

THE EXPANSION OF THE SEMIARID IN AREAS SUSCEPTIBLE TO DESERTIFICATION (ASDS) IN THE ITAÚNAS RIVER BASIN - ES.

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ABSTRACT

This work seeks to present how environmental degradation, through agrosilvopastoral activities, contributes to the expansion of the semi-arid in the direction of desertification/ASDs areas located in the Itaúnas River Basin – Espírito Santo/ES. The spatial cut-off covers a drainage area of approximately 4,350 km², located in the north of ES. The region is marked by periodic droughts and the watershed is included in the area of the Northeast Development Superintendence (Sudene). The study is part of the context of society vs. nature relations, based on the concepts of watershed, environmental degradation and desertification. A literature review was reviewed and the production of maps occurred by GIS techniques. Technical reports made available by government agencies at the federal level such as SUDENE, ANA, IBGE, INPE, as well as topographic charts, satellite images, aerial photographs and environmental data provided by ES agencies were used as sources, combined with literature associated with the theme.

A EXPANSÃO DO SEMIÁRIDO NAS ÁREAS SUSCEPTÍVEIS À DESERTIFICAÇÃO (ASDS) NA BACIA DO RIO ITAÚNAS - ES.

RESUMO

Este trabalho busca apresentar como a degradação ambiental, por meio das atividades agrosilvopastoris, contribui para a expansão do semiárido em direção das Áreas Susceptíveis à Desertificação/ASDs localizadas na Bacia do rio Itaúnas – Espírito Santo/ES. O recorte espacial estudado abarca área de drenagem de aproximadamente 4.350km², localizada no norte do ES. A região é marcada por secas periódicas e a bacia hidrográfica está inclusa na área da Superintendência de Desenvolvimento do Nordeste (Sudene). O estudo se insere no âmbito das relações sociedade x natureza, a partir dos conceitos de bacia hidrográfica, degradação ambiental e desertificação. Fez-se revisão de literatura e a produção de mapas ocorreu por técnicas de SIG. Foram utilizadas como fontes relatórios técnicos disponibilizados por agências governamentais no âmbito federal como SUDENE, ANA, IBGE, INPE, além de cartas topográficas, imagens de satélites, fotografias aéreas e dados ambientais fornecidos por órgãos do ES, conjugadas com literaturas associadas à temática.

INTRODUCTION

In recent decades, climate events have consolidated in the landscape through extreme weather and meteorological events, disasters and effects on society are immeasurable.

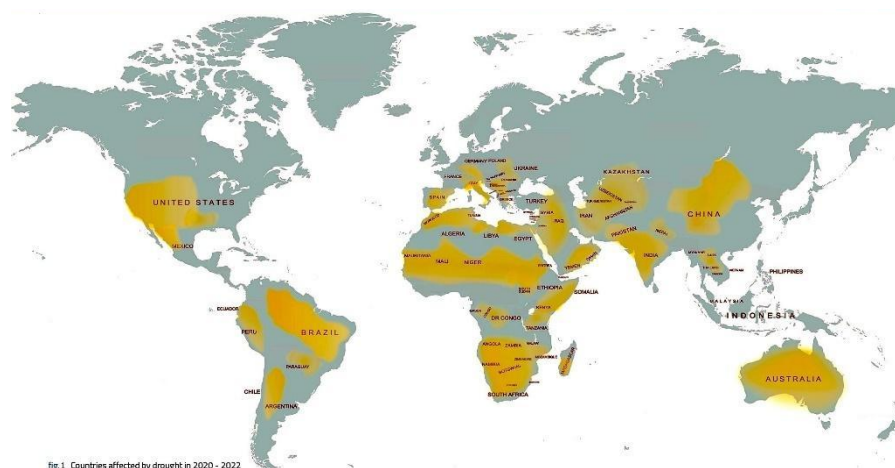
Among the implications that affect the usual population stand out as examples of environmental concerns that affect the entire planet: sudden floods, erosive processes of soils and prolonged slope, drought and dry mud, forest fires and fires, along with cold and heat waves.

The transformation of nature motivated by human action, increasingly present in our daily lives, it placed anthropic action on the level of climatic force. The anthropic action, according to Guerra (2011), generates the degradation of nature and, in most cases, does not respect the limits set by biotic and abiotic factors, which consequently impact in a harmful way to society as a whole.

In view of the transformations in landscapes, many researchers who led the IPCC 2018 reports, highlighted that limiting global warming to 1.5°C compared to 2°C could ensure a more sustainable and equitable society, with clear benefits to people and ecosystems.

However, if the planet's temperature rise is not interrupted, the various extreme events tend to manifest intensely in more sensitive regions; among them stand out the impacts of climate change forces on the Dry Lands. Figure 1 shows the countries affected by droughts between 2020-2022 in several regions of the world, including Brazil.

Figure 1 Drought-affected countries between 2020 - 2021.



Source: *United Nations. Conventions to Combat Desertification 2022.*

The effects of climate change in South America, more specifically in Brazil, can be identified by the periodicity, intensity and consequences to the populations occupying the Dry Lands. The

United Nations Convention to Combat Desertification presented concerns in Côte d'Ivoire in 2022 about the susceptibility to desertification in the face of changes in the climate system.

In Brazil, in 2021, the expansion of the semi-arid region towards regions previously considered humid, which added to the periodicity of droughts in the last decade, more exactly during the dry periods of 2010-2016 and 2020-2021, may signal the trends of new desertification *hotspots*.

The relations societies x nature directed by the capitalist model graphed in the landscape a mark of environmental misfits, which can lead to the activation of desertification triggers in tropical regions.

The results triggered by human action in the areas surrounding the ASDs deserve great attention due to the degree of sensitivity to climate change. In addition, in a pathfinder way, Ab'Saber (1977) already signaled concerns about the edge areas of the semiarid regions. According to him, these spaces suffered more from the processes of environmental degradation and "savanization", environmental changes in a more comprehensive sense than the nuclear area of the resistant caatingas itself.

In this context, Conti(2002) endorses the importance of worrying about the forms of exploratory uses through deforestation of the tropical regions, since "the subhumid or semiarid regions, are the ones with the highest risk of degradation and studies have shown that uncontrolled exploratory activities are the main cause of desertification." The light of these same notes, Suertegaray (2004, p. 253), also reveals that "[...] The term desertification is reserved to express the degradation of soil, vegetation, water and environmental conditions in general." Nascimento (2013) approximates the correlations between the "Desertification Phenomenon" with the north of Espírito Santo, when it analyzes desertification in the global scenario and brings the discussion to a national scale.

The incorporation of the high and medium course of the Itaúnas River basin within the boundary of the Areas Susceptible to Desertification followed the definition of the ASD Atlas, published by the Ministry of the Environment (MMA) in 2007.

The criteria used for inclusion were the periodic droughts that occur in the North of Espírito Santo, plus the inclusion of the municipalities of the Itaúnas river basin in the field of operation of sudene's emergency programs, regulated by federal law no. 9,690 (15/07/1998), which placed the municipalities of the North region of Espírito Santo in the list of municipalities served.

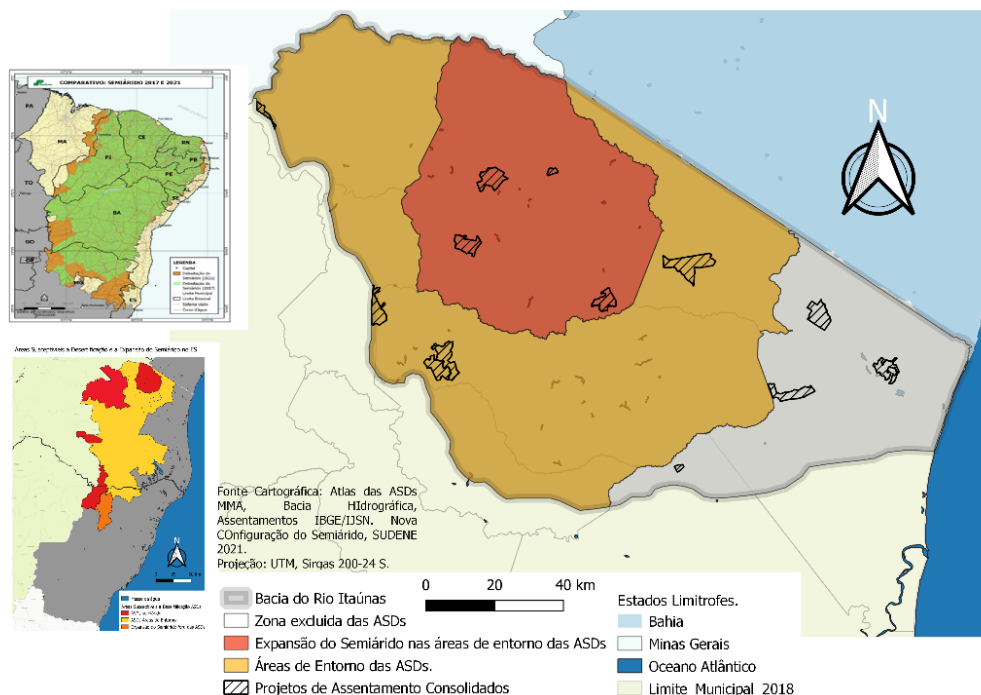
The correlations between land degradation and the expansion of the semi-arid to areas surrounding the ASDs of es, evidenced the sensitivity of the region to environmental changes that

in turn leads to concerns surrounding the advance of desertification in the Basin of the Itaunas-ES River.

In view of the scenario presented, in order to identify the expansion of the semi-arid in the ASDs of es, we will launch looks at the Itaúnas river basin supported by the definition of Cristofoletti (1980) for watershed: "river drainage is composed of a set of interrelated drainage channels that form the drainage basin"; and of the 4,350 km² of the territory, more than 90% of the coverage area is located in Espírito Santo. The exutory is 174 km long and is one of the largest in es, which integrates the East Atlantic Secondary Basin. Figure 2 shows the area of study.



Figure 2: Expansion of the Semi-arid in the Surrounding Areas of the ASDs of the Itaúnas River Basin



Source: Leonardo Matiazzi Corrêa, August 2022.

The population of the basin was estimated at 106,934 inhabitants, distributed by 8 municipalities (AGER 2018), among them are: Conceição da Barra and São Mateus, located outside the ASDs; Pedro Canário, Pinheiros, Boa Esperança, Ponto Belo, Mucurici and Montanha all located in the ASDs. However, the last municipality already falls within the new configuration of the semi-arid.

Due to the consequences of periodic droughts that occur in the region, the basin highlighted was included in 1998 in the field of operation of the emergency programs of SUDENE, this measure, together with the water scarcity contributed to incorporate the municipalities of the high and medium course within the limit of the surrounding areas of the ASDs (MMA 2007). Therefore, analyzing the occupation of areas surrounding the ASDs in the ES is relevant because it guides policies to combat desertification and the effects of drought in Espírito Santo territory due, especially under the advent of climate change.

METHODOLOGY

The way to reach the proposal was guided by a methodological procedure that went through two stages, they are:

a) Bibliographic Review

In these first steps, a literature review was conducted on the theme, more precisely, along with documents produced by government agencies at the federal level such as the Northeast Development Superintendence (SUDENE), The National Water Agency (ANA), the Brazilian Institute of Geography and Statistics (IBGE) and the National Institute of Space Research (INPE).

In addition, the literature review also advanced to the official bodies related to planning and the environment in Espírito Santo, more exactly the Jones dos Santos Neves Institute (IJSN) which is linked to the Secretary of State and Planning of ES, together with the State Institute of Environment and Water Resources (IEMA). It is linked to the Secretariat of Environment and Water Resources (SEAMA) of Espírito Santo.

Finally, after accessing the municipalities and official agencies responsible for planning at the national, state and local levels, images and environmental data were obtained that were combined with literature associated with the theme of climate change.

b) Geographic Information Systems Techniques (GIS)

In what corresponds to GIS techniques, the spatial representation of the expansion of the semi-arid to the ASDs of the Itaúnas river basin, were elaborated from cartographic bases in shapefile format accessed on the websites of national official agencies such as IBGE, as well as government agencies at the state level, including IEMA and IJSN.

After obtaining data in shapefile format, we sought from the free software *Qgis*, more specifically the *qgis 3.16 Hannover* desktop model, the organization and manipulation of the data which resulted in a map identifying the expansion of the semi-arid in the Itaúnas river basin and Espírito Santo; as well as other cartographic products used in this work.

1. Use/Occupation and Areas Susceptible to Desertification/ASDs

The debate surrounding climate change in Brazil is very present in the daily life of its population, since extreme climatic events more specifically droughts and heat waves are increasingly routine in the lives of dry land residents.

In this context, the results presented show in a certain way how agrosilvopastoral activities established in the Itaúnas river basin may have contributed to interferences in the water balance over the years. Due to this, probably, the culmination with the inclusion of part of the study area in the new semi-arid, according to the indicators that were adopted by SUDENE to characterize the new configuration for 2021.

1.2 The Contributions of agrosilvopastoral Activities to Environmental Change

The use and occupation of the soil in the north of the ES was historically predatory, characterized by the substitution of natural forests by felling the forest for the implantation of monocultures. This way of appropriation of nature, iron and fire, was announced by Becker (1969): spoke about the north of Espírito Santo as a peripheral region in transformation, both from an economic and geographical point of view.

In the early 1960s, the economy of Espírito Santo, based on coffee activity, suffered a great crisis in the face of state plans of the coffee eradication policy, according to the author:

The crisis that the State is going through, expressed in the coffee crisis, resulting from the programs for the eradication of coffee plantations instituted by the Coffee Rationalization Group – Brazilian Coffee Institute GERCA (2) in 1962 and 1966. In fact, the second program of 1966 took on violent aspects in the Holy Spirit. Violent because it released about 130,000 to 150,000 hectares of land previously occupied by 180 million feet of coffee, representing more than 45% of the state's coffee crop, the most important and the basis of its economy. (p.5)

The repercussion of the crisis in the ES due to spatial conditions, motivated by the eradication of its main economic base, was presented in the Espírito Santo space

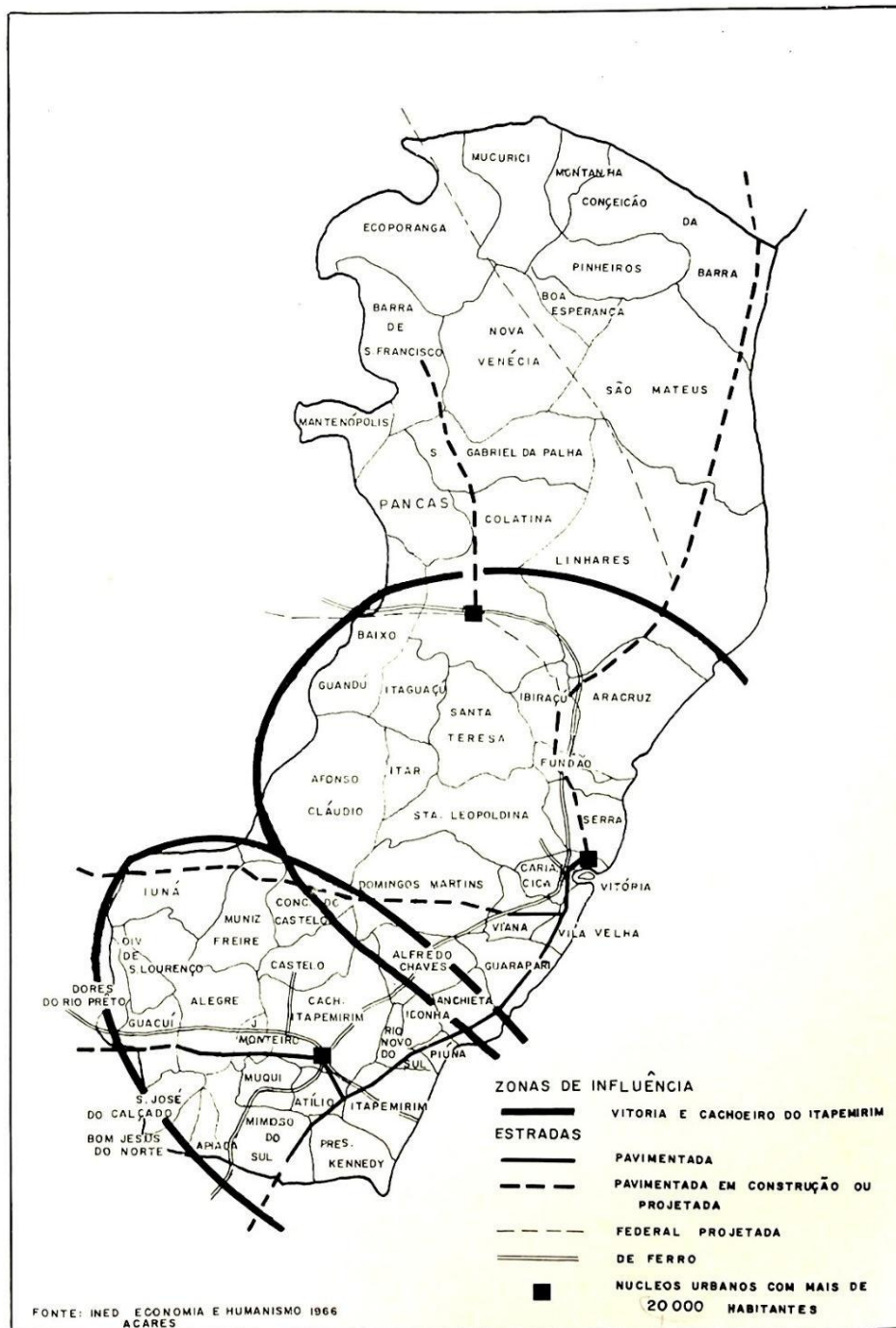
differently from the part of the state located to the South and North of the Doce River. Since this part of the territory of Espírito Santo had little infrastructure of roads with other regions, putting the area in a certain isolation. The figure such evidences in a certain way this isolation of the North of the Doce River from other cities of the State.

The transformations in the landscape in the region were modified from the moment the coffee of Espírito Santo was put into observance in the 60s, whose official policy of eradicating unproductive coffee plantation, made at that time, many farmers seek new forms of uses. One of the products that had a rapid and immediate return, still abundantly existing, was plant extractivism, and with this logging begins a highly predatory economic cycle in the region.

The North of Espírito Santo until the 1960s was practically untouched, that is, apparently the area of the basin was isolated due to the region not being integrated the main roads of circulation. Becker (1969) highlights the isolation of the northern Espírito Santo in the late 1960s. The precarious circulation routes to the north of the Doce River characterize the isolation of this region not only for the areas of influence of Vitória and Cachoeiro, but also to the main national economic centers as can be seen in the following figure.



Figure 3. Circulation Routes and Areas of Influence of Major Cities



Source: Bertha Becker (1969), p. 27.

In view of the above, the connection of the North of the State of Espírito Santo with other regions is initiated from the implementation of Br 101, established in 1962, and its subsequent paving in the biennium 1972/1973 was of fundamental importance for logging.

Before the articulation of the transport system, that is, the connection with the Federal Highway, logging was restricted to local consumption and production was drained through the rivers of the region. The extraction of hardwood, such as Jequitibá, Jacaranda and yellow Peroba, were an important source of income until the end of the 1970s, when many timber companies in the region migrated to other regions of the country in processes of the expansion of the agricultural frontier.

This exploitation model was a determining factor for the change in soil occupation, since after the exhaustion of native forests by iron and fire. In this context, the same author announces that livestock has established itself in an attempt to integrate this depressed region into other areas of the State itself and other regions of the country.

In the wake of the integration of the Northern region of Espírito Santo to other areas of the country, Ab'Saber (2006) also draws attention to the continuity of violent political decisions made in Espírito Santo to implement the first plantations of homogeneous eucalyptus forests started in 1967, destined to the "insensitive industry", called Factory I Aracruz Cellulose.

In this context, the geographical conditions offered for the development and expansion of forestry in regions previously occupied by pastures are presented Ross (2009 p. 127), when it ratifies this issue saying that:

In Espírito Santo, coastal tableland are occupied with farm creation and cut livestock in planted pastures and these alternate with large areas of eucalyptus forestry, as in southern Bahia, Aracruz cellulose is located.

Thus, the large industrial projects established in Espírito Santo, in the mid-twentieth century, to meet the logic of the global economy, were marked with the inauguration of the first Aracruz Cellulose plant in 1973.

In 2009, the company merged with the Votorantim group to form Fibria. This measure

led to it becoming one of the leading companies in the cellulose market. In the middle following years, there was an approximation between Sussano Papel e Cellulose along with Fibria Paper e Cellulose, whose intuiting was to conduct a new merger. Completed in 2019, the company positioned itself in the pulp sector as one of the largest in the world.

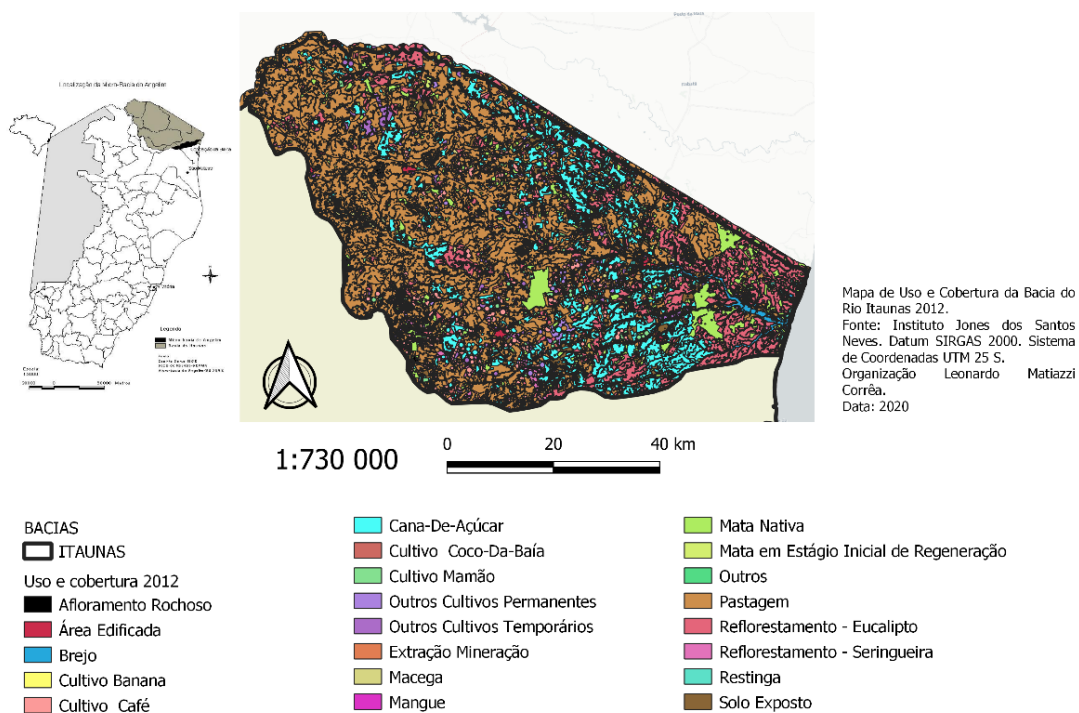
Still on the path established by the advance of agro-business in the Itaúnas basin, sugarcane activities are now highlighted as a new element in the spatial arrangement of the Itaúnas basin, whose beginning of planting happens almost simultaneously to the advent of the first agro-industries for the manufacture of alcohol.

Driven by the search for a new energy matrix due to the oil crisis, the production of alcohol and the consequent expansion of areas destined to the planting of sugarcane, once again manifests quite aggressively and is instituted in the region through great incentives.

Therefore, the increase in areas for the cultivation of this product is linked to the implementation of the National Alcohol Program (PROALCOOL), established by decree law no. 76593 of November 14, 1975.

However, the exploration and processing of wood – which in the past have been relevant functions in the production of the space-, the large volume of pastures, plus large-scale eucalyptus reforestation, together with the expansion of sugarcane planting can be seen in the current configuration of the use and vegetation cover of the Itaúnas river basin in 2012, from figure 4.

Figure 4 -Map of Use and Vegetation Cover of the Itaúnas River Basin 2012



So, the changes caused by the eradication of coffee, or even the direct action of the substitution of natural forests for the implementation of pastures, in the early 1960s, in an attempt to integrate this economically depressed region, it showed in a certain way the inheritances that livestock left as a legacy, more specifically the degradation of soils in the Itaúnas basin, as shown in Figure 5.

Figure 5. Legacy of Livestock in the areas incorporated into the semiarid



Source: Qgis 3.16 Hannover2021/Leonardo Matiazzi Corrêa 2022.

The figure above reveals how anthropic interventions can induce the activation processes of erosive processes, which cause a series of developments among them, compaction and loss of infiltration capacity.

In this context, the suppression of forests for livestock in some water recharge points of the basin, such as spring and ripiary forests, interfered with the triggers that triggered the erosive processes and hydric retention capacity, whose consequences of this conjuncture may have influenced the expansion of the semiarid region to the region because of the new indicators established.



2. The Indicators for inclusion of the Itaúnas basin in the New Semiarid Configuration 2021.

The indicators for the definition of the semiarid team were reviewed by the multidisciplinary team due to the search for new indicators, in addition to using only the average annual precipitation as a criterion. The results developed can be identified in Figure 6 that spatializes the indicators over the last 50 years.

In summary, the technical criteria used by SUDENE 2021 for the new configuration of the semi-arid, between 1991 and 2020, were:

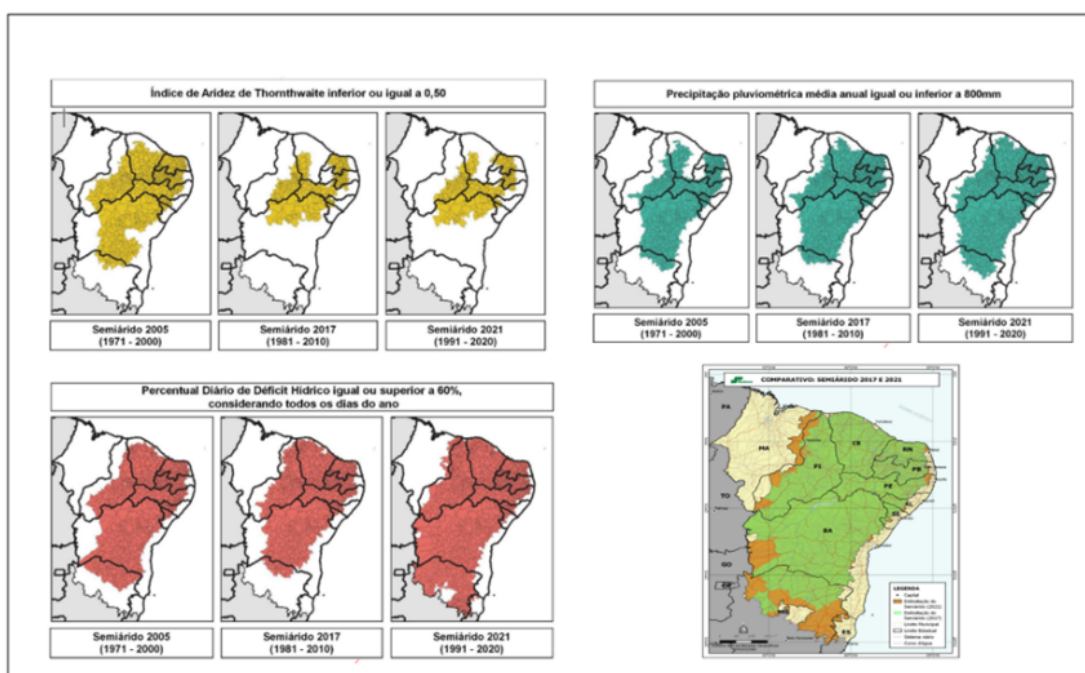
- a) Thornthwaite Aridity index less than or equal to 0.50;
- b) average annual rainfall equal to or less than 800mm and;
- c) daily percentage of water deficit equal to or greater than 60%, considering all days of the year.

The new delimitation of the semi-arid in 2021 resulted in the identification of 1,427 municipalities that met at least one of the criteria for classification of belonging to the new demarcation. The expansion of the semi-arid towards the transition areas, once considered humid in the South, triggers the warning signal for changes in the regions surrounding the ASDs.

The main concerns of these changes are located in the areas of North Minas Gerais and Espírito Santo, as they were incorporated into the semi-arid region due to the criterion of the daily percentage of water deficit equal to or greater than 60% considering every day of the year.

The method presented by SUDENE for the new design of the semi-arid in 2021, consists in the use of a daily water balance model and takes into account the characteristics of the soil with regard to storage and conductivity, whose parameters serve to analyze the dry season and rainfall irregularities during the wet season.

Figure 6 - Evolution of the sand-time criteria for a new delimitation of the semi-arid region.



Source: Sudene 2021.

The precipitation data available daily by meteorological station from 1991 to 2020 were correlated with the daily variation of evapotranspiration, defining the water balance in the period of 30 years; which resulted in the incorporation of ES territories into the new semi-arid framework through this indicator.

CONCLUSIONS

The transition regions from humid climates to semi-arid areas can be very sensitive to susceptibility to desertification, since renowned authors such as Aubreville (1949) and Ab'Saber (1977) announce that triggers triggers of desertification are initiated in areas considered moist in the past. Therefore, the use and degrading occupation, conducted by agrosilvopastoral systems installed in the environmental systems of the areas surrounding

the ASDs, graph in the landscape the fingerprints of a model that should lead future generations to inherit the consequences of climate change

The daily life of those who experience the Dry Lands are increasingly marked by the extreme events that become routine, manifested through prolonged drought and drought, whose effects cause immeasurable and unprecedented socioeconomic damage. Thus, in addition to the water scarcity in these regions, high temperatures increase the evaporation potential leading to a decrease in soil water retention capacity.

Therefore, the area of coverage of the new semi-arid region, characterized by water deficit, indicates that the delineated regions present low soil moisture, in addition, the changes in the water balance pointed out by the SUDENE studies that determined the new configuration of the semi-arid for 2021, not only revealed the expansion of the semi-arid to the areas surrounding the ASDs in the ES. However, they showed that low soil moisture can be an excellent indicator to evidence the susceptibility and advance of desertification areas in the Itaúnas river basin.

Finally, the advance of the semi-arid towards the high course of the Itaúnas basin, because of the water balance indicator, may be directly related to the process of soil degradation triggered by the use and occupation by agrosilvopastoral systems(sugarcane-eucalyptus-pasture). In view of this, the expansion of the semi-arid climate in the ES reveals not only how quietly climate change manifests itself in the areas surrounding the ASDs, but also expands the trends of desertification *hotspots*.

REFERENCES

AB'SABER, A. N. Problematic of desertification and savanization in intertropical Brazil. **Geomorphology**, São Paulo, n. 53, p. 1-19, 1977b

State Water Resources Agency. Diagnosis and Prognosis of Water Use Conditions in the Itaunas River Basins . **Preliminary Activities Report January 2018**. Vitória:AGER,2018

AUBRÉVILLE, A. **Climats, Forêts et Desertification de l'Afrique tropicale**. Paris: Societé d'Éditions Géographiques, Maritimes et Coloniales, 1949

BRAZIL. Ministry of the Environment. **Atlas of Areas Susceptible to Desertification of Brazil**.Brasília: MMA 2007.

BECKER, B. **The north of Espírito Santo: peripheral region in transformation.** Contest thesis for free teaching. Federal University of Rio de Janeiro, December 1969

GUERRA, A.T. **New geological-geomorphological dictionary.** Rio de Janeiro, 9.ed: Bertrand Brasil.2011.

IPCC, 2018: **Global Warming of 1.5°C: An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change** [V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In press, 1552 pp

NASCIMENTO, F.R. **The phenomenon of Desertification.** Goiânia: UFGO, 2013. 205-226

SUDENE, Northeast Development Superintendence. **Delimitation of the SemiArid 2021.** Final Report. Recife 2021.

SUERTEGARAY, Dirce Maria Antunes. **Desertification: recovery and sustainable development.**In: GUERRA, A. J. T. CUNHA, S.B. da (org.). **5. Geomorphology and environment.** Rio de Janeiro: Bertrand Brazil, 2004.

United Nations Conventions to Combat Desertification. **Drought In Numbers 2022 – restoration for readiness and resilience –.** COP 15 Cote d'Ivoire 2022.

