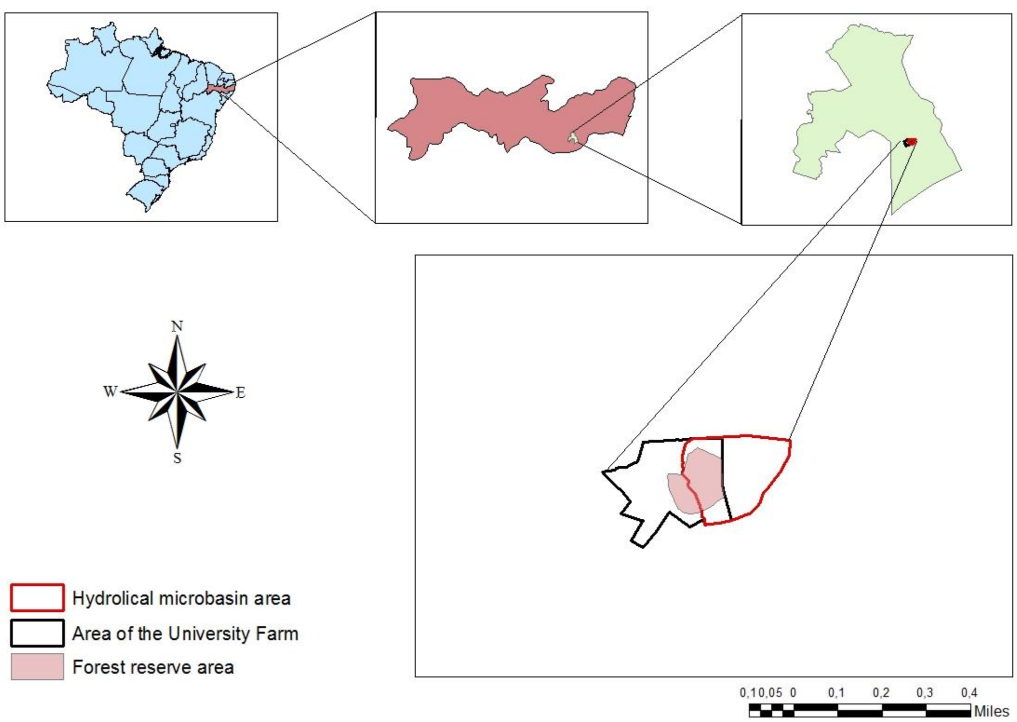

Figure 1 - Location Map of the UFRPE Experimental Farm. Source: Google Earth (2015).

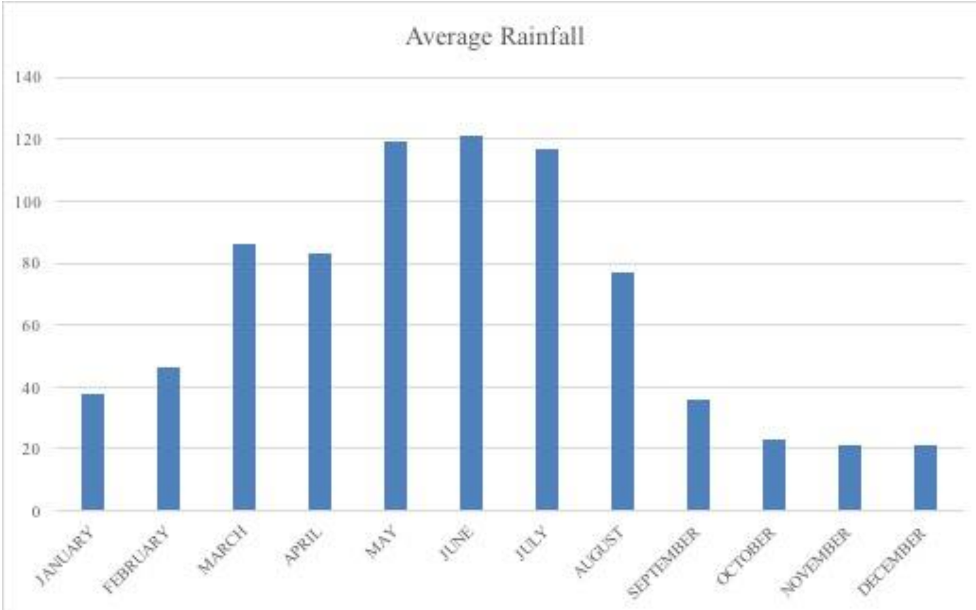

Figure 2 - Average Monthly Rainfall in the municipality of Garanhuns - PE, climatological data for the years 1961 - 1991. Source: APAC (2012).

Used materials

For the accomplishment of this work, the equip has used tires of truck, steel rods, rope, gloves, mallet, paddle, pickets and Topographic Chart. Total Station, Beam Level, Static Ruler, and Prism. GPS GarmineTrex® and camera - Nikon P510, for geographical and documentary records, respectively.

For the realization of studies and implementation of technologies: Softwares: Google Earth (photo-interpretative analysis), AutoCad 2015 and ArcGIS 14.11 (map makers).

Methodology

The dam with tires used to contain soil and water – BAPUCOSA, according to Baracuhy (2007). It is a methodology created to replace rockfills, which causes partial obstruction of water flow and of soil entrained in temporary channels and this technique allows a greater storage of water in the water table.

Thus, for the work presented in this paper, the location of the barrier was considered, obeying the lowest point of the drainage channel. This was possible due to the analyses of the Drainage and Hypsometric Maps, which consider the course of the channel and the elevation levels, respectively. After choosing the location to make the bus? demarcation, it was possible to determine the projection of an arc. To obtain the radius that promotes the angulation required for the non-breaking of the bus, we used Equation 1, as follows:

$$\boldsymbol{r = 1{,}25 \times D} \qquad (1)$$

Where:
r = radius
D = distance between channel margins

For this reason, the projection of 10% of the measured cross-section distance, i.e., the distance between the lines passing through the vertex and the one representing the barrier’s anchoring base, as shown in Figure 3, was obeyed.

After demarcating the arch, the opening phase of the trench was continued. At this stage, it is necessary to use backhoe or human labour. Finally, the tires were arranged to cross them and connect them with iron rods, which fixed the barrier.

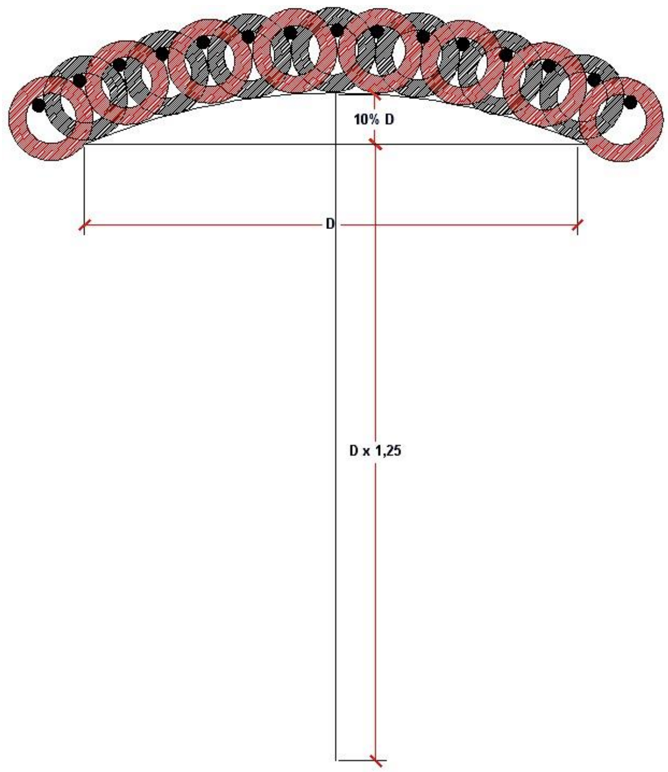

Figure 3 - Plant, without scale, of the BAPUCOSA. Source: Baracuhy (2007).

Hypsometric Map

It was generated through the SRTM (Shuttle Radar Topographic Mission) digital elevation model, with 3 seconds of arc (approximately 90 meters of spatial resolution), as described by Miranda (2005). It was extracted the Coordinate SC-24-X-D, mosaic where the Experimental Farm is located; For this purpose, the software ArcGIS 14.1 was used for the elaboration of the map.

For the calculation of the average altitude, the methodology described by Wisler and Brater (1964) was used, in which the subareas existing between the pairs of contour lines are correlated, to evaluate the percentages of these subareas in relation to the total area of the basin or Microbasin. Finally, with the sum of the quotas, the percentage of the total area that was below or above a certain altitude was calculated. With this altitude variation data, we can determine the hypsometric curve of the basin, which is the graphical representation of the altitude variation in relation to the area of the basin.

Drainage Network

It was obtained through the DEM (Digital Elevation Model) of the Experimental Farm, generated by the ArcGIS Software 14.1. In addition to this, on-site analyses were carried out to determine the watershed as well as the drainage of the property.

Storage capacity

The water storage capacity was determined in the field, disregarding the infiltration, that is, it was estimated the amount of water that the barrier would entail. For this, the planimetric survey method was used by irradiation to mark the perimeter of flood and the slope dimensions of this area. This method, according to Espartel (1987), establishes a central station in the polygonal, connecting it to all its vertices. In this way, it is possible to measure the distances of this station to its vertices and the corresponding angles. This method is used in the evaluation of small surfaces. With this technique, it was possible to calculate or estimate how much water the barrier would hold.

3. Results and discussion

Drainage Network

The Drainage Network of this farm is part of the Water Contribution Area of the Mundaú River Basin, which has a total area of approximately 169 km^2, and this basin around the University farm, covering 3 cities: Garanhuns (74.13%), Brejão (25.67%) and São João (0.20%) (Lima, 2014).

The Microbasin Drainage Network was obtained through field and laboratory studies that allowed its development from the contours and field studies for software failure adjustments. Figure 4 shows 6 channels of main channel contribution in the Experimental Farm, with four potential sources, highlighted in the image.

The drainage of the study area has a total of 3,828 m, from the taxpayer area to its exit from the farm. Of this total, there are 1,244 m of amount, which comes from the Taxpayer Area outside the property.

The protection of these areas is extremely important because, due to anthropization, mainly with deforestation, spring becomes dry and impedes the natural course of the canal and causes the consequent lack of water for locality. In the study area, the drainage channel and the springs are totally dry (Figure 5), requiring conservationist techniques of water and soil retention, minimizing the deterioration of water resources.

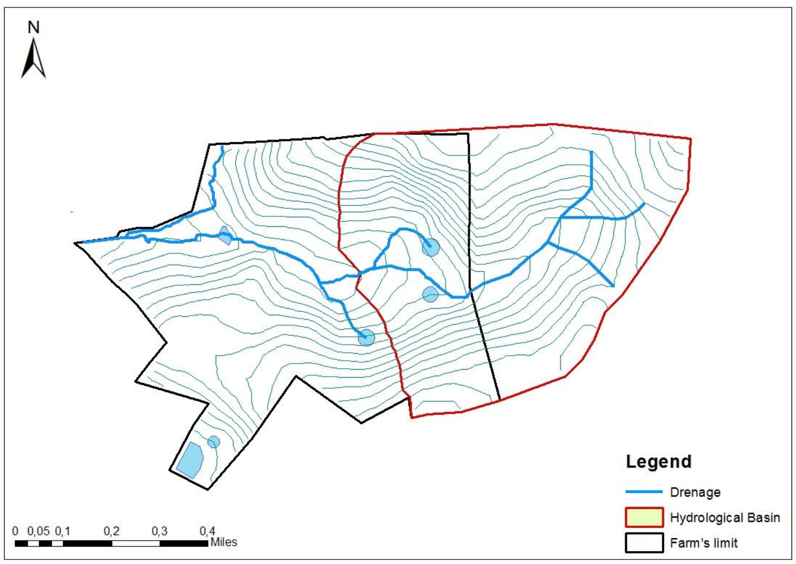

Figure 4 - Drainage network map. Source: Vasconcelos (2016).

Figure 5 - Dry Dam of the UFRPE / UAG Experimental Farm. Source: Vasconcelos (2016).

Hypsometric Map

Using the Digital Elevation Model of the SRTM (Shuttle Radar Topographic Mission) (Figure 6), extracted the Coordinate SC-24-X-D, the Hypsometric Map was obtained (Figure 7). Note the colour gradient (Figure 6), starting from the lower areas in black and higher areas in white.

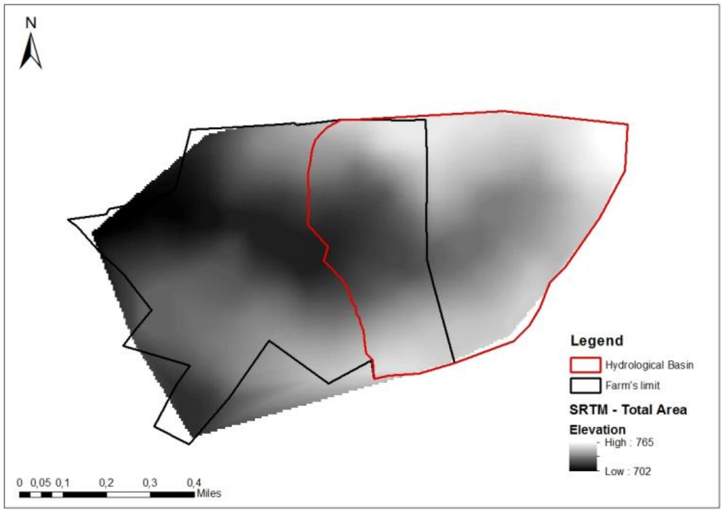

Figure 6 - Digital Elevation Model - DEM. Source: Vasconcelos (2016).

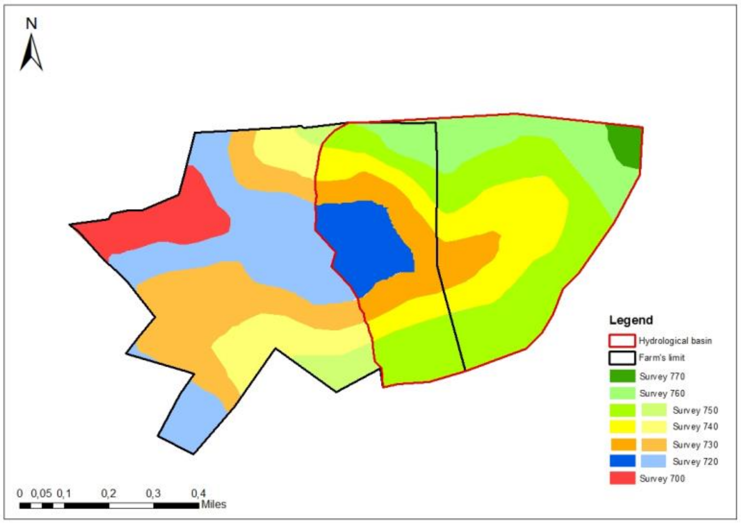

Figure 7 - Hypsometric map. Source: Vasconcelos (2016).

It can be noticed that the elevation of the terrain ranges from just over 700 meters up to 770 meters above sea level. It was considered 7 classes of elevation, distributed according to the quotas of the land, being emphasized and considered in the calculations the area of the Microbacin, as illustrated in the caption of the image. It is concluded that the elevation is decreasing from East to West, allowing drainage in this direction.

The average altitude obtained, according to the methodology of Wisler and Bratter (1964), was 739.16 m, Table 1, obtained through Equation 2:

$$\frac{\Sigma C \ x \ A}{A} \qquad (2)$$

Where:
C = Sum of the *Average Quota*
A = Area

$$\frac{60.254,60}{81,51785} = 739,16$$

With the results of the altimetric variation, it was possible to trace the hypsometric curve, in blue, as shown in Figure 8:

Table 1 - Table of Values of elevation quotas of the Hydrographic Microbasin Area under study.

Quota (m)	Average Quota (C)	Area (A) (Ha)	% Area	Accumulated Area	% Accumulated Area	Average Quota x Area (C x A)	Average Altitude
770 - 760	765	1,57821	1,94	1,57821	1,94	1207,33	
760 - 750	755	13,5402	16,61	15,11841	18,55	10222,85	
750 - 740	745	28,9679	35,54	44,08631	54,08	21581,09	
740 - 730	735	18,3294	22,48	62,41571	76,57	13472,11	
730 - 720	725	11,3194	13,88	73,73511	90,45	8206,57	
720 - 710	715	7,78274	9,55	81,51785	100	5564,66	
Total		**81,51785**	**100**			**60254,60**	**739,16**

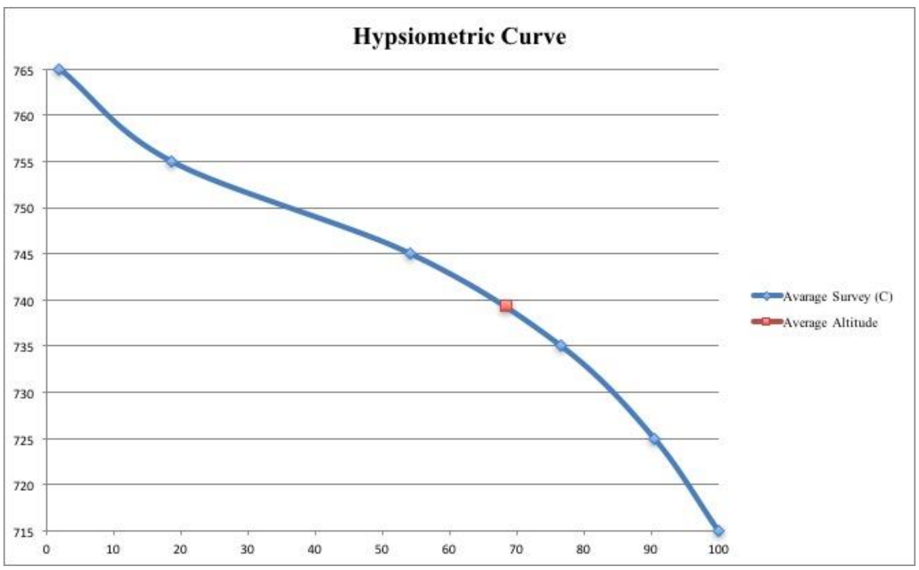

Figure 8 - Hypsometric curve. Source: Vasconcelos (2016).

BAPUCOSA

Knowing the exact location for the implementation of the technology, an arch was drawn in the field, from which the tires were placed, with a projection of 10% of the measured cross-section distance, i.e. the distance between the lines Passes through the vertex and the one that represents the anchoring base of the dam. With the use of the radius projection formula, knowing that the distance from one margin to another (D) is 8.80 m, the following result was obtained:

r = 1,25 x D

r = 1,25 x 8,80 = 11m

The projection was 0.88 m and the arc measured approximately 9.20 m, as shown in Figure 9.

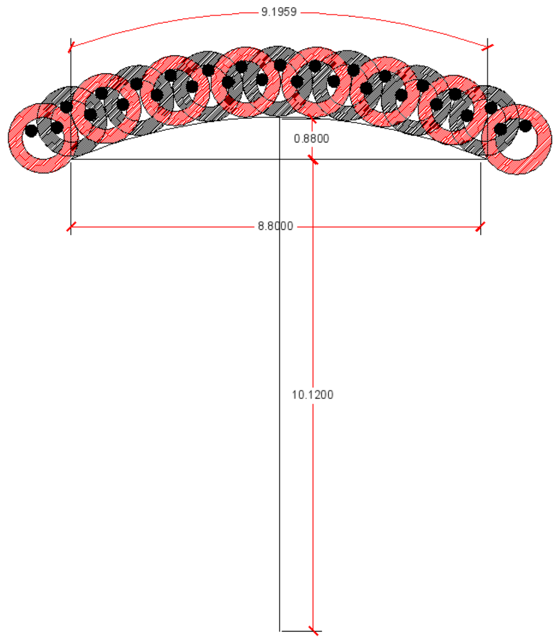

Figure 9 - BAPUCOSA plant, without scale, projected in the study area. Source: Vasconcelos (2016).

A picket was fixed using a rope producing the curve-shaped hazard (Figure 10).

Figure 10 - Arch Demarcation. Source: Vasconcelos (2016).

With this Arch Demarcation, the stakes were placed at each meter to guide the necessary excavation for the levelling of the tires, as shown in Figure 11. Two people made the measurements and prepare the arc arch of the dam, in the first photo appears the co-author of this work, photographed by the author and in the second photo stands the author himself.

It was necessary to perform the cross-section excavation for soil levelling related to the lowest point of the channel under study (Figure 12).

Figure 11 - Arch staking. Source: Vasconcelos (2016).

Figure 12 - Opening of the trench for placement of the first layer of tires. Source: Vasconcelos (2016).

For this to be possible, it was counted on the help of the outsourced employees of the Experimental Farm, 6 workers in total. The following items were required for assembly:

• 38 Used truck tires, 37 of model 275: 80 x 22.5 cm; And 1 of model 215: 75 x 17.5 cm; Of several manufacturers, distributed as described below:

1st layer- 08 tires (Figure 13) / 2nd layer - 09 tires (Figure 14) / 3rd layer - 10 tires (Figure 15) / 4th layer - 11 tires (Figure 16). It is important to note that the tires were placed alternately between layers (Figures 17 and 18).

The tires were filled with soil and stones from the excavation and compacted with water. All layers received the same fill, keeping the barrier uniform. At the centre of the tire was used a tire of a smaller model, 75 x 17.5 cm, which served as a "escaper", where the water, if it overflows the reservoir, will run.

• 24 steel rods with 1/2 "gauge, 2.5 m long (Figure 17).

At the end of the construction, a constructed area of 7.19 m^2 was obtained (Figure 19). The layers were stapled and reinforced to prevent tearing.


Figure 13 - Assembly of the first layer of tires. Source: Vasconcelos (2016).


Figure 14 - Assembly of the second layer of tires. Source: Vasconcelos (2016).


Figure 15 - Assembly of the third layer of tires. Source: Vasconcelos (2016).

Figure 16 - Assembly of the fourth layer of tires. Source: Vasconcelos (2016).

Figure 17 - Dam assembled with all layers and rods positioned. Source: Vasconcelos (2016).

Figure 18 - Tire layout alternately. Source: Vasconcelos (2016).

Figure 19 - Barrier completed, with the tires stapled to the ground. Source: Vasconcelos (2016).

Figure 20 – Area filled with accumulated water from the barrier. Source: Vasconcelos (2016).

Storage capacity

By performing the Planimetric Survey, it was possible to calculate the total dam flood area, considering as "0" the barrier "escaper" (low point where the water would escape). An area of approximately 350 m^2 was obtained (Table 2). With this area, it was possible to divide this area into dimensions of 10 cm, 6 to the total (Figure 20), to calculate their respective areas and volume (Figure 21). The accumulated volume, according to the survey, was 91,442 litres, that is, for the water to pass through the "thief", disregarding the infiltration of the soil, this amount of water is necessary.

In a 3D projection, it is possible to analyse the flood area as well as the tire barrier. It is important to observe the smoothness of the terrain, but with visible areas of unevenness, configuring the area of water accumulation.

Table 2 - Table of values of the quotas and accumulated volume of the dam.

Quota	Average Quota	Area (m^2)	Accumulated Volume (L)
0 - 10	5	50,9996	2.550
10 - 20	15	76,5135	11.477
20 - 30	25	88,2525	22.063
30 - 40	35	63,2594	22.141
40 - 50	45	45,5338	20.490
> 50	50	25,4412	12.721
Total	**-**	**350**	**91.442**

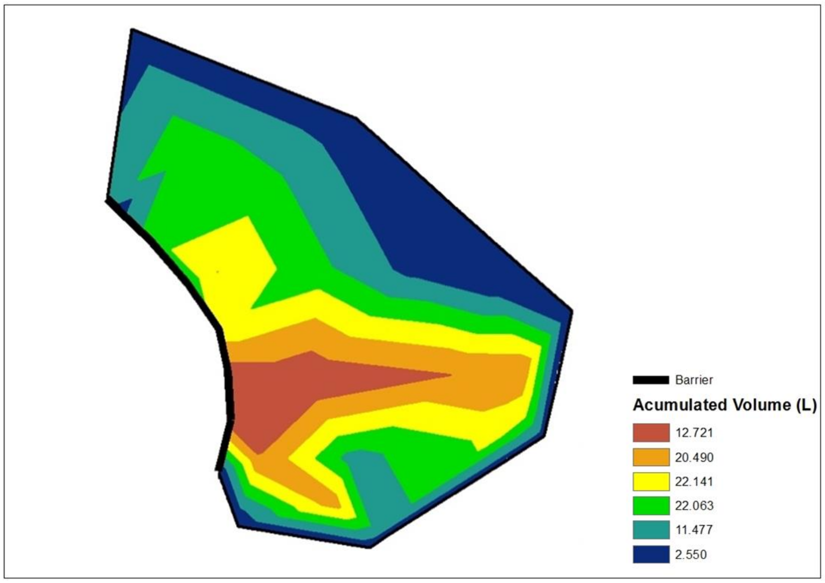

Figure 20 - Hypsometric Map of the Dam. Source: Vasconcelos (2016).

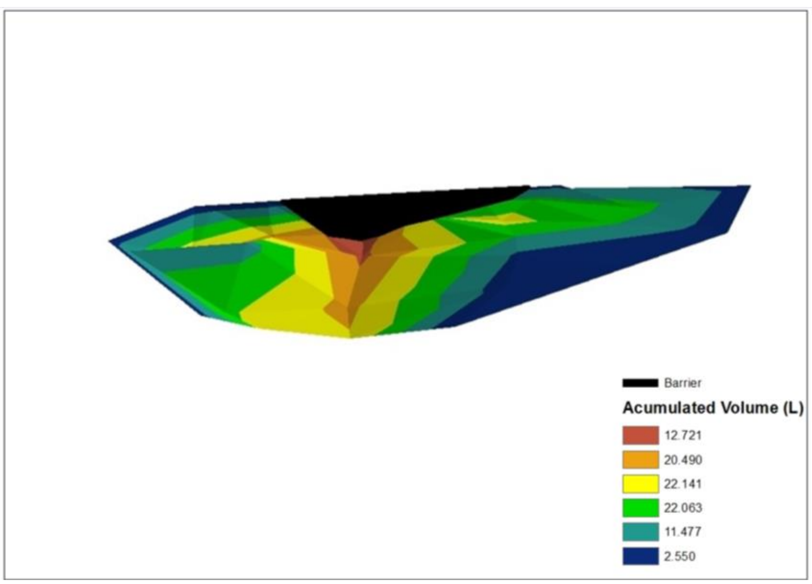

Figure 21 - 3D Map of the Dam Relief Area, with volume by dimensions. Source: Vasconcelos (2016).

4. Conclusions

The lack of water is an eminent problem and has been chastising the Brazilian population for decades, especially in the Northeast of the Country. Water is a natural, free and lawful resource, it is available in abundance to everybody. But the clear majority, those who need it most, are often deprived of their right quota. Despite the natural disasters or even climate changes that cause the rainfall to change in some way, there is a lack of public policies focused on water resources and, not least, perhaps the most important, the greatest lack of investment in research in this area.

The Experimental Farm of UFRPE / UAG, as well as its environment, mainly the area of water contribution studied, need conservationist techniques of water and soil retention, for a better environmental recovery and resumption of water accumulation. Unfortunately, when analysed the area of study, it was concluded that its springs are dry due to the deforestation that has occurred over the years. Also, the watercourse is dry and the preservation areas around it are deteriorated. However, it should be noticed that BAPUCOSA is an important technique for water retention and very sustainable, because it employs used tires that would have been trashed or that could even cause environmental pollution. It is important to consider that this structure can store water, in addition to allowing infiltration, enriching the water table.

Therefore, it is clear the importance of practical dialogues between University (centre of knowledge) and Society (centre of experience), so that a common issue could be easily recognized and clarified and, with the cooperation of University and Society, the problem will be solved. This cooperative dialogue must be plural, simple and, of course, efficient.

This paper illustrates these three points, as they propose a better study in Water Resources policies, serving everybody (plurality), using products accessible to all the parts, recyclable products (simplicity) and providing stable but malleable basis for studies and research (efficiency).

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