Potential Regions for Fog Water Collection in Cape Verde. The Monte Verde Project

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Abstract: The highest elevations of the mountainous islands of Cape Verde are influenced by strong trade winds originates, in the slopes facing the northeast, an almost permanent layer of stratocumulus. Those regions, under the intense and permanent layer of fog/cloud, are identified and the associated surface areas measured to estimate the potential amount of fog water to be collected. There are many small rural communities living on those areas with serious water shortage problems. The communities are aware of the potential water source for rural communities, which use rudimentary technologies, such as small containers and reservoirs, needle-type trees and species of agave, *Furcroea gigante*, to collect fog/cloud water. The introduction and the improvement of the alternative technologies may represent a means of supplying water from fog and rain at low cost, combining fog/cloud water collection techniques with runoff water from treated catchment areas.

1. INTRODUCTION

San Vincent island is one of the smallest of ten islands and five islets of Cape Verde Islands, scattered over an area of roughly 57,600 km2 in the Atlantic Ocean, at 455 km west of Dakar, Senegal. The total land area of the island is 227 km2, that is, about 5.63 % of the total land area of the country estimated in 4033.4 km^2.

The climatic conditions of San Vincent island are determined by West African Inter-Tropical Convergence (ITC) and characterized by low and erratic occurrence of rainfall, from July to October. The average temperature for the period of 1940-1997 is 23.5°C. The evapotranspiration is about 2,000 mm/year and the annual average precipitation is less than 100 mm. However, on the highest at Monte Verde at 600 meters, the average precipitation can reach values of about 250 mm. Also, the relative humidy increases from 50% to 80% in general correspondence to decreased temperatures. Table 1 gives some climatic parameters of San Vincent and other ecological zones of Cape Verde Islands.

Table 1. Some climatic parameters of San Vincent and other ecological zones of Cape Verde

Islands (stations)	Av temp °C	Rel. Hum. %	Wind speed Km/d	Ins o hr/d	Solar rad. mm/d	Pot. Evap. mm/y
Praia-64m	25.3	65.8	499	7.8	824	2610*
Trindad-205m	24.2	76.1	361	8.0	824	2182*
S.Jorge-350m	22	72	108	6.5	4.3	1559
L Santa- 350m	21.9	75	189	5	3.9	1541
Corda –950m	18.3	60	221	7.9	4.4	1951
Lagoa-1150m	17.2	73	232	7.8	4.5	1666
S Vicent-10m	23.5	68.5	725	8.4	817.8	2495*
Sal –54m	23.7	72	620	4.8	3.8	2629*

* Values of annual evaporation.

This paper documents the results of experiments and quantifies the areas and potential amount of water to be collected with the use of local technologies. A project for water collection in Monte Verde, San Vincent will be discussed.

1.1. Experiments Conducted at Monte Verde

Experiments have been conducted since 1962in Monte Verde, San Vincent, located at 4 km off the sea coast in the interception of the co-ordinates of 15° 52' N and 25° 37' W at the altitude of 600 meters.

Cunha (1962), Bores (1977), Juvik (1988), Sabino (1990) and other researchers used various fog collector systems in the field experiments. However, a version proposed by Juvik (1988) was used in the experiments. It consist of a vertical tower with nine vertical screens of single layer, double layers and three-fold layers with 1m x 0.50m in size, in number of three, mounted at 1-2m, 3-4m and 5-6m above the ground to simulate different hole sizes and examine the influence of elevation above surface on fog water collection. Figure 1 shows relationship between fog water interception, screen types and height above the ground for the period 1987-1990,

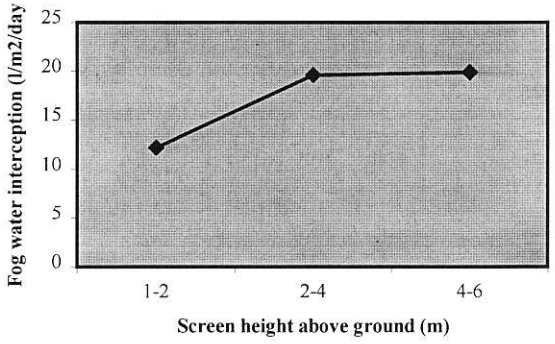


Figure 1. Relationship between fog water interception, screen types and height above the ground. (Data from Juvik, 1987)

The amount fog water collection increase with the wind speed (Figure 2-4) and decreases when the distance from the seacoast increases (Figure 5).

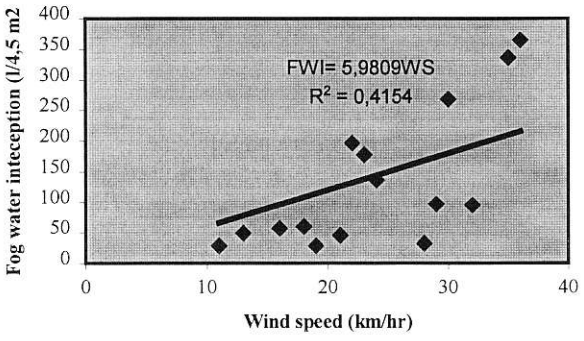


Fig 2 Relationship between amount of fog water interception and wind speed. May 1990. Monte Verde-San Vincent, Cape Verde.

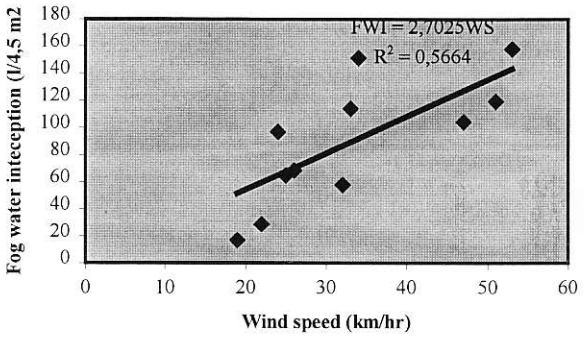


Fig 3 Relationship between amount of fog water interception and wind speed. June 1990. Monte Verde-San Vincent, Cape Verde.

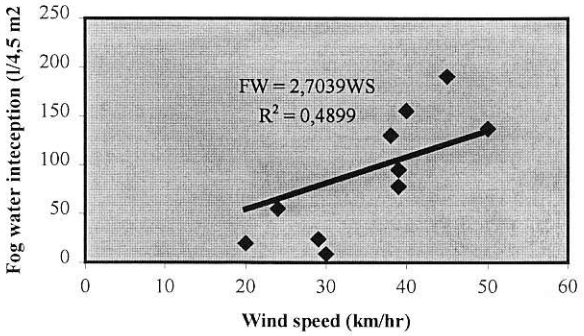


Fig 4 Relationship between amount of fog water interception and wind speed. August 1990. Monte Verde-San Vincent, Cape Verde

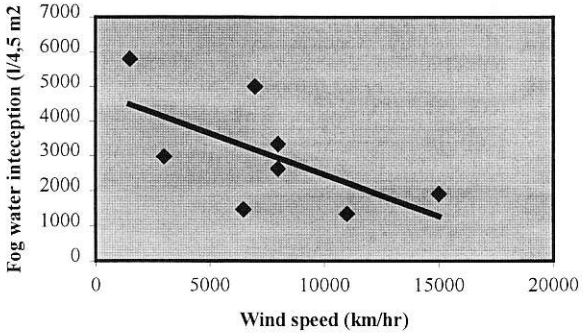


Figure 5. Relationship between amount of fog water interception and distance from the seacoast.

2. RESULTS AND THE PROJECT

2.1. Results of research

Cape Verde Islands are influenced by strong trade winds which originates, in the slopes facing the northeast between the level of 500 m and 1000 m an

almost permanent layer of stratocumulus formed by turbulence and orography convection (Cunha 1962). In these regions under a layer of fogs, the water interception of the little fog drops benefits the coffee culture and tree stands Andres *et al* (1991). Researchers and water resources specialists have been conducting various experiments using several types of collectors to estimate the potential amount of water which can be intercepted to supply water for domestic needs and irrigation in small scale. Table 2-3 shows annual fog water collected from field experiments and the monthly results of experiments conducted in the project area.

Table 2. Results of fog water interception for the period of 1961-1992 in l/m^2

Islands	1962	1964	1980	1990	1991
Brava	5791	-	-	-	-
Santiago	-	4992	4875	-	1923
SanVicent	-	-	-	2974	-
St. Antao	1350	-	-	-	3329
San Nicolau	-	-	-	2430	2623
Fogo	1474	-	-	-	-

Source: Sabino et *al* (1998)

Table 3. Results of fog water interception for the period of 1961-1992 in l/m^{2*}

Months	Fog water		Wind speed	
	//4.5^2/day	l/m^2/day	km/hr	m/s
January	-	-	-	-
February	15,2	1,90	30,92	3,07
March	34,8	7,73	29,00	8,06
April	30.9	6,87	27,33	7,60
May	54.2	12,04	30,33	8,43
June	82.0	18,22	30,67	8,53
July	30.9	6,87	19,33	5,37
August	102.4	22,76	17,33	4,82
September	99.2	22,04	24,00	6,67
October	82.7	18,38	31,33	8,71
November	51.9	11,53	24,30	6,76
December	30	6,67	28,26	7,86
Average	54,33	11,25	24,40	6,32

*Data obtained from Cunha (1962), Carvalho (1991) and Sabino (1990), Gonçalves *et al* (1991)

The estimation of the potential areas and the amounts of water to be collected are illustrated in the Table 4.

Table 4. Estimation of the areas and potential water collection in some islands of Cape Verde

Islands	Island area	Foggy area	Potential fog water		Elect. cond.
	km^2	Ha	m^3/d	m^3/yr	dS/cm
Brava	67,4	54.00	2050	748250	
Santiago	991	300.00	3420	1248300	201[1]
SanVicent	476	19,10	500	182500	
St. Antao	779	330.00	3760	1372400	
S. Nicolau	388	105,00	720	262800	
Fogo	476	325,00	2960	1080400	
Total	3177,4	1133,1	2235	4894650	

[1]pH=7.9

3.THE PROPOSAL OF PROJECT

The Monte Verde project was designed with the data obtained from field experiments. Even though, the daily mean can reach the values so high such as 60 liters/day/m^2 we based our calculation on the mean of 11,5 liters/m^2/day, which is safer.

Methodology. The methodology consisted (1) in collecting data to calculate the mean value; (2) carrying out the topographic survey (Figure 6); 3) designing the collector (Figure 7); 4) computing he total number of collectors and layout system (Figure 8) and; 6) computing the estimated budget.

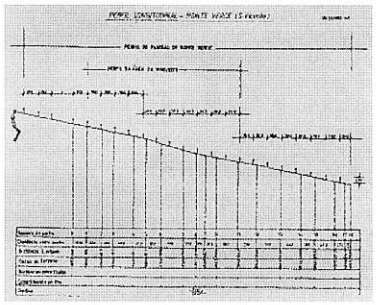
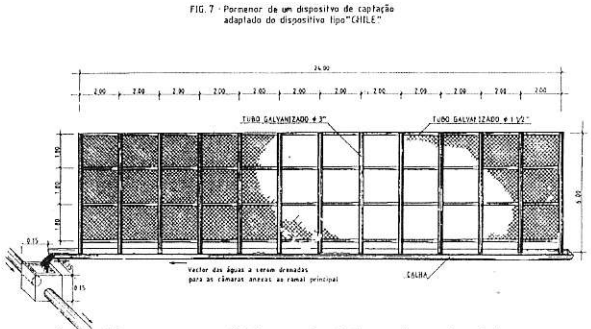


Figure 6. Topographic survey of the project area of Monte Verde, San Vincent.

Source. Sabino (1990)



g. 8. Collector type (24m x 6m) in galvanized iron p
Figure 7.Collector to be used in the proposed project.

Source: Sabino (1990)

Collectors, topographic survey and layout system. The collectors has a surface area of 144 m^2 and the amount of water collected by each collector is 144m2x 11,5l/m^2/day = 1656 litters/day. Therefore, the project area with its 300 collectors can intercept about 500 m3/day during drought period (Figure 8) which is enough to supply water for a family.

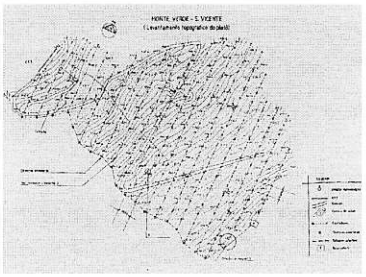


Figure 7. Total number of collectors and layout system over the 19.1 hectares of the plain of Monte Verde.
Source: Sabino (1990)

Fog water collection can be combined with water harvesting systems to increase water yield during the rainy season (Sabino 1997). Therefore, whenever it is possible, it is recommended to combine fog/cloud water interception with water harvesting techniques to increase water yield.

The cost of each collector estimated on the basis of the local costs of the material, ranges from $4,000.00 US dollars (frame of wood) to $6,250.00 US dollars (frame of galvanized iron pipes). Table 5 shows the total cost of the project in 1,469,200 US dollars.

Table 5. Estimation costs of the Project of Monte Verde, San Vincent.

Designation	Unit cost (U.S dollars	Total costs (U.S dollars)
300 Collectors	4200	1266000
Reservoirs (400 m^3)	49200	49200
Installation of 1000 m pipes PVC (ϕ = 4 ")	20	20000
Miscellaneous (10%)		134000
Total	-	1469200

4. CONCLUSION AND RECOMMENDATION

Results of fog water experiments conducted by researchers and water resources specialist since 1992 in Cape Verde Islands show that there is a potential amount of water which can be intercepted to supply water for domestic needs and, in some rural communities, to provide water for irrigation in small scale. However, the variability of intercepted water is to high and depend upon several factors such as wind speed, distance from the sea coast, elevation, height above the ground, the area of the screen holes, relative humidity, drought frequency and others unknown factors whose study is strongly recommended to pursue. Also, results indicate that there is a linear correlation between fog water collection and rainfall precipitation. The daily average fog interception which range from 3l/m^2/day to 16l/m^2/day during of drought periods, in most of cases, is higher than the rainfall precipitation. Therefore, the amounts of water yielded by the layout system is actually much higher than those of 1990 estimated on the basis of the daily mean values obtained under drought conditions, with erratic and infrequent occurrence of fog in 1990.

5. ACKNOWLEDGMENTS

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