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Desertification in semi-arid northeast of Brazil

Amanda Rodrigues Santos Costa B.Sc.[a], Gleide de Lima Ferreira B.Sc.[b], Elizabete Buonora de Souza B.Sc.[c], Fernando Cartaxo Rolim Neto D.Sc.[d*]

[a,b,c,d] Departamento de Tecnologia Rural da Universidade Federal Rural de Pernambuco

*Corresponding author: fernandocartaxo@yahoo.com.br

ABSTRACT

Desertification is the process of land degradation in arid, semi-arid and dry sub-humid areas, caused, among other factors, by human activities and climatic variations. It is a global-scale problem because it is present in the dry regions in the world and causes many losses. In Latin America alone, over 516 million hectares are affected by desertification. As a result of this process are lost 24 billion tons per year of topsoil, affecting the economic, social and environmental development. In Brazil, the most likely region to this process is the northeastern semi-arid region, where the Caatinga biome occurs, due to the dry climate of the area and human activities for the exploitation of natural resources and agricultural practices without proper management for soil conservation. As aggravating the situation there is the scenario of climate change that can alter the rainfall patterns in the region and the climate in general, increasing the desertification process. To prevent and combat this process, are used legal instruments and government programs that seek to provide guidelines for action and implement preventive and recovery practices in degraded and susceptible to desertification areas. The scientific community is also active in tackling the problem with studies and research aimed at discussion of the topic.

Keywords: degraded areas, desertification, caatinga.

INTRODUCTION

According to the definition found in Agenda 21, the Rio-92 proposal, desertification is the process of land degradation in arid, semi-arid and dry sub-humid areas, caused, among other factors, by human activities and climatic variations (BRASIL, 2004).

Desertification affects about 33% of Earth's surface, where there are about 2.6 billion people (42% of the total population). Its effects are particularly severe in sub-Saharan Africa, home to more than 200 million people. In Latin America,

more than 516 million hectares are affected by desertification. As a result of this process are lost 24 billion tons per year of topsoil, which negatively affects agricultural production and sustainable development (MMA, 2007).

In Brazil, the area most susceptible to desertification is in semi-arid and sub-humid Northeast region, representing about 181,000 km² (ARAUJO; SOUSA, 2011). Soil degradation in this region is usually associated with agricultural management without proper planning and management; the practice of poorly supervised irrigated agriculture; and the overexploitation of natural resources (SILVA; SILVA, 2015).

The desertification process is the reduction or destruction of the biological or economic potential of the land by reducing soil fertility and biodiversity, deterioration of soil structure and even disturbances in the hydrological cycle. These factors not only cause economic losses, but also environmental and social losses, causing great impact on socio-economic conditions in the semiarid region (TRAVASSOS; SOUZA, 2011).

To combat desertification, more important than remediation, which is to address the consequences of the process, the causes of the phenomenon should be eliminated, such as erosion, deforestation, salinization and inadequate soil management. When prevention is not possible, technological measures must be taken to recover degraded lands (MARIN et al., 2015).

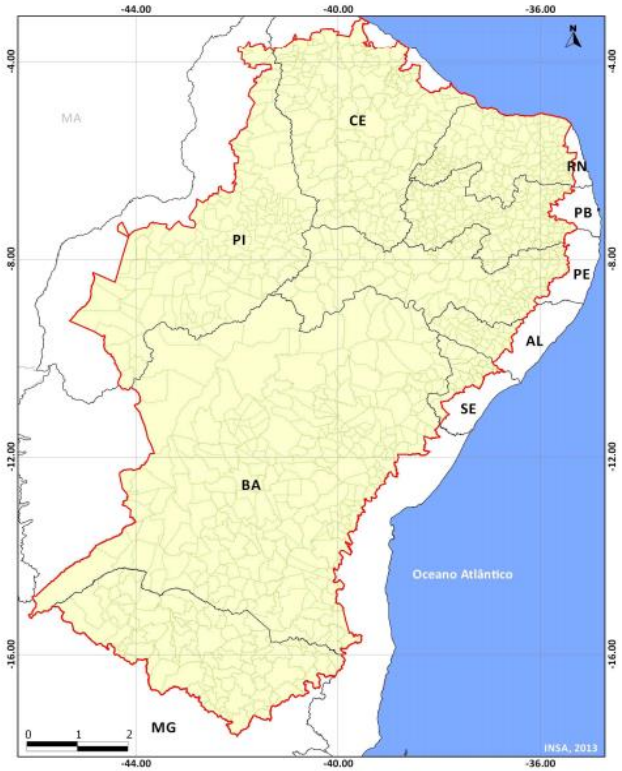
The aim of this review is to characterize, conceptualize and define the desertification process in the semi-arid northeast of Brazil, identifying the historical evolution of the theme, the natural and anthropogenic factors causing the process and, finally, the alternatives for recovery of degraded areas by desertification.

REVIEW

1. Characterization of semiarid

According to the Brazilian Institute of Geography and Statistics - IBGE (Figure 1), the Brazilian semiarid region has a population of 22,598,318 inhabitants, representing 11.85% of the population, formed by the northern region of Minas Gerais, the Northern Espírito Santo and most of the states of the Northeast of Brazil, occupying a total area of 982,563.03 km² (INSA, 2012).

Figure 1 - Territorial extension of the Brazilian semiarid region. Source: INSA 2012.



The Brazilian semiarid region is historically known as a dry region, with deficiency of water resources, associated with hunger, poverty and economic backwardness. This concept is related to

the difficultiescaused by environmental conditions of this region. The average annual rainfall is 750 mm, although in some areas does not exceed 400 mm, and the average evaporation is 2,500 mm year, generating high water deficit. Temperatures are high, with anual averages above 20 °C, the soils are shallow e few developed, and predominate intermittent rivers, featuring an environmentof uncertainty and challenge for its management (ARAÚJO, 2011; MONTENEGRO; MONTENEGRO, 2012).

2. Conceptions of desertification

The term desertification was first mentioned by the French researcher Louis Lavauden in late 1930. However, it was during the 1940s, with fellow Frenchman Andre Aubreville, the term has gained greater visibility. This researcher discussed desertification in his work entitled Climats, Forêts et Désertification - 1949, through studies in the tropical forests of Africa with the use of isohyets as analysis parameter. From this method, he noted the existence of isohyets 700-1500 mm, however, were coming deserts due to the action of human activities (SILVA; SILVA, 2015).

The definition of desertification proposed by Andre Aubreville refers to the change of productive land into desert areas as a result of land destruction by soil erosion caused by man. The causes of erosion, as noted by the investigator, were cutting the trees, the indiscriminate use of fire and inadequate management of agricultural activities (PEREIRA; NASCIMENTO, 2013).

The process of desertification began to have worldwide exposure during the drought of six years, between 1968 – 1973 in the Sahel region in Africa (MMA, 2007). This problem led to the preparation of the 'Study of Human Impact on Climate' report at the United Nations Conference on Environment in Stockholm in 1972. This was the basis for the holding in 1977 of the United Nations Conference on desertification in Nairobi, which aimed to discuss desertification and ways to combat the problem (CONTI, 2008).

In Brazil, discussions on the topic began in the 70s, when the researcher Vasconcelos Sobrinho represented the country at the conference in Nairobi and from there went on to address the issue in his studies. He conceptualized desertification as a process that stems from the fragility of the ecosystems of drylands, mainly due to human activities or, to a lesser extent, due to native fauna, resulting in lost of productivity and capacity to recovery of the affected areas (CAVALCANTI et al., 2007; RIBEIRO et al, 2016).

During the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992, it was warned of the spread of desertification and the dangers associated with it to the affected population. At Rio-92 was defined the need for a specific agreement for the theme that establish guidelines and commitments for the countries. Are signatories to 193 countries of the United Nations Convention to Combat Desertification and Mitigate the Effects of Drought (UNCCD), including Brazil, which proposes the establishment of labor Standards and international convergence targets to combat the effects of desertification and drought (SILVA; SILVA, 2015).

The UNCCD recognizes that desertification is a global-scale problem as it affects all regions of the world and is aware that the semi-arid, arid and dry sub-humid regions are a considerable proportion of

the land area of the earth and therefore, is the habitat and source of livelihood for a large part of the world population. Thus, the convention defines desertification as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities" (MMA, 1994).

3. Factors and vectors of desertification

Under Brazilian Law to combat desertification, the Law 13153 (BRAZIL, 2015), desertification factors are "unique natural conditions that make the environments more fragile and susceptible to various degradation processes" and desertification vectors are "forces that act on the environment and society, including direct human interference and natural disasters aggravated by human action. " To this law, the process of desertification is the complex set of factors and vectors that lead to environmental and socio-environmental degradation of the affected area.

The causes of desertification are related to climate and human action. To Pereiraand Nascimento (2013), each Earth biome has a biophysical production potential, and in arid, semi-arid and dry sub-humid is the lowest. A lasting overexploitation or misuse of the drylands, can quickly result in more similar conditions to a desert.

According to the United Nations Convention to Combat Desertification (MMA, 1994), land degradation is the "reduction of the biological or economic productivity and complexity of agricultural areas due to land use systems or a process or combination of processes, including man's activities and forms of occupation of the territory, such as soil erosion caused by wind and / or water; physical, chemical, biological or economic soil deterioration; and destruction of vegetation for prolonged periods" (MMA 1994).

The causes of desertification in the Northeast are not very different from those found elsewhere. It is related to the exploitation of natural resources of the caatinga biome (savanna), increased intensity of land use and the reduction of native vegetation which have led mainly to reduced fertility, demonstrating the fragility of the ecosystem (ARAUJO; SOUZA, 2011).

Travassos and Souza (2011) stated that one of the most common ways of desertification form is due to excessive removal of native vegetation. About this, they talk that "in view of the importance of vegetation and its relationship to desertification in areas subject to this process, coupled with the fact that in the northeastern semi-arid region the vast majority of the energy used comes from consumption of its native vegetation, results a very worrying degradation risk.In addition, the itinerant crops, fires, destruction of pollinators and seed stocks of native plants, as well as socioeconomic factors related to migration flows, also contribute to the degradation process (SILVA; SILVA, 2015).

Professor Vasconcelos Sobrinho, a pioneer in the study of desertification in Brazil, identified nuclei of desertification in the Northeast and found strong human intervention in the process of dryland degradation. Among them is the replacement of caatinga (savanna) by agricultural practices, livestock and removal of wood for firewood and charcoal. Some associated factors such as mining and the clayextraction of the alluvial soils are also

contributing factors to the degradation (MMA, 2007).

The areas subject to desertification in the Brazilian semiarid region have distinctive features described by Professor Vasconcelos Sobrinho, "with a typical denouncing physiognomy, easily seen in flight between 50 m and 150 m from the soil surface and then immediately conduct investigations on the ground to better detail. In the affected areas, the vegetation has reduced size, some species with dwarfism symptoms (Pereiro, *Aspidosperma sp*), and low density, that is, with greater penetration than in other areas, usually coinciding with the presence of hyperxerophyte caatinga. All hyperxerophyte caatinga is an area presumably committed to the process of desertification, which is accentuated every annual summer and especially after each drought. When the rainy season returns, there is a recovery effort that is not always complete. And so, in this uncertain balance between recovery and degradation, it is difficult to find out what condition will prevail. But if man interferes negatively, then it is certain that desertification prevails"(VASCONCELOS SOBRINHO, 1983).

It is known that the degree of anthropogenic impact is variable, depending on natural factors such as geomorphology, pedology and climate. Thus, not only human activities are causing the process of desertification.Climate acts as a vector of the problem and the current scenario of climate change as an aggravating factor. Global temperatures, according to studies by experts and publicized in global conferences of the United Nations (UN), are increasing on a small scale, but it brings great effect on the overall dynamics (RIBEIROet al., 2016) (Figure 2).

According to the Intergovernmental Panel on Climate Change Report - IPCC (2015), the northeastern semiarid region is the most vulnerable region in Latin America due to climate change, which may suffer from the reduction of the frequency of rain,soil degradation due to erosion and more prolonged droughts, increased desertification process and consequent increase in poverty and migration.

It is essential to understand the complex relationship between natural factors, human activities and climate change, for appropriate action to combat the effects of desertification. These factors directly affect the stability of supply of goods and services and the production of biomass (food) of agricultural land, as well as impact on migration and cultural aspects. Therefore, action is needed to avoid and prevent the process of desertification (RIBEIROet al., 2016).

4. Preventing desertification and land reclamation practices

In order to promote preventive actions against desertification in semiarid areas of Brazil was established on 30 July 2015, the National Policy to Combat Desertification and Mitigating the Effects of drought through the creation of the law number 13153. This law establishes principles and objectives of desertification policy and authorizes the government to create the National Commission to Combat desertification (CNCD) which will be responsible for implementing actions and coordinate initiatives of federal, state and municipalagencies (BRAZIL, 2015).

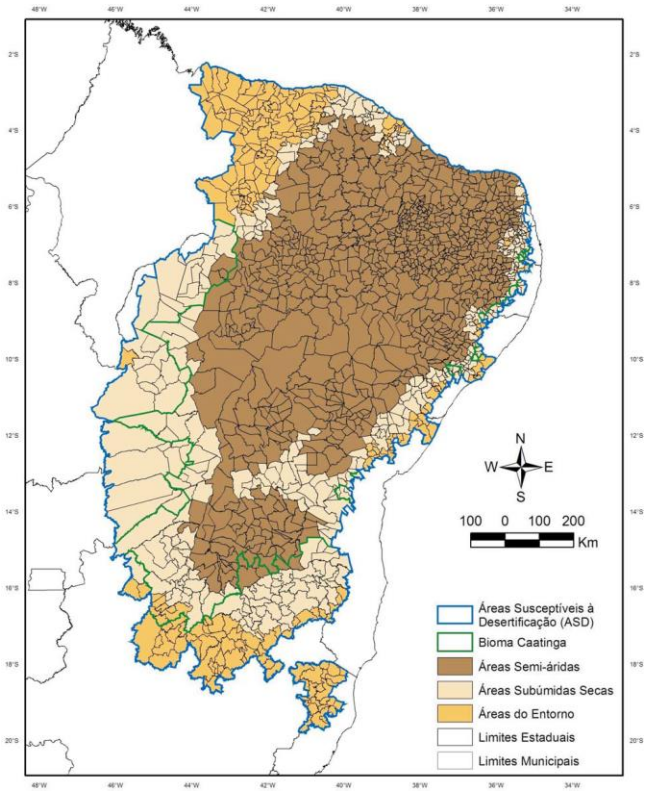
The law 13153 (BRAZIL, 2015) aims to prevent and combat desertification process. The legislation defines combating desertification as "the set of

activities of environmental and socio-environmental recovery with sustainable use of natural resources in arid, semiarid and dry sub-humid, with a view to balanced development." Combat is intended "prevention and / or reduction of degraded lands; rehabilitation of partly degraded land; and recovery"(MMA 1994).

As part of the UNCCD commitments, Brazil produced, in 2004, the National Action Program to Combat Desertification and Mitigate the Effects of Drought (PAN-Brazil), which serves to guide the actions aimed at combating desertification. Another advance was the definition of the Areas Susceptible to Desertification (ASD), which in Brazil are concentrated predominantly in the Northeast (MMA, 2007).

The areas susceptible to desertification were defined by the guiding assumptions of the UNCCD to propose the adoption of the Aridity Index (AI), which is calculated by the ratio between rainfall and evapotranspiration. Among the climatic regions of coverage of UNCCD (arid, semiarid and dry sub-humid areas), Brazil does not have areas with arid climate, occuring only semiarid and dry sub-humid with AI between 0.20 and 0.65 (Figure 2). In addition to these classes, it was decided to add a third category to the ASD - the areas surrounding the semiarid and dry sub-humid areas, since they have common characteristics to dry semiarid and sub-humid areas.

Figure 2 – Areas susceptible to desertification. Source: MMA, 2007.



The classification of ASD cover an area of 1,340,863 km² and a total of 1,488 municipalities in nine states in the Northeast of Brazil and the north of Minas Gerais and northern Espírito Santo. The pioneer actions for the delimitation of areas with high risk of desertification have been proposed by Vasconcelos Sobrinho in the 90s, which classified through studies, the so-called Nuclei of Desertification, namely Gilbués, Irauçuba, Seridó and Cabrobó. The risk areas are the object of study of PAN-Brazil, which seeks to integrate civil society, private and public powers to prevent and combat the problem of degradation (MMA, 2007).

Prevention is a long-term action to protect dryland before occur or continue the process of degradation. However, it requires a change in public policy and in the habits of populations through appropriate incentives. Studies show that

the populations in drylands, based on their experience and active innovation, can prevent desertification by improving agricultural practices and introducing sustainable grazing (CHARRUA, 2014).

Proper management of land and water are the main methods of preventing desertification. All actions that protect soil from erosion, salinization and other forms of degradation are an effective way to prevent desertification. Sustainable land use can reduce or avoid the impact of human activities such as overgrazing, overexploitation of plants, soil trampling and unsustainable irrigation practices, which increase the vulnerability of affected areas (CHARRUA, 2014).

Prevention strategies should also include actions to improve the use of water resources. These may include rainwater storage techniques which also help prevent runoff, reducing soil erosion and increasing soil fertility and moisture available. Several soil conservation practices and water should be implemented in order to improve groundwater recharge through soil and surface water bodies, for use during dry periods (ANDRADE et al., 2015).

A key preventive action against desertification is the maintenance of vegetation cover to protect the soil from wind and water erosion. A vegetation cover properly maintained also prevents the loss of the benefits of ecosystems, such as soil and water conservation during drought episodes (Ceará, 2010).

The reclamation is the return of an ecosystem to a non-degraded condition, but it can be different from the original (MONTANDON, 2015). To achieve this goal are used management and recovery techniques.

The execution of degraded areas recovery work includes basic studies of soil and vegetation, the implementation of recovery techniques, as well as monitoring and evaluation of the implemented practices. The methodology to be adopted will depend on the results of research based on soil types, the area to be recovered, the geomorphology, the state of fauna and flora, the achieved level of degradation and water availability, among others (CEARÁ, 2010).

According to Barros (2010), the action of recovery, initially, the area shall be prohibited, in order to avoid the loss of the remaining flora and also soil compaction as well as protecting the species that will be implemented. It should be performed after the use of physical shields for protection against wind erosion and promote vegetation cover, especially with native species.

Lopes et al. (2011) used for revegetation legumes (*Crotalerea, juncea, Leucaena spp, Vigna unguiculata, Ricinus comunnis* L., *Mucuna* and *Cajanus cajan*) and grasses (buffel grass and sorghum). The techniques were effective as decreased loss of soil organic matter and prevented erosion processes by setting their roots.

According to Figueiredo (2012), another species suitable for implantation of vegetation in desertified areas is *Opuntia ficus-indica* (L.) P. Mill., one of the cactus of family species. According to him, this species provides greater aggregation of soil particles, preventing remotion caused by water erosion. As thorny species, it can be used as a living fence to divert animals and people of the area in recovery. Also it can be used for food production for the population living in these areas.

Barros (2011) also highlights the need for environmental education policies for the resident

community in degraded or susceptible to desertification areas. Economic practices developed in these regions must comply with the principles of proper management and soil conservation. The author points agroforestry systems as the most suitable for these areas, providing the best soil structure, density, infiltration capacity and moisture retention.

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