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Climate Fluctuations and Environmental Impacts in Desertification in Cabaceiras - PB, Brazil

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ABSTRACT

Study-related to meteorology and its relationship with the environmental context, combined with the spatialization of physical information, such as weather, climate, soil, vegetation, relief, and hydrography for the municipality of Cabaceiras located in the state of Paraíba. The objective was to characterize, understand, and identify the influence of these elements, to verify their relationship with the desertification process. In this work, it was considered the morphological aspects, the climatic variability associated with the strong erosivity of the rains, and the erodibility of the soils, which assume greater expressiveness in the conditions of desertification. It is concluded that the data of maximum, minimum, average, and thermal amplitudes, wind speed and direction, evaporation, evapotranspiration, total sunshine, cloudiness, rainfall, a standard deviation of precipitation coefficient of variance, maximum and minimum absolute rainfall enormous contribution to the increase in soil erodibility. The elements of climatic variability such as maximum, minimum, average, and thermal amplitudes, wind speed and direction, evaporation, evapotranspiration, total sunshine, cloudiness, rainfall, a standard deviation of precipitation coefficient of variance, maximum and minimum absolute rainfall, the contributions from local effects and small and large scales have a huge contribution to the increase in soil erodibility.

INTRODUCTION

The influence of the climate is essential in the environment, it is responsible for all biogeochemical interactions between biotic and abiotic components within the ecosystem and according to the result of the current perception of the complex relationships between the environment and society necessarily passes through the environment. diagnosis of how the climate and its elements interfere. The climate of each region, located in the most diverse latitudes of the globe, does not present the same characteristics each year. (Soriano, 1997).

For Monteiro (1976), the climate is something dynamic and interactive as a whole, synthesis and dynamism (variability and rhythm) and dynamic analysis is extremely important for the mesoscale definition of morphological systems, for the interpretation of the dynamics of erosive processes of the environment and other aspects.

In this context, desertification is one of the most serious environmental problems faced today, it is associated with the reduction of the biological or economic productivity of the land, characterized by environmental, social, or economic fragility. Desertification can be understood as the deterioration of the natural situation, with the progressive reduction of biomass, the marked drying out of the environment, the sharp rise in average temperature, and the intensification of erosion processes, including wind power, which, given this, are several factors that collaborate for this mosaic of natural domains: the regional atmospheric dynamics, the medium-scale orographic influences, and the oceanic characteristics, mainly the surface water temperatures, in this conjuncture desertification can either originate in natural causes or triggered by anthropogenic actions (Conti, 1995).

Aubreville (1949), one of the first scholars on the subject, highlights two main effects of desertification: a) soil erosion, either by the laminar process or by the ravination, processes that would be installed as a consequence of the removal of vegetation; b) worsening of the soil water deficit, due to their greater exposure to solar radiation and the action of dry winds.

Silva *et al.,* (2011) states that the desertification process, in general, occurs in areas where the ratio between precipitation and potential annual evapotranspiration is less than 0.65, this corresponds to arid, semi-arid, and sub-humid areas, in which a combination of anthropic and natural factors act to accelerate or not accelerate this process.

Based on the definitions proposed over the years, the definition of desertification was the degradation of land in arid, semi-arid, and dry sub-humid areas, resulting from climatic variations, to a greater or lesser extent. Sales (1997) states that the municipality of Cabaceiras, which is located in the region of Seridó Oriental Paraibano, presents a strong commitment to the economy and the environment due to the intensity of soil degradation, and constitutes one of the four Desertification nuclei of Brazil.

Silva *et al.*, (2010) notes that the high incidences of sunlight, with consequent high temperatures, increase evapotranspiration rates, climatic variability, as well as periods of drought, the intensity of rains, soil erodibility, runoff. Superficial and anthropogenic derivation such as indiscriminate deforestation, burning, and grazing of sheep and goats above the environmental support capacity, were the factors that accelerate and aggravate the process of desertification in the region of the municipality of Cabaceiras.

The extent and intensity of the degradation seen in Cabaceiras are of great magnitude, especially when going through the dry period to wind erosion contributes to the mobilization of the material, inserting the landscape in a physiognomy similar to that of deserts (Cavalcante et al., 2005).

Due to the seriousness of the problem, studies and practical measures to be adopted in the municipality of Cabaceiras become necessary, otherwise, this space can become an atypical desert, with ecological desert characteristics, (Silva *et al.*, 2011).

In the geographical context, it is perceived that the appropriation of the soil, of the relief, as support or resource, originates transformations that begin with the subtraction of the vegetation cover exposing the soil to rainfall impacts. However, changes in procedural relationships occur, such as changes in the set of perpendicular components, corresponding to infiltration, parallel, silting, external agents, surface runoff, or earth flow (CASSETI, 1994). Studies on this degradation process are of paramount importance because they strongly compromise the economy and the environment and affect both the urban and rural population of the municipality and expand in the surroundings, very quickly through the morphoclimatic domains of the Caatinga (Cprm, 1972).

The environmental impact assessment process is a complex task, due to the diversity of social, physical, and biological factors, and also because it is not exact knowledge of the relationships between social and physical environments. Many of the socioenvironmental conflicts are associated with great risks, both natural (disasters, species extinction, landslides, etc.) as well as social ones (danger to health, deterioration in the quality of life, human rights, economic survival, etc.) (Vargas, 1997).

The objective of the study is to characterize desertification within a systematic methodology, referring to geoenvironmental aspects, to analyze the influence of natural physical factors, seeking to situate them in the context of the broader risks and environmental degradation, whose incidence has great expression in low latitudes. Becoming a chance to excite reflection on the meaning of nature and its role as a support for society.

MATERIALS AND METHODS

The municipality of Cabaceiras located in the state of Paraíba has an area of 400.22 km². Its position is between the parallels 7018 '36' 'and 7035'50' 'south latitude and between the meridians 36012'24' 'and 36025'36' 'west longitude. It is inserted in the Borborema mesoregion and the Cariri Oriental microregion, limited to the municipalities of São João do Cariri, São Domingos do Cariri, Barra de São Miguel, Boqueirão and Boa Vista (AESA, 2020), (Figure 1).

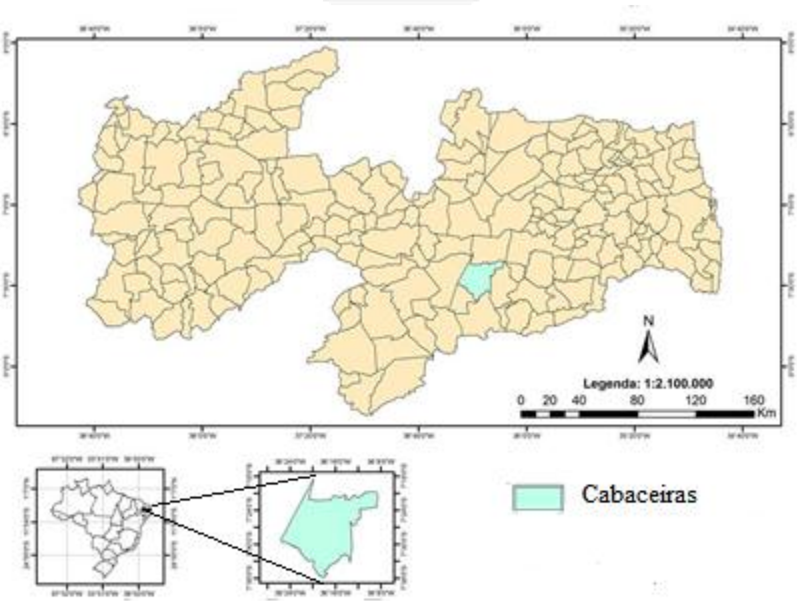

Figure No. 1: Location map of the municipality of Cabaceiras within the state of Paraíba.

Source: Medeiros (2020).

The climate of Cabaceiras according to the Köppen classification is of the Bsh - Hot semi-arid type, precipitation predominantly below 600 mm.year-1, and lower temperature, due to the effect of the altitude (400 m to 700 m), such classification is in according to the study by Alvares, Stape, Sentelha, Gonçalves & Sparover (2014).

In the table below we can see data of monthly and annual climatological precipitation, of the last 86 years obtained through the publication of AESA (2020).

Table No. 1: Average monthly and annual rainfall recorded in the municipality in the last 86 years.

County / Post	JJan	FFeb	MMar	AApr	MMay	JJun	JJul	AAug	SSep	OOct	NNov	DDec	AYearly
Cabaceiras	23.0	39.2	59.8	60.2	42.3	43.5	36.8	14.8	5.2	3.4	3.8	9.3	336.6

Source: AESA (2020).

Table No. 1 shows the variability of the monthly and annual meteorological elements in the environmental physical characterization of the study area. The municipality has minimum temperatures ranging from 17.8 to 20.8ºC with an annual rate of 19.7ºC, the maximum temperature flows between 27.8 to 32.6ºC and its maximum annual temperature is 30.5ºC, its average temperature varies between 22.1 to 25.3ºC with an average annual temperature of 24.0ºC, the annual thermal amplitude is 10.8ºC with monthly variations from 9.3 to 12.4ºC. It has an annual relative humidity of around 63.8% and its monthly fluctuation is between 48.0 and 80.0%. The wind speed flows between 1.0 to 2.0 m.s-1, with an annual value of 1.5 m.s-1. The predominant direction of the annual wind is NE - SE. The municipality of Cabaceiras has annual evaporation of 338.4 mm and its monthly fluctuation is 3.5 to 59.8 mm and annual evapotranspiration of 1,248.4 mm with a monthly fluctuation from 79.2 to 127.0 mm. Total sunstroke ranges from 119.0 to 237.9, with an annual rate of 2,224.0 tenths hours and cloud cover ranges from 1.0 to 7.0 tenths and its annual rate is around 6.8 tenths. The annual precipitation oscillates around 336.6 mm and its monthly fluctuations vary from 3.5 to 60.2 mm.

Table No. 1: Variability of monthly and annual meteorological elements in the physical characterization and environmental impacts of desertification in Cabaceiras.

Parameters / months	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	yearly
Maximum temperature	32.1	31.7	31.2	30.4	29.2	28.1	27.8	28.8	30.2	31.7	32.5	32.6	30.5
Minimum temperature	20.7	20.8	20.8	20.5	19.8	18.8	17.9	17.8	18.8	19.6	20.1	20.6	19.7
Average temperature	25.3	25.1	24.8	24.5	23.7	22.6	22.1	22.4	23.3	24.3	25.0	25.3	24.0
Thermal amplitude	11.4	10.9	10.4	9.9	9.4	9.3	9.9	11.0	11.4	12.1	12.4	12.0	10.8
Relative air humidity	50.0	70.0	75.0	77.0	70.0	80.0	80.0	66.0	49.0	50.0	48.0	50.0	63.8
Wind direction	1.7	1.5	1.0	1.1	1.2	1.1	1.1	1.6	1.7	1.8	1.9	2.0	1.5
Wind intensity	NE	NE	NE	NE	NE-SE	NE-SE	NE-SE	NE	NE-SE	NE-SE	NE-SE	NE-SE	NE-SE
Evaporation	22.2	39.7	59.4	59.8	41.2	43.4	36.3	14.5	5.3	3.5	3.7	9.4	338.4
Evapotranspiration	123.1	111.3	117.3	107.5	99.0	82.1	79.2	83.1	91.9	109.6	117.3	127.0	1248.4
Insolation	238.9	203.0	203.0	173.6	175.4	151.1	119.0	150.7	181.9	212.5	217.2	197.7	2224.0
Cloudiness	6.0	6.5	7.0	7.0	7.0	7.0	7.0	5.0	2.0	1.0	2.0	2.0	6.8
Historical rainfall	23.0	39.2	59.8	60.2	42.3	43.5	36.8	14.9	5.2	3.4	3.8	9.3	336.6
Absolute maximum precipitation	279.2	183.8	386.0	271.2	184.8	176.0	154.8	71.0	50.0	91.4	45.0	157.0	775.5
Absolute minimum rainfall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	00.0	3.6

Source: Medeiros (2020).

Maximum temperature meteorological data were used; minimum temperature; average temperature; thermal amplitude; wind speed and direction; evaporation; evapotranspiration; total sunstroke; cloudiness; climatological precipitation; absolute maximum precipitation; absolute minimum precipitation; where worked with estimated programs developed by the Department of Meteorology at UFCG, multiple regressions straight; interpolations (MEDEIROS, 2007), thematic map of the location, which contains roads, drainages, neighboring municipalities, highways, and natural bed roads. Field / technical visits were made where the following aspects were identified and recorded:

(a) climatic, hydrological, geomorphological, pedological and vegetation characteristics of the study area;

(b) climatic variability and its influence on the desertification process;

(c) causes and consequences that influence the environment.

The field control of January 2010 was used, the monitoring of rainfall intensities, soil analysis, the behavior of the intrinsic factors of the slopes, forms of appropriation, as well as the evaluation of resulting processes, analysis of documents such as technical reports and photographic records.

The data were generated in Excel by the method of estimates, interpolation of the weather stations of the surrounding municipalities, and the multiple regression lines from the geographical coordinates latitude, longitude, and altitude of the study area.

RESULTS AND DISCUSSION:

The Desertification process in the municipality of Cabaceiras is caused by a complex interaction of physical factors. The environmental consequences of soil degradation are quite serious, the most harmful aspects are; reduction in the production capacity of the land, reduction of agricultural production, changes in macro and microclimate, stability in rainfall and non-essential water supply in the soil, loss of microorganisms and nutrients in the soil, changes in the drainage pattern, risk of species extinction, reduction of biodiversity (plant, animal and landscape), disproportionate deforestation for the purpose of selling firewood to bakeries, silting up rivers, streams, streams, lakes, and lakes on an intermittent basis, impoverishing the population, abandoning land, rural exodus, and dryness of swamps and water eyes that provide water in various activities developed for humans, plants and animals in the municipality of Cabaceiras, are situations that strongly compromise the economy and the studied environment.

The panorama of environmental degradation in Cabaceiras has a wide magnitude, not only due to its expansion but mainly due to the rapid degradation process. Erosions have caused serious negative effects in both urban and rural areas, attacking highways, roads, vegetation, and the soil through the erosion process, culminating in the silting of shallows, caves, streams, rivers, lakes, lagoons, streams, weirs, and dams.

The observations were made from January to June, which coincides with the rainy season, the process worsens, due to the erosive action of rain caused by the impact of drops on the soil. The erosive action depends on the volume and speed of the rain, and also with the slope of the land and the soil's absorption capacity.

The intensity of rainfall is the most important factor, and the greater the intensity, the greater the loss from erosion. In this sense, the areas susceptible to desertification in Cabaceiras, are characterized by long periods of drought, followed by another of intense rain. Both processes, dry and/or rainy, usually cause significant environmental, economic, and social damage, affected by the climatic variability of the municipality and the region.

The spatial and temporal variability of pluviometric indexes and annual deviations of precipitations, Litolic soils, with reduced water retention capacity, hot and dry winds, high rates of total sunlight directly to the surface, low cloud cover causing the stimulus of water rates. evaporation and evapotranspiration, the daytime variability of the relative humidity of the air, and fluctuations in temperatures, the high rates of fires cause favorable conditions and accentuate the process of Desertification. In this way, the relief is being completely razed, taking the vegetation cover, and leaving the field without protection.

However, the morphological aspects, as well as the climatic variations associated with the strong erosivity of the local rains and the erodibility of its soils, assume greater expressiveness in the conditions of desertification, resulting in a severe erosion in the furrow, as observed in Cabaceiras.

In this sense, the climate is something of extreme value, a heritage for humanity, considered as an important natural resource. In other words, the Climate is, in reality, a natural input extremely linked to the physical and economic processes. In this way, the relationship between climate and the organization of space depends on the degree of economic and technological development of each society, in particular, and which climatic attributes are most relevant in each region or location.

In this way, environmental issues linked directly or indirectly to the climate demonstrate the intense vulnerability of contemporary society in relation to the phenomena of nature (Mendonça, 2007).

According to Nicholson (1999), the expansion of desertification nuclei is one of the biggest problems caused by droughts in semiarid regions, since the meteorological phenomena that contribute to desertification are, in order of importance, droughts, avalanches, wind erosion and climatic variability.

The low latitude geographical position exposes the municipality of Cabaceiras to intense solar radiation, which depletes surface water reserves, threatening the balance of the biosphere. The amputation of the vegetation cover exposes the soil to erosion and high reflectance, where it causes a destabilization in the energy balance in the soil (Galvão, 1994).

In terms of the reduction or dissipation of the vegetation cover, the thermal balance is unbalanced, with an increase in the reflectivity of solar radiation, that is, from the albedo to the surface level. This, in turn, intensifies the atmospheric subsidence, bringing dry air from the upper troposphere to the surface, inhibiting the formation of clouds and reducing the likelihood of rain. Likewise, unprotected soil and directly exposed to solar radiation has very low water retention capacity (Silva *et al.*, 2010).

Betone (1990), states that the intense degradation of the area is a consequence of the processes of water erosion by the action of the waters on extremely friable soils. Climatic irregularities have a strong influence on the desertification process.

The problem is faced both in the rainy season (rains drag large amounts of land) and in the dry season, a time when the soils become too dry and the action of the wind further accentuates the erosion process. The swamps and riverbeds are being buried by eroded soils. It should also be noted that climate changes determined by natural causes are, as a general rule, slow, occurring on the scale of thousands of years, whereas the changes produced by anthropic action manifest themselves in a few decades (Casseti, 1994).

However, Mendonça (2007) clarifies that the climate system is formed by a set of highly dynamic elements that interact with the geographical factors of the climate, thus having a permanent exchange of energy and interdependence. In this sense, studies of climate in the field of geography are directed towards the spatialization of elements and atmospheric phenomena, seeking to explain their procedural dynamics.

In this way, both meteorology and geography aim to integrate the different terrestrial layers to understand the production and organization of space, in the study of time and climate, it has a very important vector in the spectrum of its spatial and temporal analyzes (Silva *et al.*, 2010).

Anyway, there are several other criteria to evaluate the desertification process, such as, for example, the interannual variability of precipitation, using formulas that take into account the phenomenon's annual standard deviation, in addition to conducting spectral analyzes of precipitation time series, to detect cyclicalities, periodicities, and trends (SILVA et al., 2010).

Ab'Sáber (1970) defines six morphoclimatic domains for Brazil, among them Paraíba is inserted in the Domain of Caatingas - the northeastern region of crystalline formations, inter-mountain depressed area, and semi-arid climate, according to the climate the soil has similar characteristics as: shallow and rocky, with a lot of physical weathering in the oxisols and little erosion in the litolics and with the presence of salts in the soil, such as Solonetz, Solodizado, Planossolo, solódicos, and soonchacks. The vegetation is characterized as tortuous herbaceous, having as species the cacti, the mandacaru, the xique-xique, vegetations that survive periods of extreme drought and because of that they have adaptations, such as the hard and dry bark, conserving the humidity inside.

With regard to vegetation, the caatinga is widely diversified, both in its phytophysiognomy and in its floristic composition, due to the diversity of environments that make up the Brazilian semi-arid region, commanded by local changes in the elements of the climate, especially in terms of the amount and distribution of rain. Several authors, recognizing this diversity, classify the caatinga in a plural way in different subsystems, which leads to the conception of it as the Caatingas Biome (Cavalcanti *et al.*, 2007).

The municipality of Cabaceiras is inserted in the domains of the hydrographic basin of the Piranhas River, sub-basin of the Seridó River. Its main tributaries are: the Cabaceiras, Letreiro, and Passagem rivers, in addition to the several streams the main accumulation bodies are: the Várzea Grande dams (21.532.560m3), Carrapateira, Conceição, do Dedo, Carrapato, Cabaceiras, and Jurema, in addition from the lagoons: from Canto, do Deserto, Cercada, do Junco and from Montevideo, all watercourses have an intermittent flow regime with a dendritic drainage pattern (CPRM, 2005).

From the water point of view, the semiarid is known for its average rainfall of 800mm per year, with a small portion of that space having an annual average of less than 400 mm. The driest years are hardly less than 200 mm, and there is never a year without rain. What explains the water deficit is the high potential for water loss due to evapotranspiration (remembering that the Brazilian semiarid is located in the tropical zone); poor distribution of rainfall over time and space; the almost inexistence of perennial rivers that can guarantee the quality and quantity of water not even minimally necessary for the local populations; low level of use of rainwater; option for the technology of large dams, with large mirrors of water that facilitate evaporation (Cavalcanti *et al*., 2007).

The predominant drainage pattern is dendritic, alone tending to pinch (CPRM, 1972). About the natural environment, the region's edaphoclimatic characteristics, such as the heavy rains that transport large amounts of sediments to drain the region (lagoons, lake, streams, caves, streams, rivers, weirs, dams), occurring the intense process of silting up of these intermittent or perennial watercourses. The silting process of rivers in the region is quite common, due to sediments from the current erosion process in the area (Galvão, 1994). The deposition of sediments in the rivers ends up altering the watercourses, generating features called abandoned meanders.

Meteorology, in the last decades, has presented new methodological techniques with an updated guise of conceptual parameters and a technological base supported by computerized tools. Thus, the objective is to apply geographic knowledge, specifically to physical aspects, in an effective way to study and management of environmental impacts (Silva *et al*., 2010).

In view of the new challenges to be analyzed today, from the perspective of the meteorological and geographical approach of weather, climate, and climatology, the use of the systemic method has been widely used since it expresses an extremely interactive view, relating processes and responses. The systemic approach provides a new way of investigation, opening up new relationships for more complex interpretations about the climate.

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With regard to biography, there is a lack of determination and literature in the coverage area in studies of desertification. It is believed that given real meteorological data are of fundamental importance to base the studies on better analyzes.

In final considerations, desertification can be understood as a set of natural phenomena that lead certain areas to become deserts or to resemble them. Therefore, due to being a region of sandy soils, poor in organic matter, after constant winds, irregular rains that drag enormous amounts of sediment, climatic variability determined by natural causes or by anthropogenic derivation, on fragile ecosystems, being, in this case, the peripheries of deserts have the greatest risk of generalized degradation due to their uncertain environmental balance.

The climate as something dynamic and interactive, its character as a whole, synthesis and dynamism (variability and rhythm), dynamic analysis is extremely important for the mesoscale definition of morphological systems, for the interpretation of the dynamics of the erosive processes of the environment and other aspects.

In terms of natural coverage, the region is characterized by the Caatinga biome, which is quite expressive, but quite degraded overtime for the exploitation of firewood, production of charcoal, occupation of the soil with agriculture and pasture for livestock. It is also possible to detect that the predominant vegetation in this region reflects the soil, the relief, and the prevailing climate; therefore, a high degree of the impoverishment of the vegetation predominates, consisting of extracts composed of trees, trees, shrubs, and herbs that dry in the dry season.

Deforestation of native caatinga to form agricultural fields for planting subsistence crops. Fires using the "coivara" technique are implemented in short intervals for the preparation of new plantations. Removal of native wood to be sold to the owners of pottery, bakeries, ceramics and for their consumption, as an energy product to feed their ovens.

CONCLUSION:

The desertification phenomenon in Cabaceiras is directly related to climatic variability, geological structure, landforms, soils, and vegetation cover. In terms of natural coverage, the region is characterized by the Caatinga biome, which is quite expressive, but quite degraded overtime for the exploitation of firewood, production of charcoal, occupation of the soil with agriculture and pasture for livestock;

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It is also possible to detect that the predominant vegetation in this region reflects the soil, the relief, and the prevailing climate; for this reason, a high degree of the impoverishment of the vegetation predominates, consisting of extracts composed of trees, trees, shrubs, and herbs that dry during the dry season; Tendência de crescimento nas áreas de desertificação e, consequentemente, uma redução das demais classes de fauna e flora encontradas na região estudada;

The elements of climatic variability such as: maximum, minimum, average and thermal amplitudes, wind speed and direction, evaporation, evapotranspiration, total sunshine, cloudiness, rainfall, standard deviation of precipitation, coefficient of variance, maximum and minimum absolute rainfall, the contributions of local effects and small and large scales have an enormous contribution to the increase in soil erodibility;

The degraded area needs the population's awareness, encouragement from the government, and the private sector, in relation to the creation of study groups that seek ways, which are less expensive and time-consuming, to smooth or even reverse the process of desertification.

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