Geoprocessing tools to temporal analysis of size variation of the Paraná River islands in Sao Paulo, Mato Grosso do Sul and Paraná Border

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Abstract

To navigate the Parana River, between the states of Sao Paulo and Mato Grosso do Sul, it was common to find islands in most of the route. These were formed by the accumulation of sediment deposited by water at certain points, over thousands of years. Nowadays, some small islands in some of the local reservoirs are left, especially in areas farther upstream, near the beginning of the impoundment of the river. This study aimed at evaluating the changes in size occurred on the islands in the Parana River, from 1984 to 2001 using geoprocessing tolls. The results enabled to observe that most of the assessed islands had variations in the size or shape.

Key words: geoprocessing; islands; Parana river.

Introduction

It is usual find islands navigating on Parana River, between the states of Sao Paulo and Mato Grosso do Sul. These islands were formed by the accumulation of sediment deposited by water at certain places, over thousands of years. However, from the decades of 60 and 70, with the beginning of the projects of construction of dams for electric power generation in this river, the islands began to disappear. The majority was simply coverage by accumulated water in the reservoirs, and some by erosion caused by the release of large volumes of water with the opening of floodgates.

Nowadays there are some small islands in some of the local reservoirs, especially in areas farther upstream, near the beginning of the impoundment of the river. Moreover, there are also some islands throughout the Municipal District of Rosana, Brazil, where the Parana River has one of a few stretches of running water in the State of Sao Paulo. This running water and the river bed similar to the natural course didn't prevent, however, that the islands of the area face serious problems, mainly from erosion and silting. Moreover, the material used in the construction of the dam's hydroelectric Sergio Mota, located in the Municipal District has accumulated in the river bed and now when added to the material brought by tributaries of Parana, mainly from erosion and silting from some islands, it is generating a process of creating new islands.

Souza Filho et al. (2001) said that after the conclusion of the Porto Primavera dam and its tank at the end of 1998 there were significant changes in the dynamics of the high current of the river Parana.

Hayakawa (2007) says that nowadays the load of sediment in suspension portion of running water in the Parana River - area examined in this study - is not very significant. But he stresses that the movement of sediment from the bed of the river still exists, which has caused changes in the location of banks of sand in the river bed.

For the analysis of these issues Brites et al. (1998) recommended the use of geoprocessing, because it is becoming an important tool for the implementation of projects related to the area of environment. This is because the vast areas normally covered by these projects, and the large number of variables requested by them, are using the geoprocessing as the primary resource for the handling of large databases involved in them.

As New (1992) data from remote sensing have wide application in quantitative description of basins and drainage networks. Thus, a number of morphometric studies, first made from data taken from topographic charts, began to be made on the basis of data from remote sensing, or on the images collected by remote sensors.

According to Pinto (1991) the use of orbital images obtained through Landsat has been intensified while their potential application in different themes

has been demonstrated and concrete results were achieved. The best results have been found in the targets of discrimination that occur on the surface, for surveys and environmental monitoring, highlighting to the orbital images for their spectral characteristics and its repetitiveness

This work was developed seeking to quantify the impact of changes on the islands in the Parana River, from 1984 to 2001, mainly on their shapes and sizes. Identified and located new islands that are being formed in areas of intense silting.

Materials and methods

The materials used in the development of the work were:

- A satellite image Landsat 5 - Thematic Mapper of September 29, 1984;
- A satellite image of the Landsat 7 - Enhanced Thematic Mapper of August 19, 2001;
- Computer equipment (computer, printer ...);
- A unit of the GPS receptor ;
- A boat equipped with engine;
- Materials of office and field;
- Applications for texts editing, images treatment and Geographic Information System (GIS) Idrisi for Windows 32.

Methodology

The work consisted of georreferencia of satellite images from 1984 to 2001 in Idrisi application for Windows. Then the georreferenciadas images were analyzed and compared, seeking to identify the changes in the islands in the period to obtain the two images. At the same time, historical documents concerning the case of occupancy for Regional attempt were sought to understand the factors that generate the current situation.

Each island of the studied area was visited by at least three different times to examine the possible changes resulting from periods of flood, drought and normal flow of the river. It's important to stress that the two images, both of 1984 as of 2001 were obtained in a period of drought in the region studied.

In mailings to the study of the islands, it was noted information concerning to the processes of erosion, silting, characteristics of water, soil, vegetation, fauna and other anthropogenic changes.

Results and discussion

Analysis of satellite images

In the satellite image of 1984 (Figure 1) you can see the beginning of the construction of the Porto Primavera dam reservoir. It may have already noted some changes in the river bed, and the natural flow of water. The first thing that draws attention is the reduction of water in the plains of Mato Grosso do Sul, in the region known as Pantanalzinho, which has major environmental changes in its degree of humidity and flooding.

It is also possible to see that the islands are still visible in the area.

Looking to the islands downstream of the dam, we see that they already had at that time, major changes related to its vegetation cover, arising from the occupation, since that period, with agriculture activities, with houses and homes for holidaymakers (known regionally as rancho).

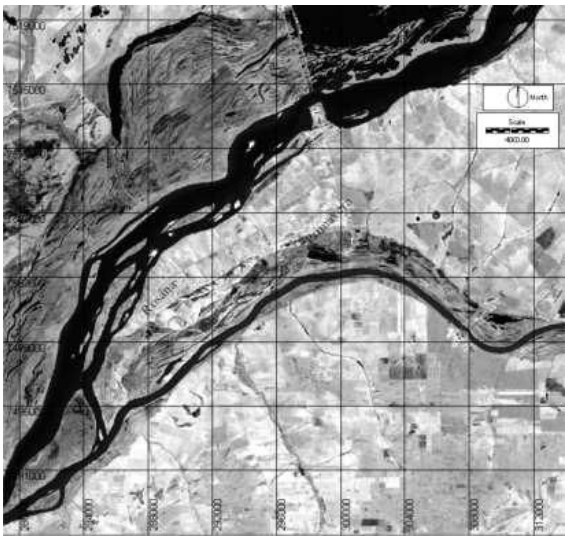
It should be noted that even in the Paranapanema River, south of the picture, there was the construction of another dam, the dam of Rosana.

Figure 1 shows the composition 5, 4, 3 of the image of the satellite Landsat 5 TM in 1984 of the study area. It can be seen the Parana River (dark blue waters), the north and west and the Paranapanema River in South Centre, with a shade of blue waters clearer.

We can see the district of Rosana (current headquarters of the council of the same name) and the core housing of Primavera, then under construction by CESP.

Figure 2 shows the study area in 2001. It appears that the two dams had already been completed, with their tanks filled. In this picture, looking to the existent islands in the Paraná River bed downstream, we see that there is a variation quite intense in their shapes, sizes and occupation.

Figure 1. Composition false color 5,4,3 of image of Landsat 5 TM satellite of the study area in 1984, highlighting the environment and Parana rivers and urban areas of Rosana and Primavera.



Starting the further analysis of each section of the river now, aiming to facilitate the understanding of the changes in the islands.

It is noted in figure 3 the detail of the construction of the dam in 1984 and in 2001 with the construction ready. The islands have been listed to facilitate analysis. The islands that emerged after 1984, only present in the image on the right, 2001, are identified with letters.

It is observed that the island 1 had a significant increase in size mainly to the downstream; it's the result of the accumulation of sediments carried by the currents of the river, especially during the construction of the dam. This increase was the order of 12.8 hectares (ha) in 1984 to 35 ha in 2001. In its sequence to downstream, are forming two islands (a and b), with total area of 9.8 ha in 2001. You should pay attention to the channel of the river diverted

Figure 2. Composition false color 5, 4, 3 of image of the satellite Landsat 7 ETM of the study area in 2001, highlighting the Parana and Paranapanema Rivers and urban areas of Rosana and Primavera.

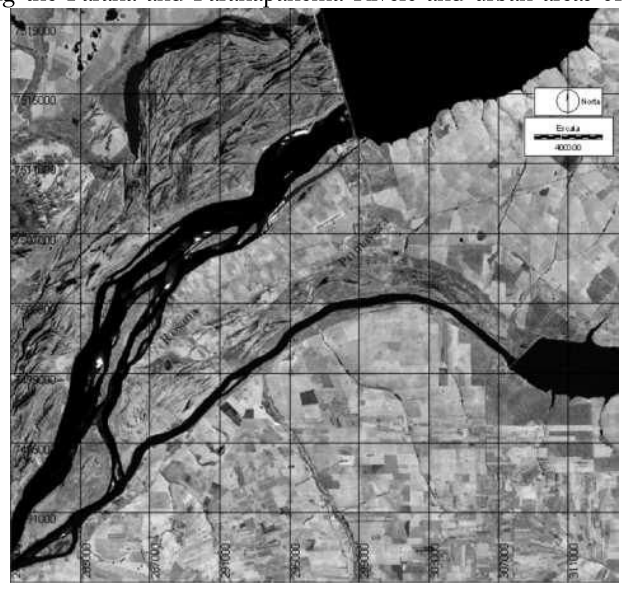


Figure 3. Area near the dam in 1984 (left) and 2001 (right).

in that direction in the image in 1984, during the construction of the dam.

The islands 2 (24.7 ha) and 3 (7.9 ha) disappeared. Most likely due to erosion caused by the large volume of water directed to them over almost two decades. Consider the fact that before the construction of the dams, the occurrence of floods during the summer was normal. However, during the construction, the volume of water increased in times of floods and concentrated in the channel was probably the determining factor for the disappearance of these islands.

The island 4, to be also in the path of the water, had a significant decrease. Its size which in 1984 was 17.3 ha fell to 7.12 hectares in 2001. Figure 4 shows photos of the current margin of the island. Pay attention to the fallen trees in the picture from left and the mango tree root system completely exposed to the figure of the right.

The island 5 has remained unchanged, as between it and the waterfront is the channel of the reservoir lock. However, in its downstream, you can see that there has been the formation of a new island (c) in 2001 with an area of 45.7 ha. The island 6, in the sequence of 5 has changed shape and size in the period the two pictures were taken.

The island 7has lost part of its land to southeast and had an accumulation of sediments in the southwest, and thus changed its shape and size.

Figure 5 presents the sequence of the islands downstream.

On the River fountain side of the island 8 in 1984 there was a small island with an area of 2.94 ha that isn't visible in 2001. Moreover, on the River fountain side of the island, there was an intense process of corrosion, it happens until today, which has made the island diminish in size. In 1984 the area of the island was 147.8 ha and in 2001 it was reduced to 136 ha. Figure 6 shows the River fountain side of the island, highlighting the intense process of corrosion of its head.

The island 9 in 1984 had an area of 27.9 ha. In 2001 it was reduced to 12.8 ha, which ratified the intense corrosion found in the work of field and observed in the satellite image. The island 10 had an area of 9.4 ha in 1984 and it has an area of 3.1 hectare now, or its area reduced almost 70%.

The island 11 remained exactly the same during the two decades. The maintenance of the original vegetation can explain why the area was not reduced, due to the protection against erosion given by the roots of vegetation.

The island 11a showed a small reduction of its area. The island 12 has had major change in its form and also in its size, going from 26 ha in 1984 to 12.7 ha in 2001. Note that the image of 2001 on the River fountain side there is a withdrawal of intense material surface, but still identifies its presence below the water line by the reflectance of the ground covered with small blade of water.

Figure 4. Photographs of the island 4 showing the impacts of erosion.

Figure 5. Sequence of the analysis of the islands downstream of the Parana River.

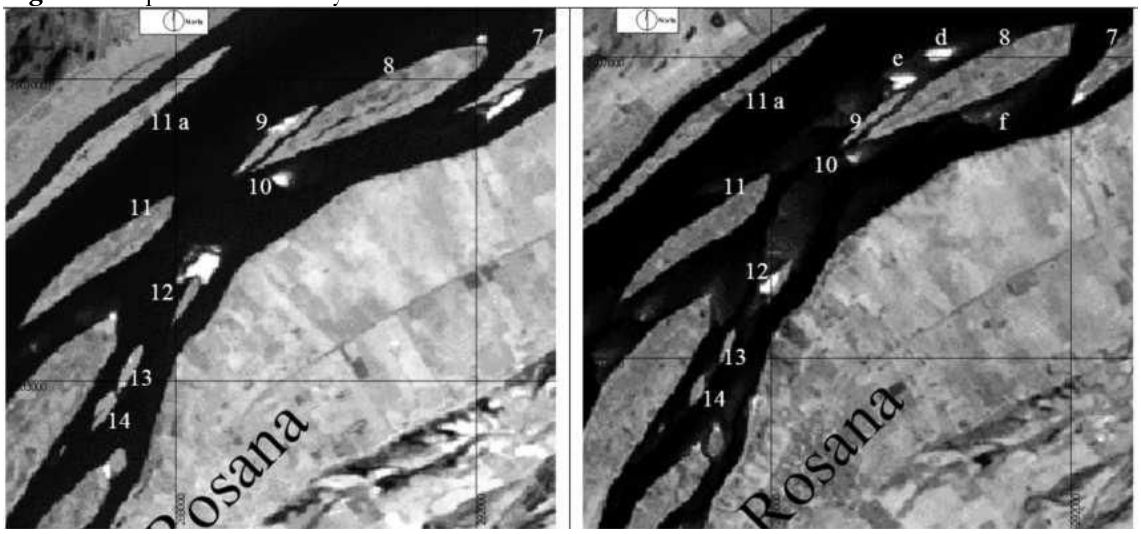


Figure 6. Process of corrosion of the island, in which blocks of land will be dropping. Here you can see that it is being split into two. In the photo on the right you will see an embaúba toppled by erosion.

The islands 13 and 14 in the image of 1984 are intertwined, adding a total area of 18.7 ha. In 2001 was divided, leaving 14, 5 ha, completely separated into two islands.

It should be noted in figure 5, the development of 3 new islands (letters d, e, f), which is occurring probably by the accumulation of sediments on points where the water speed and the volume decreases in certain periods.

As can be seen in figure 7, the island 15 remained virtually the same size and shape, having lost a small area between the two dates that the pictures were taken. As example the island 11a that is also located on the shores of Mato Grosso do Sul, at a point where the current is less intense.

The island 16 has remained with an area exceeding 420 ha in two images, which shows that the island size determines if the island has a lower risk of losing ground with the current. This fact can also be explained by the presence of larger size vegetation in these areas, which gives greater resistance from the ground supported by the roots the action of water. However, as you can see in figure 8, it is currently suffering with the process of intensified erosion. It should also be noted that this figure the owner of the island portion on the River fountain side is trying to protect it from erosion by the use of tires.

The island 17 despite having suffered the opening of a channel in its upstream portion remained roughly the same area. What can explain

Figure 7. Sequence of the analysis of the islands.

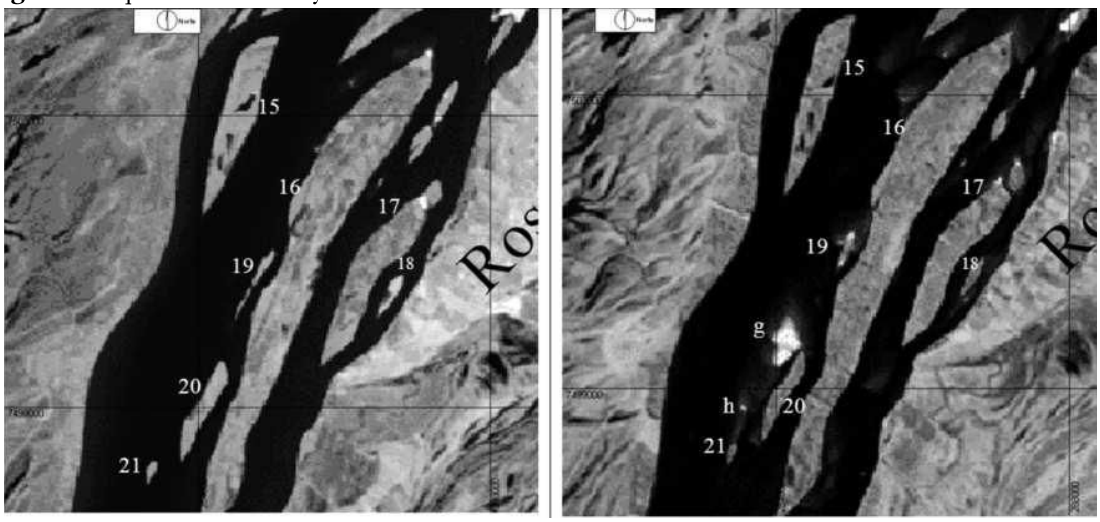


Figure 8. Protection of the island with tires. The arrows highlight the trees falling along with portions of the ground that support them.

this fact is the accumulation of sediments in the headboard of the island, brought from other parts of the river and especially from other islands.

The island 18 had a decrease of 1.4 ha on its surface. Once, the island 19 remained the same. However, you can see that there has been changing in its form, which indicates that the material was taken from some parts and deposited in others, in the same island. The island 20 had a reduction in its area from 1984 until 2001, (32.6 to 26.8 ha). The island 21 remained with the same area.

In the analysis of this figure needs to be emphasized that according to the figure 5, you can see the process of formation of new islands (letters g and h), which indicates an intense process of silting in the regions where the speed of the water decreases. Figure 9 shows the final portion of the Parana River in the state of Sao Paulo.

In the analysis of the islands of the final portion of the Parana River in the state of Sao Paulo, we must observe the process of silting around the biggest island (number 23), known regionally as crude oil. Moreover, needs to be emphasized that the island 24 had an area of 16.31 ha in 1984 and currently has been reduced to 13.31 ha. It's important to note that on the River fountain side you can see the complete lack of materials accumulated in the image of 1984. However, in 2001, a silting in a large area could be identified. This is also visible in the islands 25 and 26.

Figure 9. Analysis of the islands in the final portion of the Parana River in the state of Sao Paulo.

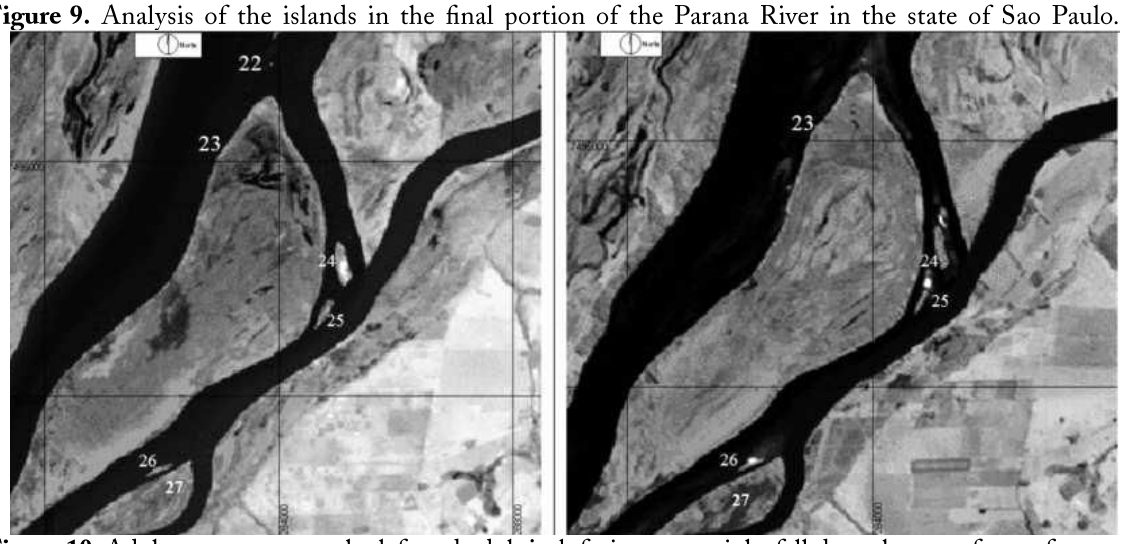


Figure 10. Adult mango tree on the left and adult jack fruit tree on right fell down because force of water from the Parana River in its constant fluctuations.

Analysis of results

In the analysis of individual islands was verified that most of them had significant changes in shape and size. We noted that those located in the areas of greatest current of the river, are suffering severe erosion processes. In these cases, the vegetation presented in the ravine is being toppled and dragged to the river bed. Figure 10 represents well the situation; showing an adult mango tree on the left and an adult jack fruit tree on the right fell down, both were pulled by the water and now they will be inevitably swept away by currents for the river bed. We must pay attention to the details of the sandy soil, therefore with a low capacity to support the investment of water, especially, considering the level of oscillation between wet and drought period, weakening it a lot.

Even those islands positioned in areas of lesser flow or in standstill water are taking accumulation of sediment brought in by water. Moreover, the process of emergence of new islands is happening and also an intense silting of the river bottom.

This process according to CRISPIM (2001) is due to changes of the water speed and the displacement of the forms of the bed.

This decrease of depth in some places has number of problems mainly for navigation, as the Parana River is considered an important waterway. In addition, several fish species, such as jaú, for example, that require spacious and deep habitats, will have problems to adapt to these new conditions, presenting a very small population and at the risk of extinction in the region.

The report of the environmental impact of Engenheiro Sergio Mota hydroelectric power foresaw the possibility of impacts on the islands in the study area. However, the company was not forced to protect the islands, which has further contributed to the degradation of the islands.

Conclusions

In the field of analysis and data presented could be verified that most of the islands with lótica water of the Parana River in the state of Sao Paulo have suffered considerable impacts of the constant change in their level of water.

However, this is not the exclusive factor to the occurrence of the problem. The forest devastation that was submitted throughout the Paraná River basin, especially in the State of São Paulo, is another determining factor for this situation, since the basin soil is not so structured and somewhat resistant to erosion, without its coverage can not resist naturally and has just drawn into the bed of rivers and streams in the region and ends up being loaded to the Parana River.

Thus, the urgent awareness of the integrated management of river basin may be a solution to reversing this problem.

It was also observed that the use of the tools of geoprocessamento together with the work of field allowed the proper analysis and reaching the purpose proposed in the work, allowing the handling of large volumes of data and analysis summary of the study area.

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