SEVEN publicações acadêmicas

The impacts caused by drainage channels in wet areas of the Gravataí River – Rio Grande do Sul - Brazil and in Praia da Coronilha – Rocha – Uruguay

Crossref doi
https://doi.org/10.56238/sevened2023.001-012

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ABSTRACT

Throughout history, many watercourses have undergone transformations to meet the demands for land and water use for agriculture and human supply. In both Uruguay and Rio Grande do Sul – Brazil, the human action that most contributes to the degradation of wetlands is the cultivation of irrigated rice, through the drainage of areas, the use of pesticides and fertilizers, the removal of water for crops . In the scientific literature, there are few studies addressing the topic of anthropogenic impacts related to drainage channels in coastal Wet Areas (UAs) located in the south of Brazil and north of Uruguay. This work involves showing some impacts caused by the opening of drainage channels in AUs in different locations, which result in environmental impacts such as erosion processes, fires, changes in vegetation, degradation of wetlands, interventions in the dynamics of marine life, especially turtles. In summary, it is essential to adopt integrated and sustainable approaches to the management of AUs, considering the diverse impacts of human activities and interventions on the environment, to ensure the resilience and health of these areas in the long term.

Keywords: Drainage and irrigation channels, Andreoni Channel, Big Bath.

1 INTRODUCTION

Wetlands (UAs) are defined as lands with predominantly hydric soil, flooded or saturated by surface or groundwater at a frequency and duration sufficient to support vegetation adapted to saturated soil conditions (COVINGTON et al., 2003).

Historically, UAs were seen as sites of slimy swamps that harbored disease. This idea led to the drainage and conversion of these sites into areas of intensive agriculture, aquaculture, industry and housing. However, in recent years, there has been awareness that natural UAs perform important functions, such as mitigating floods, recharging aquifers and retaining pollutants. The number of countries that have adopted a policy of containing the destruction or degradation of AUs is significant, recognizing that these areas must be used sustainably, encouraging research that qualifies and quantifies their values, highlighting the importance of their preservation (EDWARD, MIKE and DUNCAN , 1997).

Regarding Brazilian AUs, there are still many divergences regarding the definition criteria which, in turn, compromise the processes for protection and sustainable management of these systems of great socio-environmental relevance (GOMES and MAGALHÃES, 2017).

One of the most important physical components of AUs is the soil. Through its depth, mineral composition, organic matter content, humidity regime, temperature regime and chemistry, it is possible to justify a greater or lesser incidence of the types of plants and species of organisms that adhere to the soil. For these and other reasons, it is essential that the soil is considered in the classification of AUs (COWARDIN et al., 1979).

Within the characteristics of Aus, Banhado is a typical name from Rio Grande do Sul with etymological terminology from the Spanish "bañado". Wetlands are formed where fresh water is dammed and flows slowly, and the water that supplies the wetlands comes from nearby water bodies, such as lakes, lagoons, rivers and/or the outcrops of the water table and rainfall (BURGER, 2000; CARVALHO and OZORIO, 2007).

As awareness of UA ecosystem services grows, so does public interest in their protection. Among the fundamental purposes of classifying AUs is improving the management of natural resources. By better understanding the functional attributes of each unit, society is more likely to manage its AUs to improve the management of these environments (BRISON, 2004; MITSCH and GOSSELINK, 2015).

Throughout history, many watercourses have undergone transformations to meet the demands for land and water use for agriculture and human supply. Of the changes established by the introduction of irrigated agriculture, the rectification of river channels and the drainage of wetlands sought to expand the cultivated area and allow for irrigation (BRENNER, 2021).

In both Uruguay and Rio Grande do Sul, the human action that most contributes to the degradation of wetlands is the cultivation of irrigated rice, through the drainage of areas, the use of pesticides and fertilizers, the withdrawal of water for crops and the return of these waters with waste to natural systems (BRASIL, 2002). In addition to destroying and fragmenting habitats, cultivation requires a significant volume of water for irrigation and the systematic use of fertilizers, insecticides and herbicides, substantially impacting natural ecosystems (DIAS and BURGER, 2005).

The drainage and irrigation works in Banhado Del Este in Rocha – Uruguay, date back to the first half of the century, in 1920, with the plan to "recover" land for agricultural purposes. From this perspective, plans and projects began to be drawn up with important water regulation and drainage works. This includes projects led, in the first instance, by the Uruguayan State (1930-1935) and Lagoa Mirim Commission (1967-1972). Thus, in 1979, by decree the drainage works of the wetlands of the department of Rocha for agricultural use were declared of national interest.In the period between 1979 and 1981, important drainage and irrigation works were carried out by the Uruguayan State (BARILANI, 2011).

The drainage process of AUs in Brazil, such as in the Coastal Plain of Rio Grande do Sul, occurred in a similar way to the neighboring country. Drainages intensified in the 1980s, with encouragement from the Federal Government, the National Program for the Use of Irrigated Floodplains - PROVÁRZEAS NACIONAL was created, with the purpose of promoting the rational and gradual use of national floodplain areas at rural property level, through of decree no. 86,146, of 1981 (BRASIL, 1981).

After the promulgation of the Federal Constitution, and the consecration of the Socio-Environmental Rule of Law, environmental legislation has evolved and strengthened over the years, aimed at due environmental protection (GASPERINI and REZENDE, 2020). However, the State itself throughout history has promoted works that impacted fragile environments such as Australia.

The appropriation of environments through human occupation results in a change in pre-existing dynamics (SILVA, 2019). The long-term alteration of natural resources has major impacts, such as drainage works in wetlands and AUs.

For Silva (2019), changes in natural environments carried out through artificial channels can promote changes in local dynamics and adjacencies and recognizing the behavior of these features is essential to understanding the changes throughout an entire basin, especially in areas downstream of the changes. and its repercussions on landscapes.

In southern Brazil, the Gravataí River has part of its sources in the AU known as Banhado Grande. This river underwent changes that began with the diversion of the channel at its mouth in 1955 (BOHRER, 2001). In the 1960s, the middle and upstream stretches of the Gravataí River underwent a rectification process, the initial objective of which was to drain the basin's humid areas for agricultural expansion and human supply. The rectification work was planned and carried out by the extinct National Department of Sanitation Works (DNOS), with no responsibility for the liabilities generated (BRENNER, 2021).

Still on the changes resulting from the opening of canals in AUs, the case of La Coronilha beach in Uruguay portrays the impacts of these works. With the aim of optimizing rice cultivation in the region and livestock farming, the canalization caused an adverse and irreversible impact that has continued over the years due to the artificial drainage of fresh water into the ocean, adding suspended material and agrochemicals (LEICHT, 2014) .

This study will address state-funded works in coastal AUs covering two different countries, Uruguay and Brazil. In Brazil, the canalization work on the Gravataí River in the Banhado Grande Environmental Protection Area (APABG) and the diversion of its mouth, changing its position from west to south; and in Uruguay the opening of the Andreoni drainage channel, in the Lagoa Mirim watershed, which flows into Praia da Coronilha.

In the scientific literature, there are few studies addressing the topic of anthropogenic impacts related to drainage channels in coastal AUs located in the south of Brazil and north of Uruguay. Such areas, according to Sell (2017), are located in the Pampa Atlântico. An eco province[1] constituted in the lowest and flatest portion of the Pampa, coinciding with the Coastal Plain of Rio Grande do Sul (TOMAZELLI and VILLWOCK, 2000). In this way, they have the same geomorphological formation and are similar in their natural characteristics.

Therefore, the aim is to identify environmental impacts and liabilities generated by these works. Since the State invests in short-term works that benefit society and, at the same time, impact the environment in the long term. With the advancement of environmental legislation and studies focused on this topic, the State can intervene to ensure the rational use of these environments, in addition to the possibility of their restoration, recovery, maintenance and preservation.

2 LOCALIZAÇÃO E CARACTERIZAÇÃO DA ÁREA DE ESTUDO

2.1 ARTIFICIAL CANAL - MOUTH OF THE GRAVATAÍ RIVER

According to Hanke et al., (2013), the flow of the Gravataí River into Guaíba in the 1940s occurred through a channel heading north. In the 1950s, a canal was opened leaving directly to the south, cutting the area called Humaitá into two parts: one the current Humaitá neighborhood and the other the Humaitá Island. With this work, the river began to flow into Saco do Cabral.

In the 1940s, with the extension of the urban fabric of Porto Alegre, work began on Cais Navegantes, continuing, in the north direction, with Cais Mauá. Starting at Largo da Conceição until Sertório Avenue, it was 2600 meters long. This work was only completed in 1955 during the construction of the Gravataí canal, which transformed the tip of the floodplain into Humaitá Island (BOHRER, 2011).

2.2 DNOS CHANNEL - BANHADO GRANDE

As described by Etchelar and Guaselli (2018), interventions resulting from agricultural activities in the Gravataí River Hydrographic Basin (BHRG) began in the 1960s, with the execution of a macro-drainage channel by the extinct National Department of Works and Sanitation (DNOS) . The work aimed to improve the flow conditions and drainage of the wetlands with the intention of expanding the rice production areas (DNOS, 1985).

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[1] Eco provinces, whose delimitations are important because they help to understand the limits of resilience of each landscape and, in the specific case of tourism, the attractive potential of each of them (SELL. 2017).

Another existing channel on this river is located in the Banhado Grande area and was built at the end of the 1960s by the surrounding farmers. This channel connects to the channel built by DNOS and was intended to rectify and drain the wetlands for agricultural expansion aimed at planting irrigated rice (ETCHELAR, 2014; BRENNER, 2016; BELLOLI, 2017 and SIMIONI, GUASSELLI and ETCHELAR, 2017) .

Banhado Grande is part of a Sustainable Use Conservation Unit, the Banhado Grande Environmental Protection Area (APABG), which was created in 1998 through State decree nº. 38,971. The central objective is to protect an area of permanent preservation represented by the wetlands present in the region and its important water regulatory function (Rio Grande do Sul, 2021).

2.3 ANDREONI CANAL – CORONILHA BEACH

According to Méndez (1991), the Andreoni canal is one of the canals built in the Lagoa Mirim Basin – Uruguay, with the purpose of conveying surplus waters from the lowlands located south of the Serra de São Miguel and the Lagoa Negra basin to the ocean. , on Coronilha beach, Figure 1.3. The aforementioned canal has existed since the 1920s, where its length was 3 km, then in 1959 there was an extension of 13 km and in 1965 the Andreoni canal connected with the Laguna Negra canal.

In the 1970s, the Andreoni canal collected the contribution of a network of canals built for the desiccation of AUs, which negatively affected the environmental quality of this area (SCARABINO, 2004).

However, it was the works carried out from the 1980s onwards, during the period of the military dictatorship in Uruguay, directed by General Abdón Raimúndez, which caused profound damage to the ecosystem by extending it to a total of 78 km (RUBIO, 2013).

Figure 1 - Location Map, 1.1. Canal da Foz do Rio Gravataí – Porto Alegre – Rio Grande do Sul - Brazil, 1.2. Banhado Grande – Glorinha – Rio Grande do Sul -Brasil e 1.3. Canal Andreoni, La Coronilha – Rocha – Uruguai.

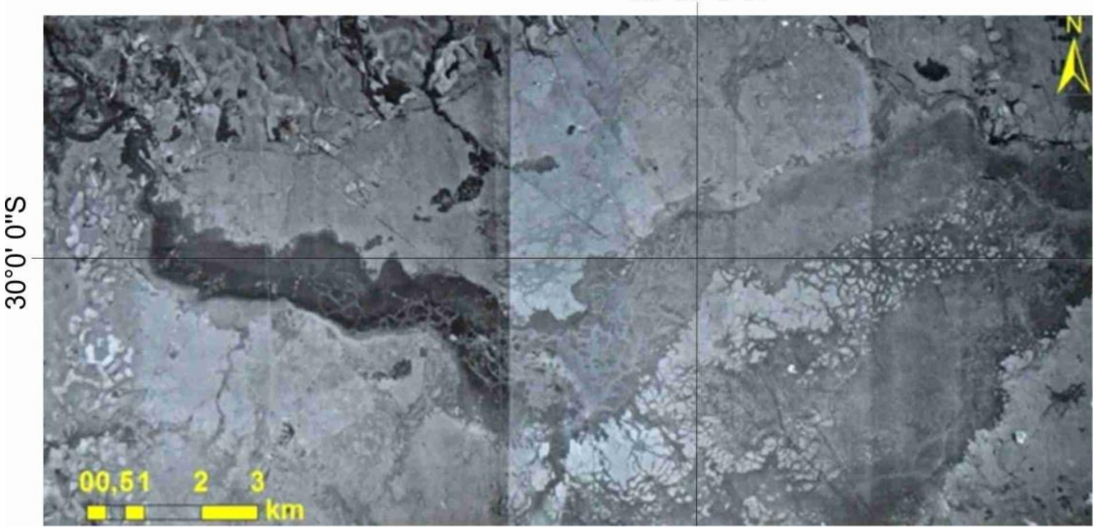
Source: Prepared by the author.

3 IMPACTS BY DRAINAGE CHANNELS

3.1 EROSION IN BANHADO GRANDE

Originally the Gravataí was a river with meandering features, which favored a low speed flow. Photograph in Figure 2, from 1960, illustrates a flooding event in the Gravataí River floodplain area, in darker tones. It is noteworthy that the floodplain is completely flooded and that the old meanders are connected by the flood event.

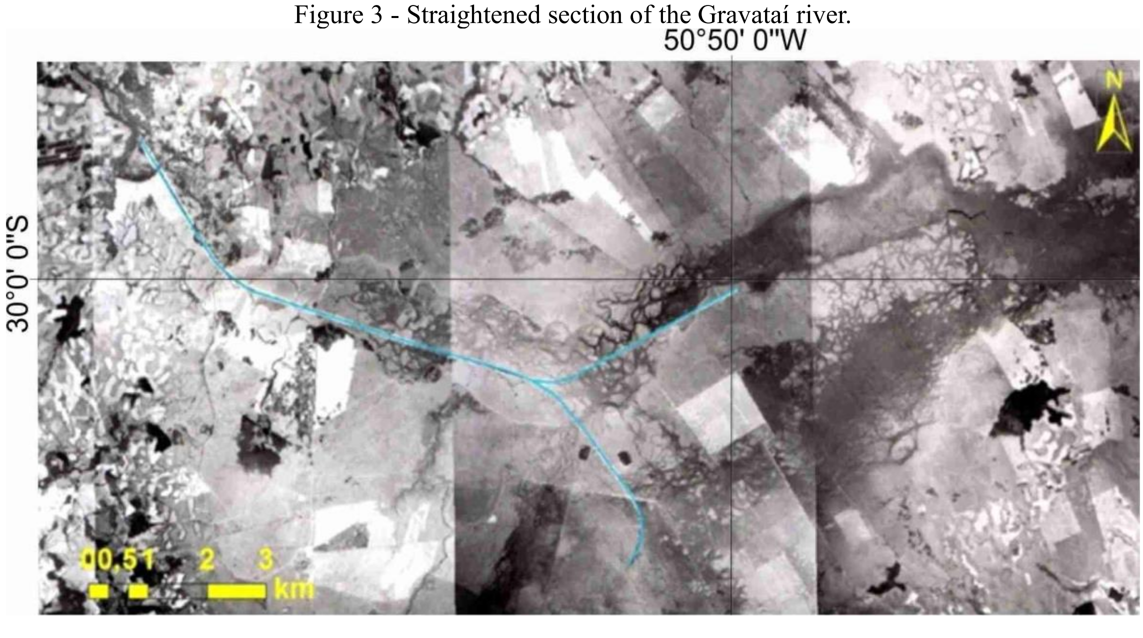
Figure 2 - Flooded area and connectivity of the old meanders of the Gravataí River floodplain.



Aerial photograph supposedly dating from the 1960s. Source: Image provided by - Association of former scholarship holders in Germany (AEBA). Belloli, 2016.

The 1975 aerial photograph (Figure 2) shows the straightened stretch of river. Highlight is the meander network, to the north of the straightened section, which is largely disconnected from the Gravataí River. In this section, the speed of the water becomes different in relation to the natural condition of the Gravataí River (BRENNER, 2016).

Figure 3 - Straightened section of the Gravataí river.

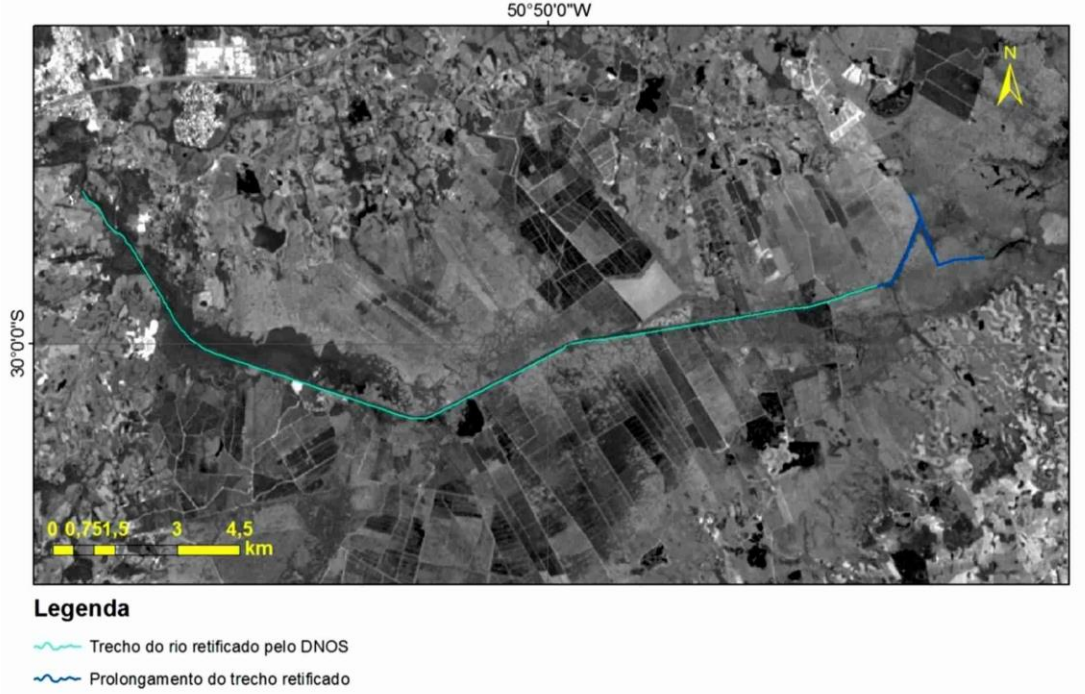


Source: Mosaic of georeferenced aerial photographs from 1975. Belloli, 2016.

The Landsat 8 satellite image from January 24, 2015, Figure 4, shows the enlargement of the straightened section to the east, highlighted in sky blue. According to Engineer Paulo Muller from the Gravataí Environment Foundation (FMMA), this expansion of the straightened section, next to Banhado Grande, was at the initiative of local rice producers, since works by the public sector had been suspended and were not had covered their production areas.

The work carried out by rice producers does not follow the original layout of the project, which provided for the execution of a main channel, straightening meanders in the upper course of the Gravataí river and entering the Banhado Grande for 35 km, to which two other secondary channels were connected. , totaling 66 km, whose objective was to "recover areas for agriculture". However, the project was not fully implemented, with 37.5 having been built.

Figure 4 - Expansion of the straightened section of the Gravataí river.



Source: Landsat 8 OLI sensor image from 01/24/2015. Belloli, 2016.

The presence of water erosion in Banhado Grande is directly associated with land use and occupation. The straightening of the Gravataí River and the expansion of the straightened section for irrigating rice crops increased surface runoff and consequently lowered the water table (BRENNER, 2017; BELLOLI, 2016). Once physical variables are disturbed by human activities, advanced processes of water erosion begin to be triggered, although the process is not common in wetland areas.

The physical characteristics of the groundwater flow (RUBBO, 2004) and periods of high precipitation that cause flood pulses (SIMIONI, GUASSELLI and ETCHELAR, 2017) become an agent with erosive potential, once the gully begins. It should be noted that, regardless of the precipitation regime, there is a permanent flow of water in the gully gutter, even during dry periods. The water table resurfaces at all times of the year, typical of wetland areas. As a result, there is a continuous dragging of sediments, where in periods of high precipitation the dragging of soil particles intensifies. The advancement of the gully may be associated with groundwater dynamics, as the flow of the water table inside the gully maintains continuous erosion of sediments (ETCHELAR, 2017). Figure 5, with an image of the gully erosion process in Banhado Grande.

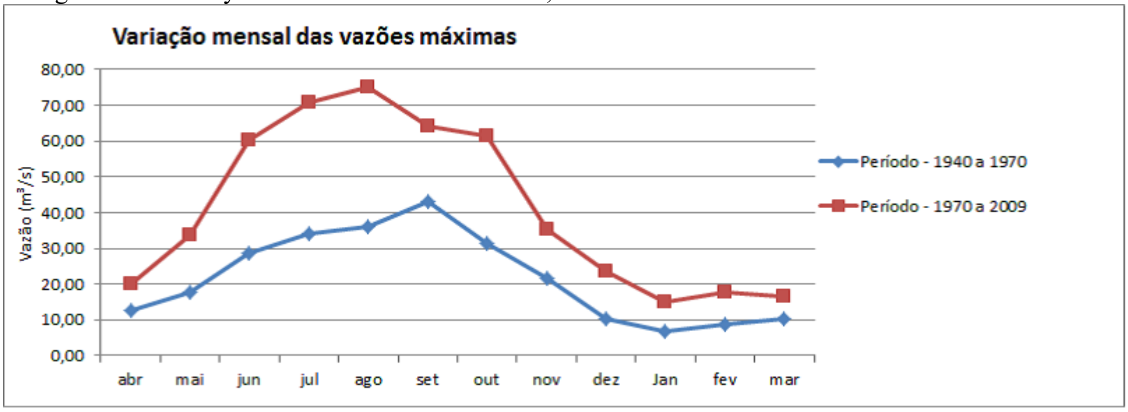
Figure 5 - Segment with the greatest widening of the gully in Banhado Grande.

Source: Cecilia Balsamo Etchelar, 06/28/2017, personal archive

According to Belloli (2016), the analysis of maximum monthly flows Figure 6, between the years 1940-2009, shows a large increase in flow values, especially between the months with the highest precipitation in the basin (June to October). The maximum flow recorded from the years 1940-1970 for the pre-rectification period was 42.89 m³/s, in the month of September and the minimum flow was 6.27 m³/s in the month of January. In the post-rectification period, from 1970-2009, the maximum flow recorded was 74.93 m³/s in September and the minimum was recorded in January, with 15m³/s.

According to the author, the amplitude between the month with the lowest maximum flow (January) and the month with the highest maximum flow (September) was 36.62m³/s. In the post-rectification period, the amplitude between the month with the lowest maximum flow (January) and the month with the highest maximum flow (August) was greater, 59.93m³/s.

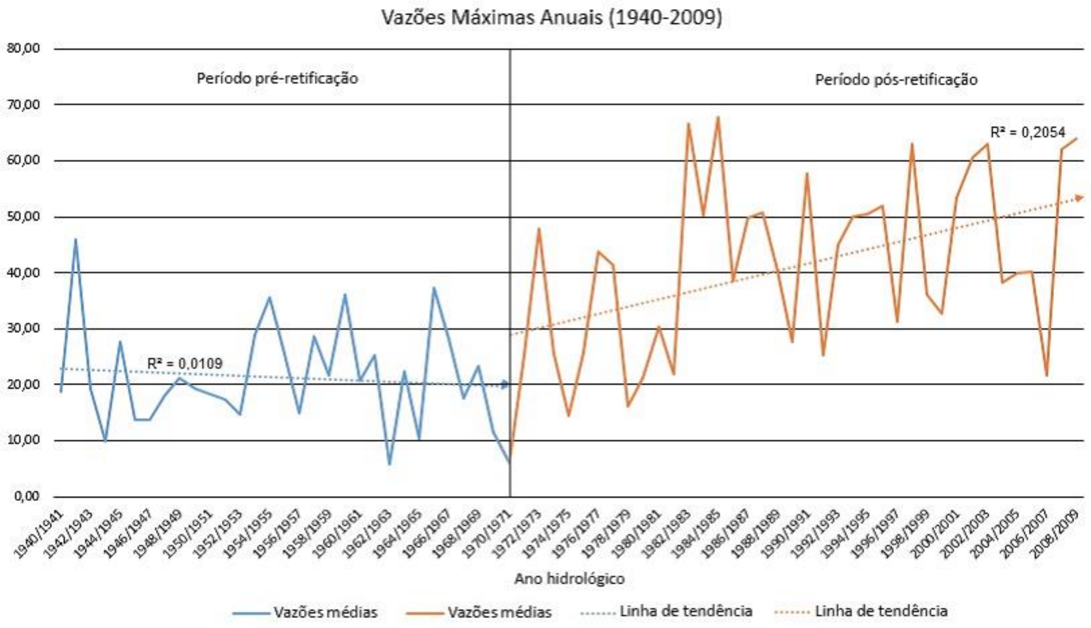
Figure 6 - Monthly variation in maximum flows, before and after rectification of the Gravataí River.



Source: Belloli, 2016.

The analysis of maximum annual flows (Figure 7), according to Brenner (2016), shows a tendency for flow values to increase in the post-rectification period. Maximum flows increased due to the ease of flow provided by rectification, as the course of the river previously circulated a pattern of curves that dampened and reduced the flow speed and with rectification the straight course favored an increase in water flow speed. The highest value of annual flow found refers to the hydrological year 1984/1985 with 68.51 m³/s, while the lowest value in the series of maximum flows was found in the hydrological year 2006/2007 with 21.28 m³/s .

Figure 7 - Maximum Annual Flows for the period 1940-2009.



Source: Brenner, 2017.

The analysis of flow patterns makes it possible to prove the increase in flows after the straightening of the Gravataí River. To the extent that the initial objective of DNOS in rectifying the Gravataí River was precisely to increase the speed of water flow and drainage of the Banhado Grande, we can affirm that this intervention has faithfully fulfilled its creation objectives (BRENNER, 2016).

Also according to Brenner (2017), when analyzing the standard behavior of flows on a longer time scale (69 years), an increase in flows after the rectification of the Gravataí River is confirmed. Such an extreme variation in flow rates gives rise to the need to rethink the route of the rectified course of the Gravataí. The straight section further favors accelerated flow from upstream to downstream, preventing the Banhado Grande from fulfilling its function as a “sponge” basin, by absorbing large peaks of rainfall and releasing water slowly and gradually.

Some considerations in the report prepared by a working group designated to evaluate the environmental impacts resulting from drainage works in the Banhado Grande (LUSCOSA, 1979) mentioned the increase in flooding downstream of the river, after the start of drainage works, and predicted consequences in long term, such as more drastic changes in the landscape, such as: the intensification of secondary drainage for rice farming and the use of pesticides and fertilizers, predictions that have become reality.

Another relevant factor in erodibility processes concerns pedology. Etchelar (2014), collected soil samples in January 2014 at coordinates 29° 58' 29.65" S and 50°44'19.71", inside the gully. These samples were analyzed at the Center for Coastal and Oceanic Geology Studies (CECO), at the Federal University of Rio Grande do Sul, through the PANICOM/SAG program. This granulometric analysis made it possible to verify the percentages of Sand, Silt and Clay in each horizon of the profile.

Through the granulometric analysis of the soil (Table 2), in the horizons exposed on the slope of the gully, it indicates the first three samples of the profile, ordering from top to base, a predominance of sandy soil. The fourth sample demonstrates a large percentage of clay, in this horizon the base level of the gully is reached. It can be said that, as it has a more sandy particle size fraction, this type of soil would be more susceptible to the action of erosive processes, which justifies the erosive process reaching the base level, when it reaches the horizon called clay-silt-sandy (ETCHELAR, 2014).

Table 2 - Particle size analysis of the gully soil

	Sample 01 Arenosilteargiloso	**Sample 02** Arenoargilosiltoso	**Sample 03** Arenoargilosiltoso	**Sample 04** Argilosilearenoso
Sand	63,96%	74,80%	52,24%	16,75%
Silt	29,87%	10,39%	18,11%	22,61%
Clay	6,16%	14,80%	29,63%	60,62%

Source: Etchelar (2014).

Once the gully-shaped erosion process has begun, soil particle size samples in the wetland area indicate greater susceptibility to erosion processes in the first three horizons that have a higher percentage of sand, unlike the fourth horizon, corresponding to the fourth sample that contains the highest index. of clay and indicative of the base level of the gully. When the verticalization of erosion inside the gully reaches the base level, the gully tends to evolve towards the horizontalization of this erosion process (ETCHELAR, 2014).

For Etchelar (2014), another important factor that leads to the formation of gullies is through erosion caused by subsurface flow, which gives rise to ducts, pipings or pipes. Gullies have steep side walls and, in general, a flat bottom, with water flowing inside them during rainy periods. By deepening their channels, gullies reach the water table and constitute a process of accelerated erosion and instability in landscapes (SUERTEGARAY et al., 2008). This type of erosion process called ducts or pipings, are channels in the form of tunnels carved into the subsurface, with great oscillation in size and extension, with diameters varying from a few centimeters to several meters.

The flow of water that percolates through these pipes transports large quantities of material into the subsurface. As this material is removed, the river channel in the straightened section increases, which could result in the collapse of the soil above. Thus, leading to a significant evolution of a gully (SUERTEGARAY et al., 2008).

Erosion in tunnels occurs under the effect of surface and subsurface runoff water, which penetrates biogenic holes or cracks of different origins. If the water reaches the tunnel via a subsurface route, the forces and factors that act on erosion due to leakage predominate; If water originates from surface flows, turbulent flows predominate, thus, erosion by pipelines constitutes an excellent example of interaction between different fundamental mechanisms that can generate erosive features (GUERRA et al., 1999).

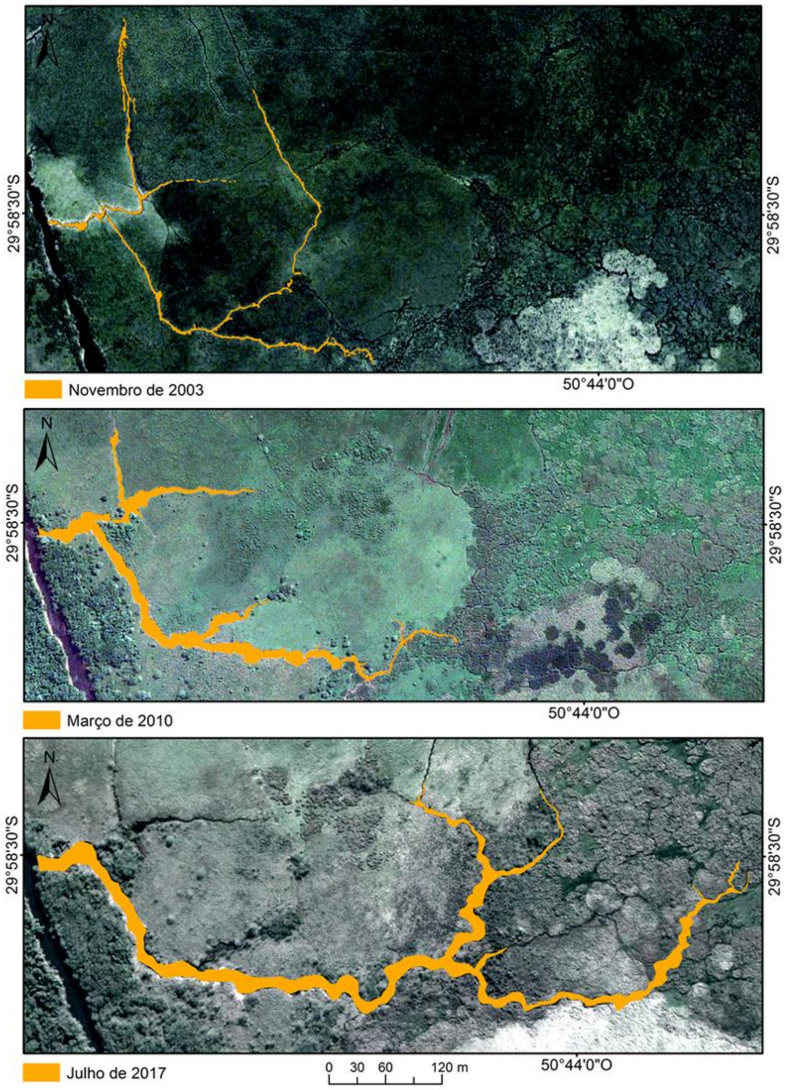
These subsurface erosion processes were identified in the wetland area, both on the slopes of the gully and on the slopes of the straightened section, as we can see a pipeline with water flow in Figure 8.

Figure 8 - Presence of an active pipeline with water flow on the riverbank, in the straightened section.

Source. Cecilia Balsamo Etchelar, 08/17/2018, personal archive.

The mapping of the gully, Figure 9, highlights the advancement of the erosion process, as well as the stabilization of erosion in some points. This fact may be associated with the advancement of shrub vegetation, identified in the field as a phytophysiognomy with a predominance of Maricás (Mimosa bimucronata), which developed in the area surrounding the erosion process. The stabilization of part of the erosion can be observed to the north, in images from 2003 and 2010. The time series of images shows the existence of an intense process of lateral widening of the gully, in addition to the process of remounting erosion, towards the interior of Banhado Grande, as shown in the 2017 image.

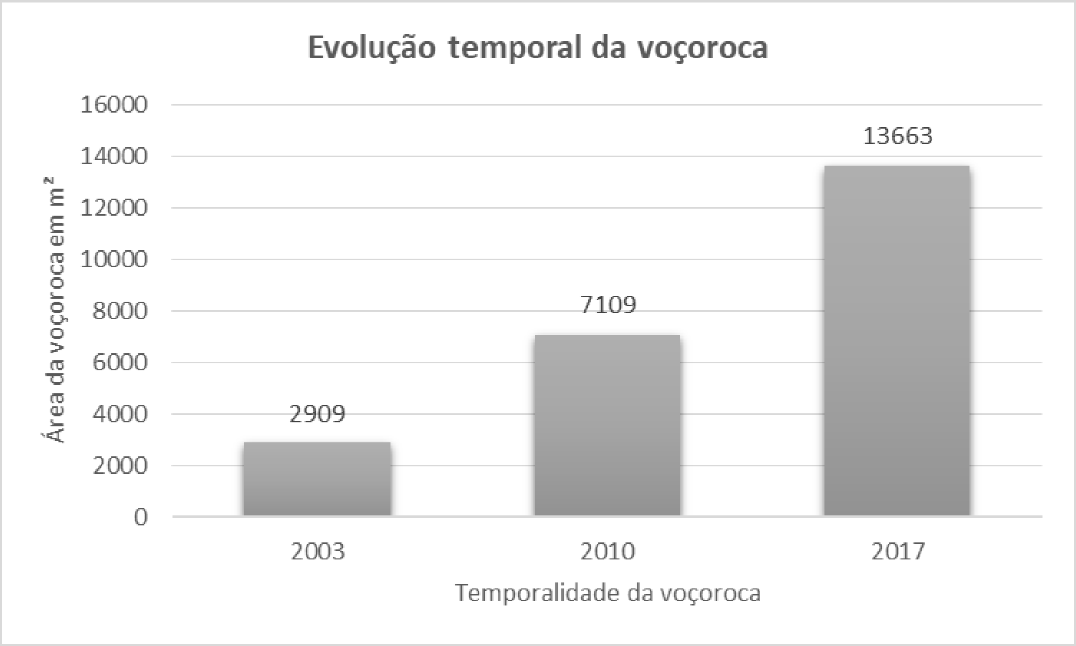
Figure 9 - Mapping of the temporal advance of the gully in Banhado Grande.



Elaboration: Etchelar and Guasselli (2018) based on images from 2003 and 2010, referring to the Google Earth image mosaic. Image from 2017, ARCGIS base map.

The time series of Google Earth images, in the analysis of the gully's features, made it possible to map and quantify the dynamics of the evolution of its erosion process. The eroded area increased from 2,909 m² in 2003 to 13,663 m² in 2017, Figure 10.

Figure 10 - Temporal evolution of the gully.



Source: Etchelar and Guasselli (2018).

According to Augustin and Aranha (2006), for a channel to evolve into a gully, the necessary condition is, in addition to erosion, the presence of a set of processes, including soil undermining and pipelines. These destabilize the walls and head of the channel, causing its widening and its evolution upstream, characterizing a gully.

Gully-shaped erosion in Banhado Grande and erosion in the straightened section cause negative environmental impacts of significant importance in this important and fragile ecosystem. Variables that cause environmental imbalance include: the lowering of the water table associated with the increase in flow and water drainage from the wetland towards the floodplain, the loss of soil and the silting of the river. There is also the possibility of access by hunters, from the gully, which becomes an access route to the interior of the marsh, as the place serves as a refuge for a great diversity of native and migratory fauna (ETCHELAR, 2017).

Through the visual interpretation of images for a time scale of the years 2003, 2012 and 2019, Figure 11, the impact that the gully causes on the typical vegetation of the wetland is identified. In the section upstream of the gully in the image: a) corresponding to the year 2003, when there is no presence of the erosion process; b) dated in 2012, the evolution of the gully and the retreat of vegetation can already be seen. In 2019: c) the gully reaches a stage that isolates part of the vegetation, leading to its replacement by another type of vegetation.

Figure 11 - Temporal analysis of a gully area in Banhado Grande where the conversion of vegetation type is observed as a result of gully expansion.

Elaboration: Etchelar (2020).

This vegetation is a species of large size, up to approximately 2 m in height, predominantly formed by Scirpus Giganteus, known as Tiririca or Palhão, Figure 12. The importance of these aquatic macrophytes is related to their metabolic activity, which develops micro- organisms associated in the collaboration of water purification by oxidizing the organic matter it contains (FZB, 1983).

Figure 12 - Highlighted in the image, the Scirpus Giganteus vegetation in the Banhado Grande area.

Source: Cecilia Balsamo Etchelar, June 25, 2015.

In addition to the damage to the water balance, the erosion processes triggered by the drainage dynamics of wetlands can drastically alter the vegetation adapted to the conditions of hydromorphic soils. For FZB (1983), the richness of the submerged vegetation in the wetlands provides the maintenance of inocula that will feed the river. If the base of the food chain, made up of these synthetic vegetables, capable of producing organic matter, is not maintained, the other components of the system will be threatened, such as: fish, amphibians, crustaceans, molluscs, insects and other consumers.

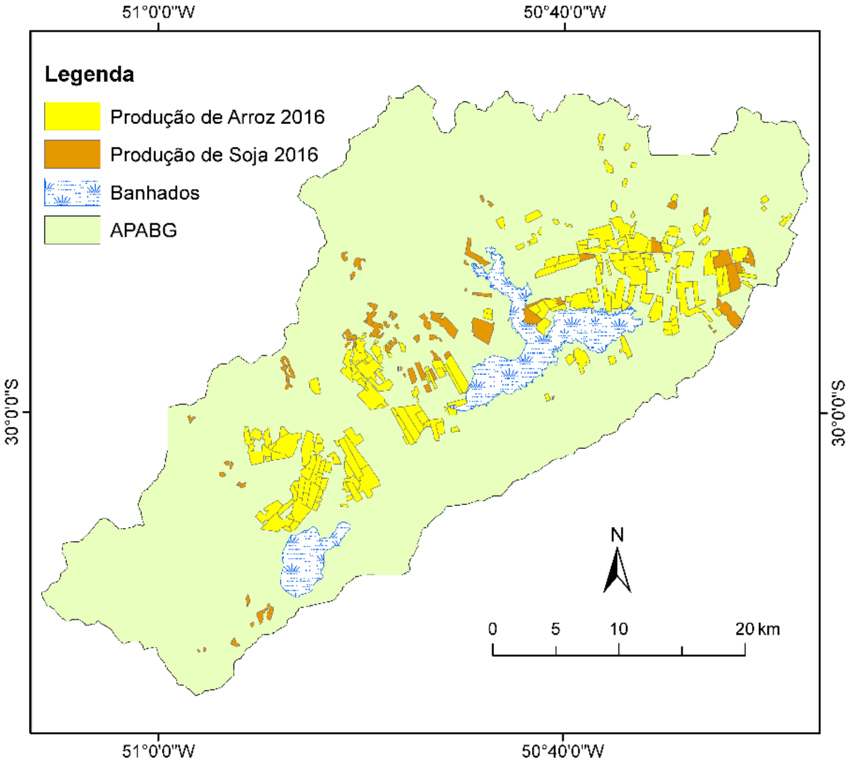
Wetlands have high nutrient availability and high vegetative/food production, but are highly vulnerable to drainage, landfills and rectification. Surely, because these cause changes in soil humidity that reflect on vegetation; since the fauna is dependent on it for refuge, shelter and food, both outside and inside the water (FZB, 1983).

3.2 RICE AND SOYBEAN PRODUCTION IN APABG WETLANDS

In APABG, irrigated rice cultivation predominates in the flat areas next to the Gravataí River. According to Mertz (2002), the first large irrigated rice field in the Metropolitan Region of Porto Alegre was established in the municipality of Gravataí, in 1905. Rice production is, traditionally, the main temporary cycle agricultural production, due to the topographic, hydrological and pedology in the area. More recently, soybean cultivation was inserted into the agricultural rotation cycle, occupying representative areas.

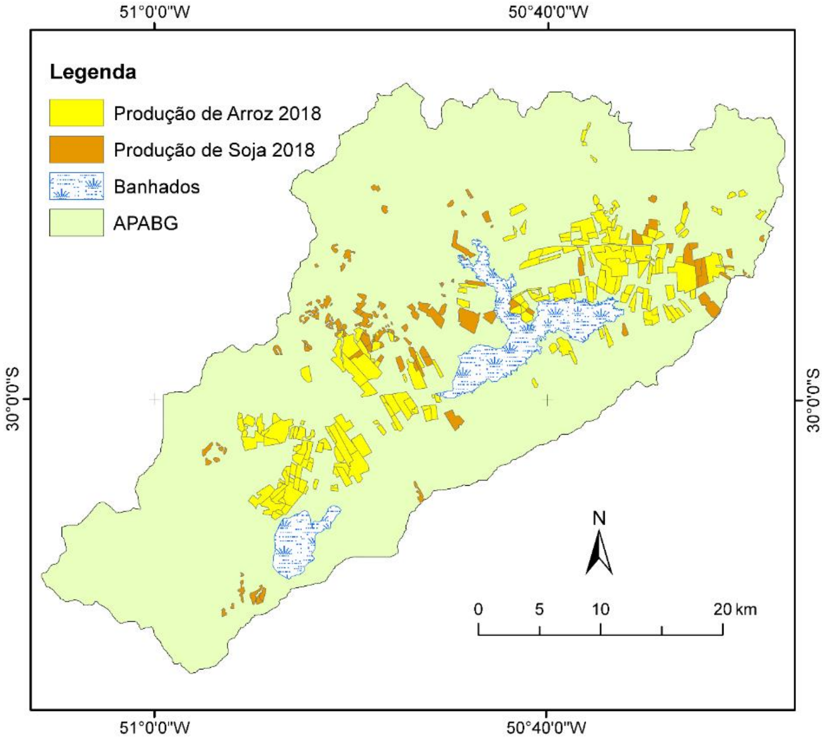
According to the mapping of rice and soybean production at APABG, Figures 13, 14 and 15, rice production decreased by 852.69 ha between the 2016, 2018 and 2020 harvests, while soybean production increased by 2,722.36 ha in the same period, demonstrating that the increase in soybeans is not equivalent to the decrease in rice area. This does not show an inversion of culture in the area, but rather an increase in agricultural production in the same area that is probably used for rotation and fallow areas.

Figure 13 - Mapping of the 2016 rice and soybean harvest in the APABG area.



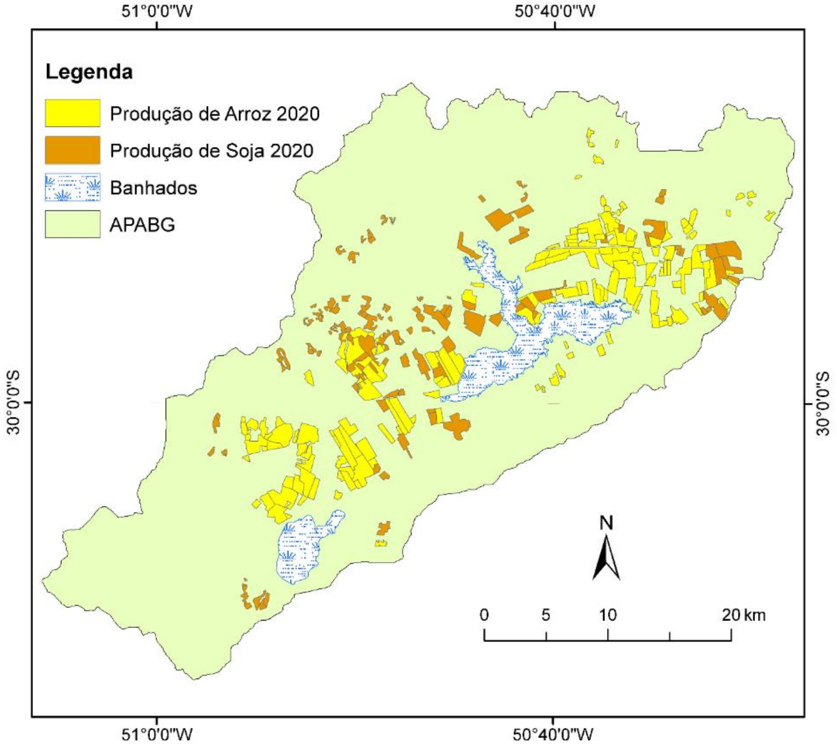
Prepared: Etchelar (2022) Source: Belloli and Etchelar (2020)

Figure 14 - Mapping of the 2018 rice and soybean harvest in the APABG area.



Prepared: Etchelar (2022) Source: Belloli and Etchelar (2020).

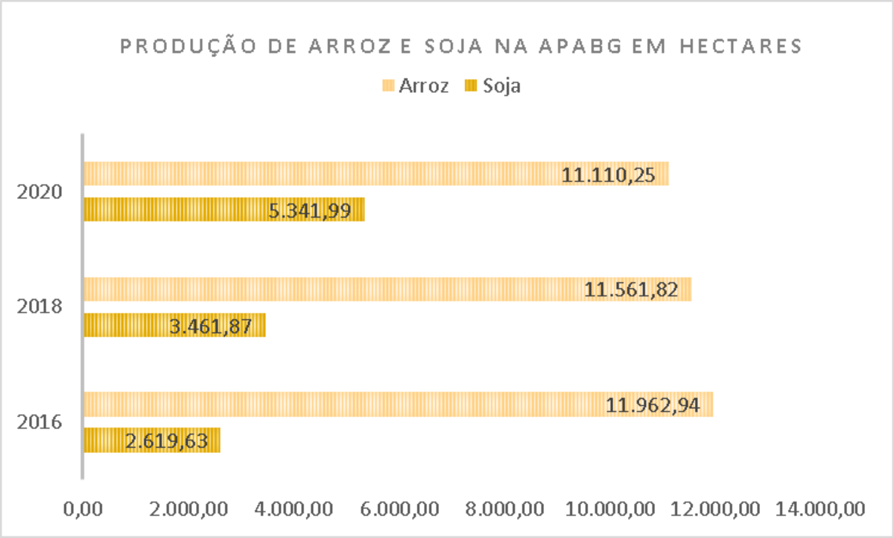
Figure 15 - Mapping of the 2020 rice and soybean harvest in the APABG area.



Prepared: Etchelar (2022) Source: Belloli and Etchelar (2020).

We noticed the increase in soybean cultivation in APABG in the mapping presented in the previous figures, which are highlighted in orange. However, when we transfer this data to the graph, Figure 16, we can see the progression of soybean production and a small decrease in rice cultivation.

Figure 16 - Production of rice and soybeans at APABG in the years 2016, 2018 and 2020.



Prepared: Etchelar, 2022.

3.3 FIRES IN BANHADO GRANDE

Ecosystems and society must be better prepared for the new scenario of extreme fires. Climate change is the present and the future and it is urgent to take adaptation and mitigation measures to reduce the expected impacts (Hernández, 2020).

In April 2020, a large fire impacted Banhado Grande, as seen in Figure 17. One of the difficulties encountered in controlling this fire, in addition to difficult access, were the several fires that occurred in the subsurface in peat deposits. Peatlands have not yet been studied according to Accordi et al. (2003)

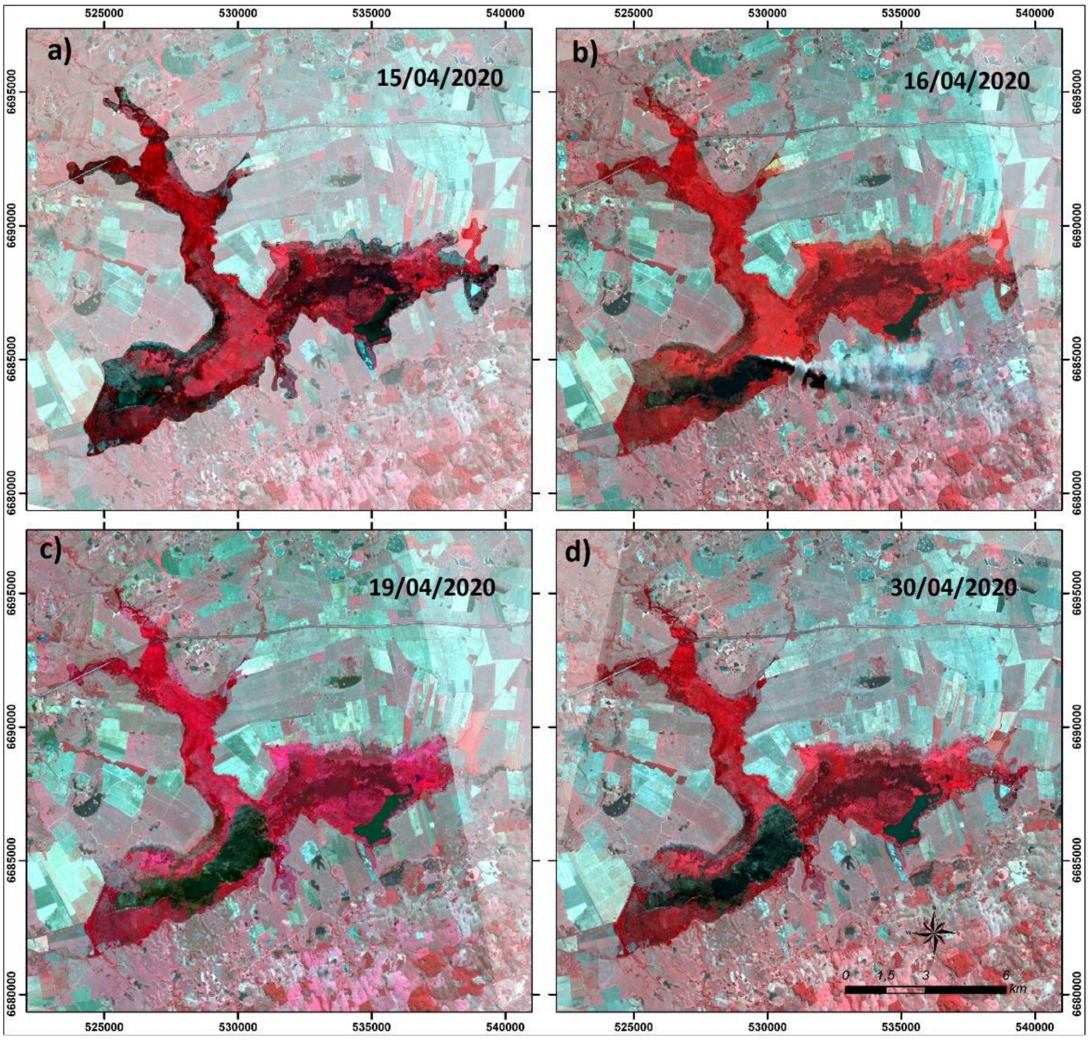
.Figure 17 - Vegetation burning at APABG in April 2020.

Source: Banhado Grande APA Collection. Photo: Cecília S. Nin (2020).

The APABG AUs are home to the two largest peat bog areas in the Coastal Plain and a paleo-environmental archive with a geological history of more than two billion years that is intertwined with the history of the formation of the continent itself and, particularly, the events that formed the continent. Atlantic coast of South America (ACCORDI et al., 2003).

According to Simioni (2021), the fire devastated approximately 12% of the total area of the wetland, where the areas with the presence of emerging vegetation were the most devastated. Through Planet Scope images, we observed that in Figure 18a, on 04/15/2020 the fire had not yet reached the emerging plants. On 04/16/2020, the image captured the advance of the fire over the emerging plants, Figure 18b, shows that the fire had consumed more than 60% of the area with the occurrence of emerging plants. The image from 04/19/2020, Figure 18c, shows that the surface fire had been controlled in the area of emerging vegetation, with the work of firefighters and volunteers and also the presence of a water body that prevented the fire from advancing to the east and southwest arms of the BG. However, although the surface fire was controlled, the so-called underground fire continued, with the burning of peat, which lasted until the end of April, when the fire was completely controlled, Figure 18d.

Figure 18 - Temporal variation of the area burned by fire in Banhado Grande.



Source: Planetscope image, RGB 432 bands. Prepared: SIMIONI, 2021.

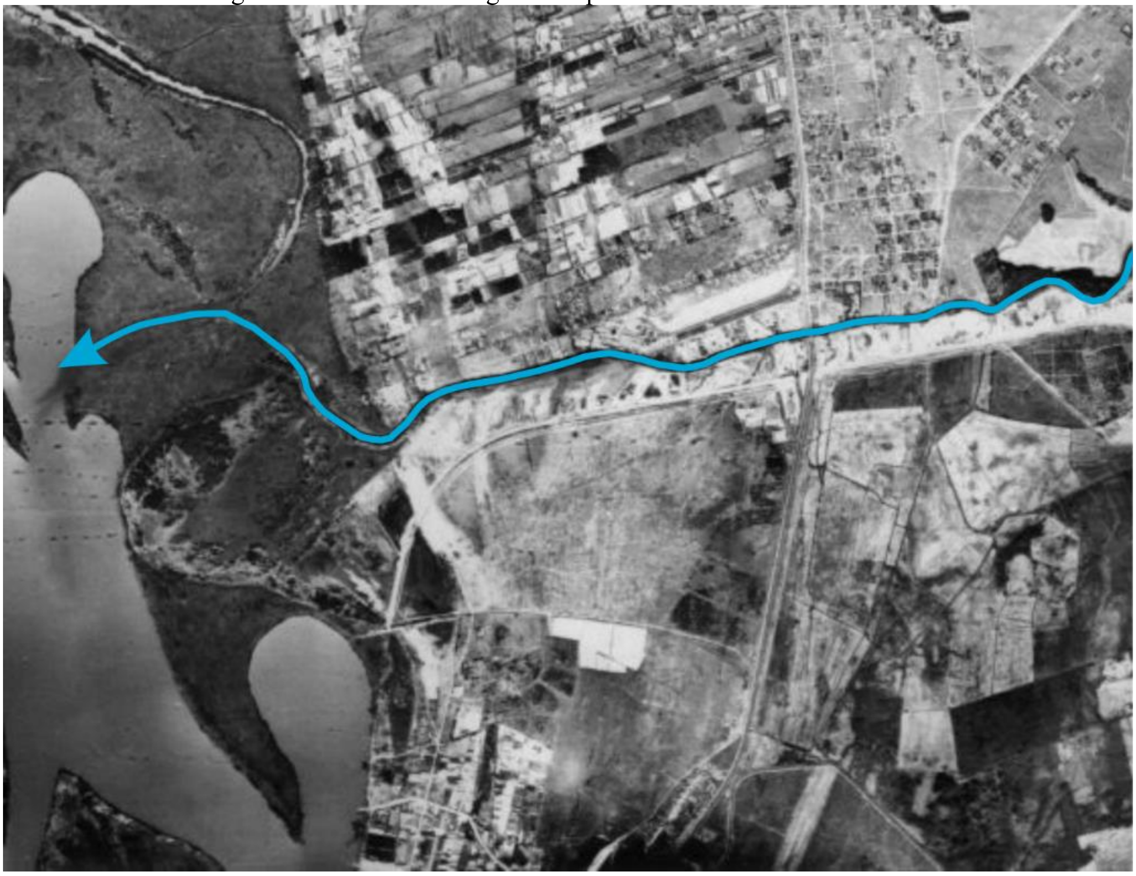
The lack of precipitation during this period was another major aggravating factor in the fire situation. From January to April 2020, rainfall levels were well below the monthly averages, with the months of March (12.2 mm of rainfall) and April (13.2 mm of rainfall) coinciding with the growth of the COVID pandemic -19, further aggravating the need for water for the municipalities supplied by this water source – at a time of emergency in terms of sanitation and public health (VERDUM and VIEIRA, 2020).

3.4 MOUTH OF THE GRAVATAÍ RIVER

The 1950s period in Porto Alegre was marked by urban growth, which took on a very rapid pace, with the construction of commercial buildings, the installation of the railway that connects Porto Alegre to São Leopoldo and the construction of the new Cais do Porto, with the embankment of an extensive strip between Avenida Voluntários da Pátria and Lake Guaíba. Landfills are established as alterations caused by human action, in the form of borrow areas (DIAS, 2011).

According to a work presented by Hanke et al., (2013), we must analyze the consequences of a rectification work carried out in the 1950s, at the mouth of the Gravataí river, which caused problems and changes in the functioning of the entire river basin, as Before this work, the Gravataí River flowed into Guaíba through a channel heading north/west, next to the stream in the Jacuí delta, as seen in Figure 19.

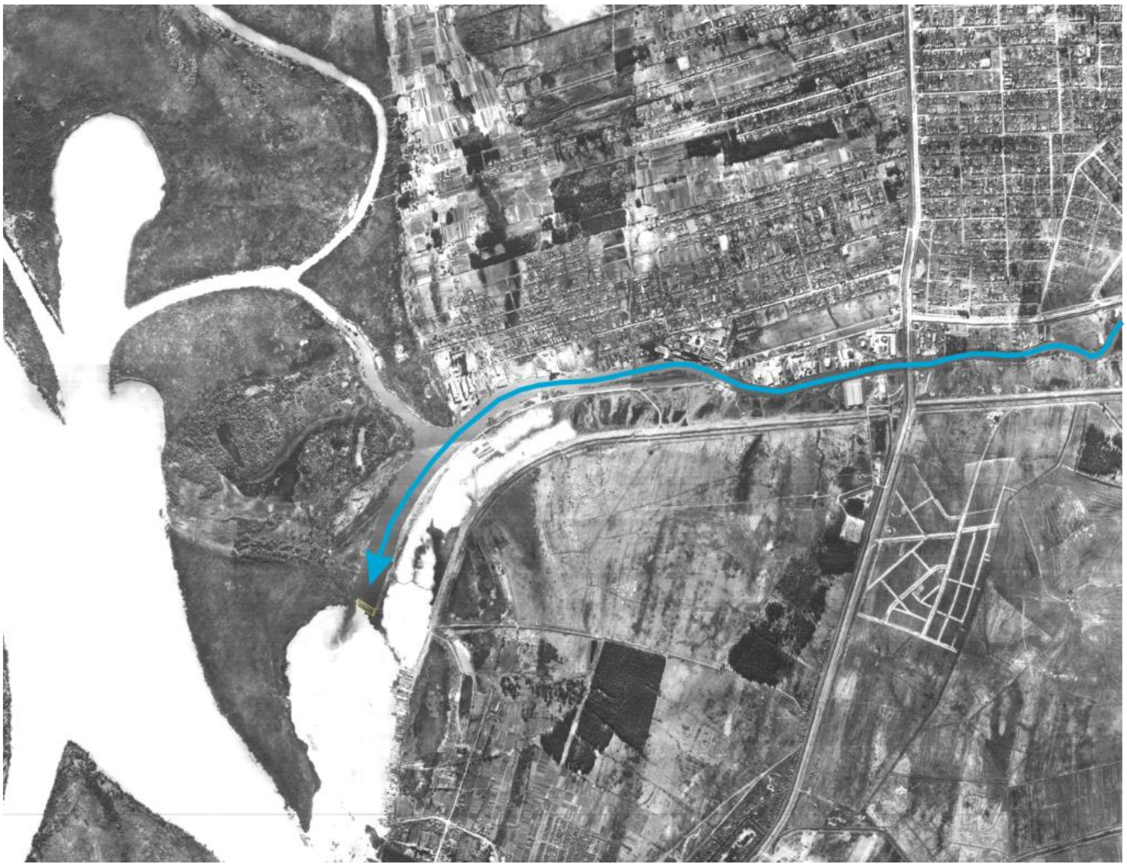
Figure 19 - Historical image of the preserved Gravataí river mouth.



Source: Image without defined date, HANKE et al., (2013). Prepared by the author.

In Figure 20, from 1956, we can see the opening of the canal leaving directly to the south, cutting through the area called Humaitá, where the river started to flow into Saco do Cabral. In Figure 21, we detail that the canal in 1956 was not yet fully open. In Figure 22 we see the fully consolidated channel with its darker waters of the Gravataí River meeting the lighter waters of the Jacuí River.

Figure 20 - Image from 1956 that shows the incomplete opening of the channel that changes the mouth of the Gravataí river.



Source: Aerosurvey of 1956 1: 2000. Coordination of Geoprocessing and Urban Information – CGIU, Municipal Secretariat for the Environment and Sustainability – SMAMS. Prepared by the author.

Figure 21 – Detail of the incomplete opening of the channel in the 1956 image.

Source: Aerosurvey of 1956 1: 2000. Coordination of Geoprocessing and Urban Information – CGIU, Municipal Secretariat for the Environment and Sustainability – SMAMS. Prepared by the author.

Figure 22 - Satellite image showing the current condition of the channel at the mouth of the Gravataí river.

Source: Image from August 5, 2022 from Google Earth Pro. Prepared by the author.

3.5 CANAL ANDREONI

3.5.1 Impact on the beach

In October 2019, with a large amount of plant debris that was coming out with the fresh water from the Andreoni channel added to the oceanic algae, it formed a kind of very dense blanket that did not allow the turtles to swim, and caused them to rush into this vegetation (Figure 23). A similar phenomenon had already been recorded in 2012 and in 2016. The rescue was carried out in the Coronilla beach area (Figure 24), where there is a rehabilitation center that cleaned, hydrated and checked the physical conditions. Fortunately, this action managed to rescue all the turtles alive (URUGUAY VISIÓN MARÍTIMNA, 2019).

Figure 23 - Typical wetland vegetation on the edge of Coronilha beach – Uruguay.

Source: elpais.com.uy (2019).

Figure 24 - Turtles rescued on the edge of Coronilha beach – Uruguay after becoming trapped in vegetation coming from the AUS mixed with algae.

Source: Uruguay maritime vision, (2019).

3.5.2 Erosion of the Andreoni channel

The temporal evolution of the stretch of the Andreoni channel, next to Coronilha beach, shows a progressive widening in this section demarcated by the red line in Figures 25 and 26. Between the years 2002 and 2018, it increased from 43.8 m to 61.5 m , resulting in a widening of 17.7 m over a period of 16 years.

Figure 25 - Satellite image of July 7, 2002 – Representation in the red line of the width of 43.8 m in this section of the Andreoni channel next to Coronilha beach – Uruguay.

Source: Google Earth Pro image. Prepared by the author.

Figure 26 - Satellite image of March 22, 2018 – Representation in the red line of the width of 61.5 m in this section of the Andreoni channel next to Coronilha beach – Uruguay.

Source: Google Earth Pro image. Prepared by the author.

4 FINAL CONSIDERATIONS

The study of the works on the Gravataí River drainage channel at APABG and the Andreoni drainage channel in the Lagoa Mirim Basin – Uruguay, together with the change in direction of the mouth of the Gravataí River in the 1950s, reveals significant impacts on urban areas (AUs) and agricultural areas of these regions.

Canalization and drainage interventions alter the natural course of rivers, affect local topography and drainage, and influence the environmental conditions of surrounding urban areas. The change in the direction of the mouth of the Gravataí River may have disturbed natural water flow patterns, impacting local ecosystems and communities dependent on them.

The mapping of areas of agricultural use for crops such as rice and soybeans in APAGB and in the Lagoa Mirim hydrographic basin highlights the pressure exerted on these areas for agricultural purposes, and the increase in soybean production around the wetlands, which may have implications significant environmental impacts, such as loss of natural habitat and soil degradation. As well as the increase in fires and the destruction of the natural vegetation of this environment.

The canalization of the Gravataí River triggered major erosion processes in the Banhado Grande area in the long term. The impacts caused by the Andreoni channel on Coronilla beach in Uriguay are similar in terms of erosion to those that occurred on the Gravataí River, in addition to causing a major impact on the beach line with the deposits of waste from the wetland on marine life, such as turtles.

In summary, it is essential to adopt integrated and sustainable approaches to the management of AUs, considering the diverse impacts of human activities and interventions on the environment, to ensure the resilience and health of these areas in the long term.

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