

TERRITORIAL DYNAMICS ABOUT THE INSERTION OF INTERCITY HIGHWAYS

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ABSTRACT

Mapping satellite images is an important aid tool between urban areas and their infrastructure, especially with highways. In Brazil, these have the purpose of interconnecting urban and industrial centers, which, consequently, triggers challenges in relation to functionality. In the last decade, what has been highlighted in the discourse on the insertion of highways is the environmental variable, highlighting the contextualization, mapping and analysis of the impacts caused by them. From this, the mapping and analysis of the impacts caused by the Aristides Bolan highway between two South-Brazilian municipalities is studied. Considering the results obtained, the mapping of the areas showed that during the application of the classification carried out, the implementation of highways implied, in the long run, a change in the landscape to which it was inserted. The greatest impact occurred with agriculture and pasture sectors, while deforestation, when observed in the period of 8 years, had a decrease.

Keywords: highways, mapping, Aristides Bolan, landscape.

Research line: City and project.

Theme: Metropolitan and territorial studies.

Introduction

The implementation of highways, according to Sestrem and Kormann (2013), may involve different regions along their layout, with specific characteristics in relation to relief, vegetation, geology, geotechnics and climatic conditions. In Brazil, often the main responsibility of highways is the interconnection of important urban and industrial centers, which represents challenges in relation to their constructions and operation.

Magalhães, Martins and Santos (2011) point out that even if the construction of highways promotes improvement in the quality of life of the population, besides subsidizing the development of certain areas, they can cause impacts that affect both the anthropic environment as for the environment. Therefore, it is necessary to consider the survey of environmental impacts in the area of coverage, when in the phase of construction planning addresses all phases of the project, such as implementation, maintenance and operation.

Furthermore, the urban space is characterized by the intensity of human activities, where Júnior and Ferreira (2008) indicate that these are often surrounded by a series of conflicts of various factors. In Brazil, the great stimulus to road transport began in the 1950s, where in the government of Juscelino Kbischeck, with the government's plan of goals, where the Brazilian territory began to be interspersed by several highways in order to connect and integrate the entire national territory.

Thus, Villaça (2017) describes that the phenomenon occurred through the construction of highways becomes more flexible, because "intra-urban transport then emerges as a byproduct of the long-distance system, representing a part of this system that the city receives not only before demand, but also free of charge." Furthermore, the authors complement their thinking when he mentions that regional transport routes are the most powerful element in attracting urban expansion.

This research has as main objective the contextualization, mapping and analysis of the impacts caused by the insertion of the Via Rápida, between the municipalities of Içara and Criciúma. It is intended, first, to discuss some important themes for understanding the study, such as environmental impacts, monitoring areas of interest and the object of study of this research, identifying and mapping areas of environmental interest and urban growth along its emerging perimeter and discuss the main results analyzed.

1. Highways and environmental impacts

Villaça (2017) starts from the hypothesis that urban growth is highly influenced by roads – regional highways and railways. For this statement, the author brings Milton Santos' concepts that the richness of the location and the importance of accessibility for growth, due to the differences in accessibility (time, frequency, price) independent of his own condition. Thus, the space produced has value, and its price, as the price of products produced in general is the monetary expression of this value, where intra-urban transports are the greatest determinants of spatial transformations, transport routes have enormous influence not only on the internal arrangement of cities, but also on urban expansion differentials, where the first effect of a regional route or urban transport terminal causes on adjacent land the improvement of their accessibility, hence their appreciation.

In addition, the spaces between municipalities are strategic places for the promotion of development and economic growth, since most of these occur in a disorderly and unplanned manner. This common reality triggers the lack of control of institutions and organs related to the use and occupation of urban soil. The State has contributed in a very relevant way to territorial restructuring and support of growth and redirection of flows, through the implementation of infrastructure such as highways, bridges, tunnels and accesses, since they are characterized by a heavy flow of vehicles and a relatively large number of side accesses to the exit of vehicles, as well as representing an indicator of regional development. (SOUZA, 2006; FOGLIATTI, FILIPPO and GOUDARD, 2004).

On the other hand, the insertion of highways represents one of the greatest evils of civilization in relation to the impacts on the natural environment, since the preservation of environmental areas of interest in emerging regions highways are of utmost importance, given the role environment for human life. According to Bellia and Bidone (1993), the impacts caused by road construction should be analyzed at stages of construction of the project, obeying the project phases, which include stages of trace and preliminary studies, during and after the execution of the work and delivery to the public, involving the conservation and restoration of stretches, and in the operation phase.

Over the past decade, the environmental variable as one of the feasibility criteria in road developments becomes a significant factor, where the environmental impact assessment should include all phases, but in Brazil it is still incipient in the operation, being little or nothing required by the laws (BANDEIRA and FLORIANO, 2004).

With this, environmental management, according to Holzmann (2014), should be present since the planning of the new highways, where localization alternatives are sought that generate fewer environmental occurrences. To compose it, we have the Environmental Impact Study (EIA), the Basic Environmental Project (PBA), the Environmental Impact Report (RIMA), Environmental Control Plan (PCA) and the Degraded Areas Recovery Plan (PRAD), being instruments that assess in theory the prevention, mitigation and compensation of environmental damage that possibly affect the environmental, social, economic and physical balance caused by deployments and road operations. The purpose of these studies is the issuance of the Environmental license for the construction of road infrastructure.

In Santa Catarina, agencies such as DEINFRA (Department of Infrastructure), have established a technical staff of environmental experts, where it seeks to adapt the standards and instructions of service with the care that should be taken with physical means (air, water and soil), biotypes (flora and fauna) and socioeconomic (surrounding population, employees and highway users), infrastructure projects with emphasis on the implementation, restoration and improvement of highways, and the view of the structuring of measures is premised environmental interest areas, making it possible to avoid damage to this, and not just mitigate them (NEVES and HENKES, 2013).

In this sense, the recovery of an area around a road is of fundamental importance, since the impacted area may suffer natural regeneration, depending on how the degradation process occurred, and thus propose measures that mitigate the damage caused by construction of the

surrounding area, aiming at a form of sustainability of the long-term impacted ecosystem (MAGALHÃES, MARTINS E SANTOS, 2011).

2. Monitoring areas of interest

Prado, Ferreira and Guimarães (2006) point out that road construction is a mechanism of fragmentation of high impact, removing the original vegetation cover of areas where inserted, generating an edge effect and changing the function and structure of the landscape. In order to map areas of environmental interest, or to study a map of land use capacity with division of areas, a Geographical Information System (GIS) is used, which is a set of digital tools for acquisition, analysis and dissemination of spatial information (RODRIGUES, ZIMBACK and PIROLI, 2001). In recent years, with the advancement of technology there have been major changes in the sciences related to the environment and mapping in general. The advent of the satellite era made it possible to obtain reliable information, with great repeatability and at a relatively low cost.

Through gis, it is possible to take a wide range of variables, which are usually considered in analyses and decisions of land use. This system consists of a set of computational modules, intended for the acquisition, storage, recovery, transformation and output of spatially distributed data. The data is described on the aspect of its positioning in relation to a system of coordinates, its attributes, and existing topological relationships. Thus, it is possible to work with data by which the geographical position, the value of the characteristic at a given point and its spatial relationship structure are known. By these factors, a GIS can be used in environmental studies, in the research of the prediction of specific factors or in support of planning decisions (RODRIGUES, ZIMBACK and PIROLI, 2001).

The identification of areas of interest, as well as changes in the environment from the insertion of road systems, generate the need for constant monitoring that, in turn, keeps the information up to date. GIS favors monitoring this information through the use of multispectral images, which are periodically being obtained by orbital sensors. Thus, the ease of mapping and visualization of information, after classification and analysis, assists in decision making and minimizes possible risks and local environmental damage, as well as the appropriate areas for urban expansion (MONGUILHOTT et al., 2010).

3. Via-Rápida and Territorial Management

In view of the discourses on the environmental problem, in different scales, it converges to the questioning of the relationship between human actions and the environment as a generator of various conflicts. On the other hand, more and more significant studies are proposed to establish conditions of balance in the relationship of man and nature, in order to reduce the negative impacts especially experienced in cities, such as urban environmental impacts, in this case the insertion of new road systems (GARCIA, 2013).

The landscape treated in this research is the Aristides Bolan Highway, better known as Via Rápida, between the municipalities of Içara and Criciúma, located in the state of Santa Catarina. The construction of the highway was inaugurated on December 20, 2017, so, as construction is still recent, it is gradually perceived the impact that the insertion of the road generates between municipalities and emerging areas. On the other hand, it allows more accurately analyzed data on areas with vegetation and urban growth along it, so that precautionary measures can be taken to environmental damage and disordered growth through a system geographic information. The main objective was the redirection of flows and reduction of access time between BR-101 and the municipalities of the southern region of Santa Catarina, and its project includes 12.7 km of extension and 17 viaducts, being considered as the main work of mobility and infrastructure of the region (Fig. 01). According to Vilhena e Silva (2017), in general, during the works of implementation of a highway are monitored according to the environmental management system chosen and the use of programs to reduce possible negative consequences related to the Construction.



Fig. 01 Source: (Lenzi, 2017) Insertion of the highway in the city and its surroundings with consolidated vegetation.

However, the road system, as a force promoting the change of urban space, is a process that acts over time, and considering the role that mobility has on the evolution of cities, one must understand the issue of preserving the means to which the development and effectiveness of engineering projects for those traveling along the highway and for the population of municipalities that are in their area of influence.

Thus, an environmental protection plan for the socioeconomic environment becomes a relevant item in the preparation and execution of road engineering projects, because DEINFRA does not have as a priority the application of improvements and resources in emerging environmental areas the highways, nor in control of urban expansion of cities to these areas. Moreover, although environmental management and review of urban legislation cost the projects, it is known that if not implemented there may be greater consequences, since sooner or later, this damage will have to be repaired, with even higher costs or with irreversible damage to the environment and society (NEVES and HENKES, 2013).

To perform actions such as environmental management and control of the disordered growth of cities along the highway, a previous study is required, which aims to identify the areas of expansion and environmental interest. The knowledge and mapping of these areas are relevant tasks to contribute to local actions of the government, providing accurate information, easy to understand and can be used in the management of municipalities or region. This type of study is based on the production and analysis of a broad set of information that represents the physical and social aspects of the regions. The procedures for mapping, modeling and cartographic representation to identify the areas of preservation and verification of irregularities regarding land uses favor decision-making regarding the proposition of recovery for those who are already and control of future occurrences.

4. Methodological procedures

The methodology was structured in two parts, the first qualitative analysis of the impacts generated by the construction of highways, and the second, quantitative in nature sought to show through the mapping and calculation of the areas the transformations that the highway in study brought to the framework of urban expansion. To meet the research objectives, the technique adopted will be qualitative and quantitative in the face of how the problem will be discussed and analyzed, focusing on understanding and explaining the dynamics of sociocracies relationships. According to Godoy (1995), qualitative research allows an understanding of the phenomena studied, paying attention to detail and knowledge about specific situations. This work has a descriptive character, as it intends to describe the characteristics of the studied phenomenon (GIL, 2002). This research model has as main characteristics the understanding, description and explanation of the facts, being main objective the production of new information for a practical application (GERHARDT; SILVEIRA, 2009).

In the case of the proposed research, it will be characterized by qualitative with regard to the exploration of subjective aspects of data analysis and the study site, and quantitative for using statistical methods to synthesize and process the information obtained. In this sense, as mentioned above, the research will outline about a case study, between the municipalities of Criciúma and Içara, with geographic clipping the region of the Via-Rápida, as a unit of analysis.

4.1 Geographic clipping

The SC-446, Aristides Bolan highway, better known as Via-Rápida, connects the municipalities Içara and Criciúma, located in the south of Santa Catarina, as observed in Fig. 02, where it begins in the region of the Prosperous neighborhood, in Criciúma, with two accesses in the urban perimeter and continues for ten kilometers until the BR-101, passing through Içara. The implementation of the highway was the first duplicate link between these two municipalities and BR.

According to Correa (2017), the idealization of the highway project occurred in mid-2008. The project began to come off the paper on May 31, 2012, when the then-governed Santa Catarina announced the bidding process. In addition, the highway was built for a possible expansion in the

future, without the need for expropriation along its perimeter, since during its construction process the demands made by emerging neighborhoods characterized the largest difficulties.

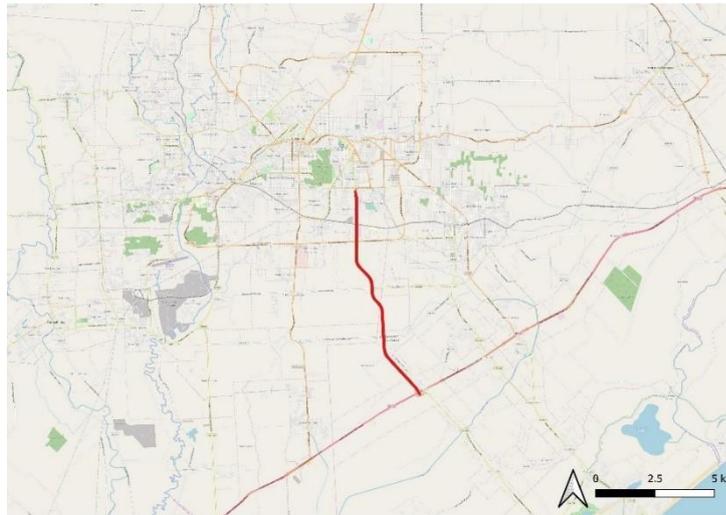


Fig. 02 Source: (2020) Own creation based on data from Google Maps.

In the later analyses, a temporal analysis is presented between the main years of the history of the highway: 2008, 2012 and 2016, years related to the beginning of the project, beginning of execution and a year earlier of the completion of construction. Analyses were performed over an eight-year period, so that the objective proposed in the study was reached.

4.2 Mapping

To perform the analyses on the study area, georeferenced maps provided by the MapBiomias platform were constructed, where images of the Atlantic Forest biome were removed in tif resolution from collection 2 - from 2000 to 2016. As for the methodology used for the MapBiomias classification, maps are produced from pixel to pixel classification of Landsat satellite images (MAPBIOMAS, 2019). The entire mapping process is done with extensive machine learning algorithms through the Google Earth Engine platform, a cloud computing platform capable of analyzing remote sensing data on a global scale (Gorelick, Hancher, Dixon et al., 2017). In addition, for the parameterization of algorithms and organization of the steps, 556 letters from the Brazilian Institute of Geography and Statistics - IBGE are used.

QGIS software® was used to construct and analyze maps. Images were collected for the years 2008, 2012 and 2016, respectively, imported into QGIS® and vectorized. From the vectors, together with the archive of Brazilian municipalities, the clipping of the municipalities of Içara and Criciúma was extracted, as well as the vector of the Via-Rápida through the complement of QuickMapServices and OSMDownloader maps. Finally, a buffer was made, demarcating the Via-Rápida in 1 km in 1km, thus covering a total area of 5km from the road.

With the buffer realized, it was together with cut-out vectors each year, and thus extracted the data to analyze the impact of the Via-Rápida on the sectors of urban and industrial infrastructure, dense forest and mosaic of agriculture and pasture. With each classification sector selected, calculations of the areas could be extracted to perform quantitative analyses of the proportion of how much were modified over the years evaluated in this study. Finally, the area data of 1 km were extracted to perform a sensitivity analysis, with the aid of software R, from a correlation of each sector and year, having as a variable dependent on distance, generating finally a scatter plot, where observations on the distribution were made.

4.3 Data validation

In view of the mapping produced through the previously established platforms, a statistical analysis was performed in order to verify and validate the data for further discussion. Plots of dispersions were created, referring to the years of study in relation to the mapped sectors, so that the main relationships between the variables listed, the years of study and the kilometers from the highway were established.

For this, The *R-Software* was paramount for the generation of graphics. Fig. 03 shows the correlation of the dense forest sector. The correlation between the sectors, especially in 2012, indicates the strong relationship between the road project years and the increase in the forest area for this year.

In the urban infrastructure sector, Fig. 04 shows a higher correlation of variables in 2016. The other data under pruning this analysis are discussed in the next chapter. In Fig. 05, the largest relationship between the agriculture and pasture sector over the years with the kilometers of the highway occurs in 2016. Furthermore, it is observed that all variables of the sectors studied have a positive correlation, indicating that they follow a normal distribution, being valid for the proposed study.

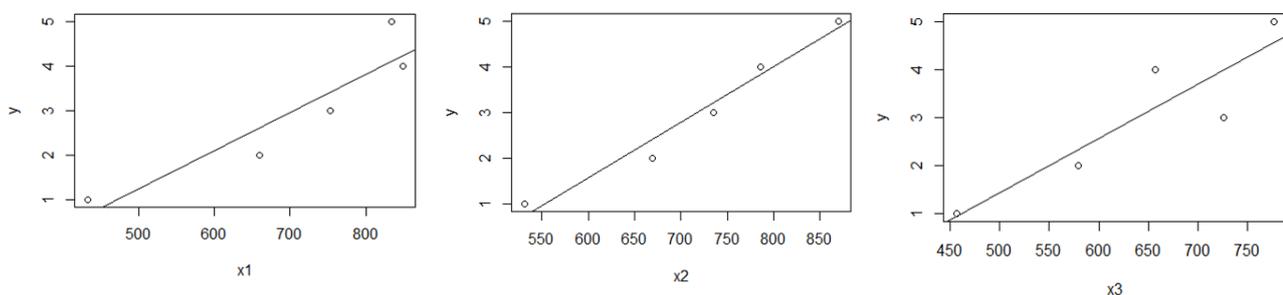


Fig. 03 Source: (2020) Dispersion analysis and dense forest correlation of 1 in 1 km from the highway layout in 2008, 2012 and 2016 respectively. Own creation based on data from *R-Software*.

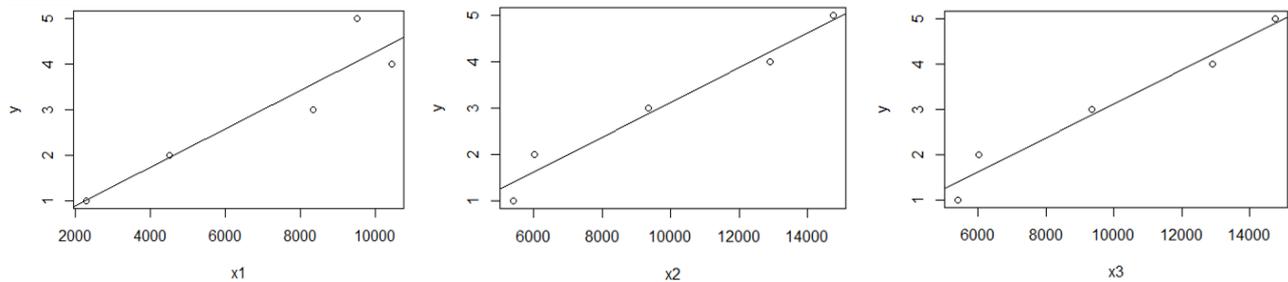


Fig. 04 Fig.4 Source: (2020) Dispersion analysis and correlation of urban infrastructure of 1 in 1 km from the layout of the highway, in 2008, 2012 and 2016 respectively. Own creation based on data from *R-Software*.

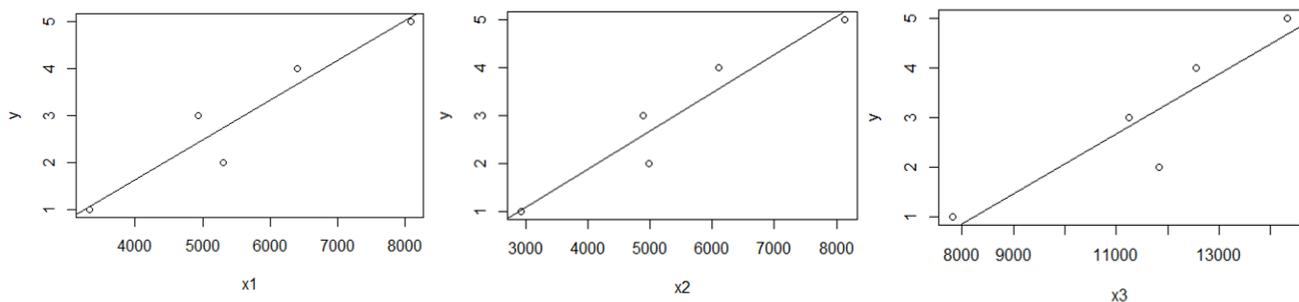


Fig. 05 Source: (2020) Dispersion analysis and correlation of agriculture and pasture of 1 in 1 km from the layout of the highway, in 2008, 2012 and 2016 respectively. Own creation based on data from *R-Software*.

5. Results and Discussion

Regarding the temporal analyses performed in the period of 8 years between 2008 and 2016, the evaluation of the mapping and calculation of the image area generated the results presented in the following graphs, in relation to areas of agriculture and pasture, infrastructure urban forest, emerging the Via-Rápida, object of study. In general, the selected images had geometric quality in positional terms compatible for surface mapping, enabling a better evaluation of the product, and verifying that for the applications studied and found during mapping they had a satisfactory accuracy.

With regard to the dense forest area, according to Matias (2011), the impacts on the environment caused by road engineering works occur differently in the planning, implementation and operation phases. According to the mapping performed, and expressed in Fig. 06, over 5 kilometers from Via-Rápida the dense forest area has reduced about 9.43% (333 m²) since 2008. Between the years of construction of the highway (2012 to 2016), the forest area reduced by 396 m² (approximately 11%). In this case, Guimarães, Guedes and Dourado (2013), highlight that in the phase of highway implantation, the physical, biological and anthropic media are impacted to a greater degree, depending on the works performed and the size of the project, which in this study presents itself as the implementation between the municipalities of southern Santa Catarina, as well as the

environmental characteristics to its surroundings, such as the vegetation areas present in the area of influence of the project.

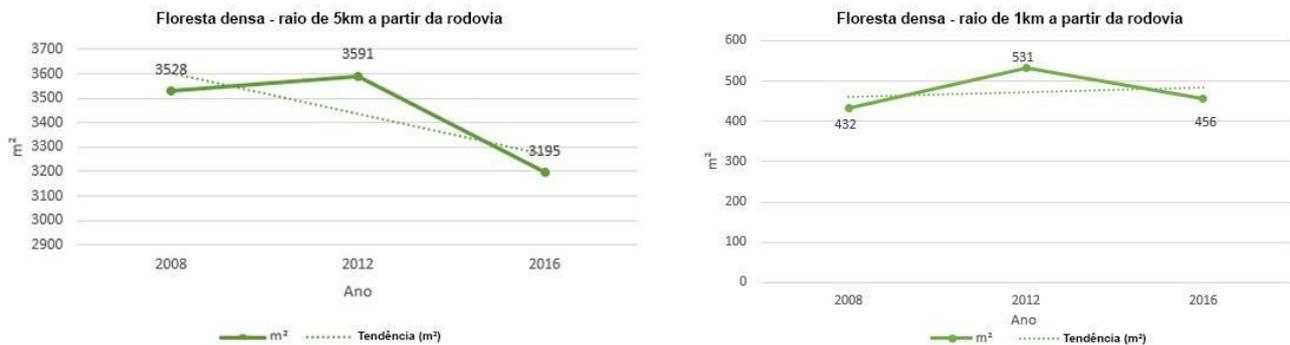


Fig. 06 Source: (2020) a) Dense Forest - radius of 5km from highway b) Dense Forest - radius of 1km from the highway. Own creation based on data from *MapBiomias*.

However, when analyzing the areas of dense forest emerging 1 kilometer from the highway, there was an increase of 5.55% (24 m²) between the year of project (2008) and the year of construction beginning (2012), indicating that, according to the proximity of the route, there may have been a recovery of areas that had been deforested to construction sites of the highway and temporary infrastructure for the implementation of the highway. In addition, in Santa Catarina, the new Forest Code (Law 12,651), was approved in May 2012, the year of the beginning of the implementation of the highway, which may have helped even more in the increase of dense forests emerging the highway. This can be perceived according to Fig. 07, referring to the mapping of dense forest areas, in which the change of vegetation is highlighted in the total radius of 5 km.

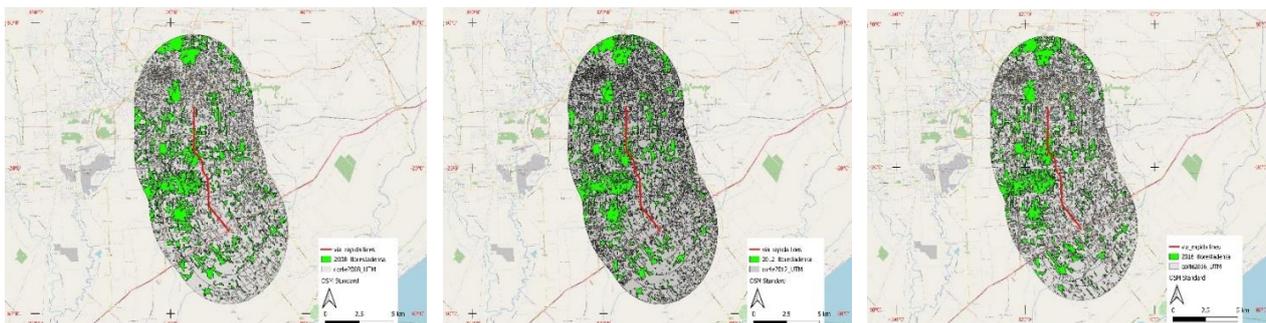
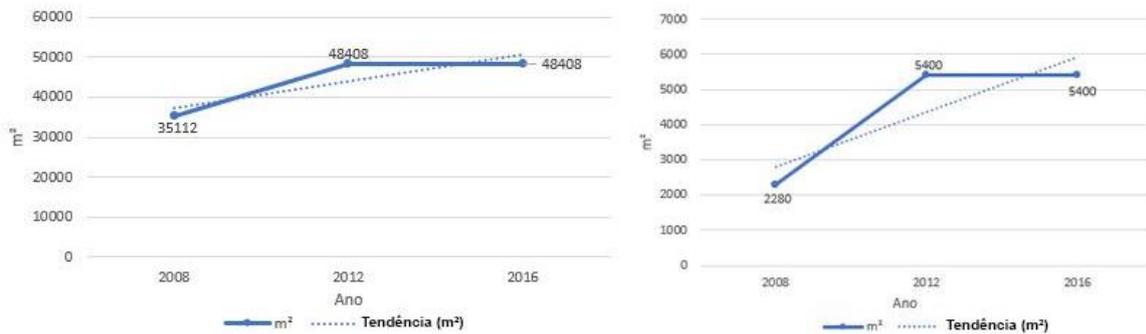


Fig. 07 Source: (2020) a) Dense forest mapping within a radius of 5km from the highway layout in 2008, 2012 and 2016, respectively. Own creation based on data from *MapBiomias*.

When analyzing the mapped areas related to urban infrastructure, such as buildings, industries, there was a significant increase during the time period analyzed, and at a perimeter of 5 km from the highway, the increase was approximately 13,296 m², equivalent to about 37.86%, as observed



in Fig. 08.

Fig. 08 Source: (2020) a) Urban infrastructure - radius of 5km from highway b) Urban infrastructure - radius of 1km from the highway. Own creation based on data from *MapBiomas*.

As discussed at the beginning of the study, the implementation of highways is a thermometer of the capacity of a given place to effectively guarantee the process of economic development, so it is expected that, with the insertion of highways in Brazilian cities, increase local infrastructure, as the works, in addition to facilitating access to established locations, end up creating new ones. If we analyze this issue, from 1 km from the highway, in Fig. 08, the increase in local infrastructure increased by 136.84% (3,120 m²), which converges with the issue of research that the closer the highways, the more real estate developments tend to be located, often reducing areas of vegetation for infrastructure rental. It can be seen the change in the stain of this sector in Fig. 09, in which the difference in the increase in area is mainly concentrated in the northwest and southeast portion of the map.

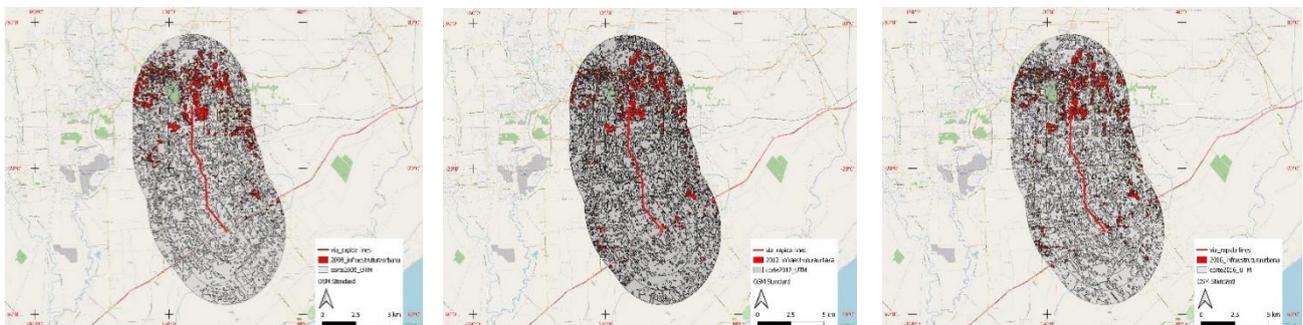


Fig. 09 Source: (2020) Mapping of urban infrastructure within a radius of 5km from the layout of the highway in 2008. Own creation based on data from *MapBiomas*.

The areas of agriculture and pasture have stood out over the years in the landscape. Among the period analyzed, within a radius of 5 km from the highway, the growth of this sector was

characterized around 105.91%, with the highest growth of the three sectors analyzed in this study. The area computed in 2008 was about 28,056 m², while in 2016 it was 57,771 m², observed in Fig. 10. Fig. 11 shows that although the area of the sector has reduced in the southern portion, it suffers a shift to the northern portion, which can happen due to the demarcation of environmental protection areas, since demarcated areas of dense forest in 2016 in 2008 they were destined for agriculture and pasture.

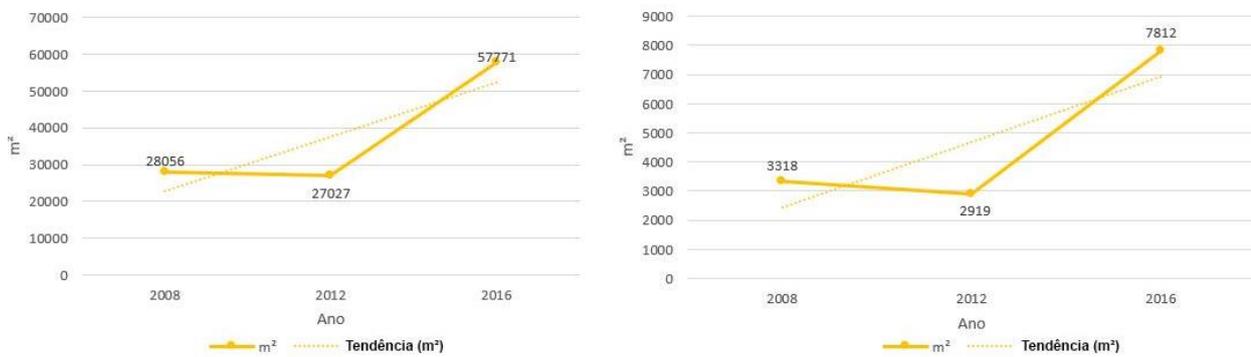


Fig. 10 Fig.10 Source: (2020) a) Agriculture and pasture - radius of 5km from highway b) Agriculture and pasture - radius of 1km from the highway. Own creation based on data from *MapBiomias*.

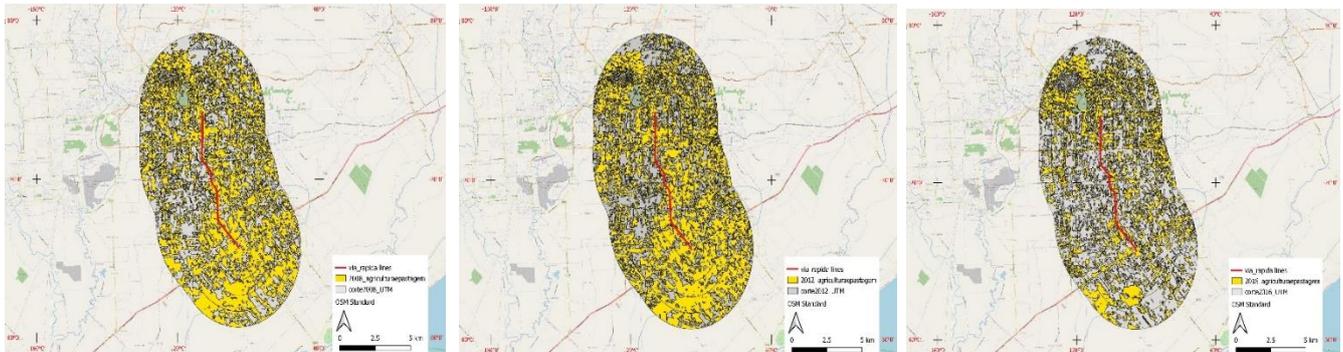


Fig. 11 Source: (2020) Mapping of agriculture and pasture within a radius of 5km from the layout of the highway in 2008. Own creation based on data from *MapBiomias*.

Castro (2003) shows that an inefficient transport system carries high travel costs and is an obstacle to development, and the impact of transport for the agricultural development of the regions is relevant. One of the main reasons, according to the author, is in relation to the relatively lower value of products, in relation to their weight, and freight being lower than the final price of the product, because many agricultural products have their prices fixed in the markets the transfer of transport costs to final prices. Regarding the sectors located 1 km from the highway, as shown in Fig. 10, the percentage of the increase in the area was 135.44%, equivalent to 4,494 m². It focuses, therefore, on the specific role played by the insertion of the road transport network and its relationship with the

increase in agricultural production, especially attention to the areas most emerging to the Fast Track.

Among the analyses performed, presented in the maps and in the calculation of areas, shown from graphs, the mapping of the classes dense forests, urban infrastructure and agriculture and livestock were changed, both in the change of concentration of sectors on the map, as well as by the percentage of increase or reduction of the areas, so that it is possible to visually observe the territorial changes along the implementation of the highway between the municipalities. In relation to urban infrastructure areas, one can see an increase in relation to the centrality of Criciúma, indicating that the highway has expanded this sector especially within cities, and little along its perimeter. Furthermore, it can be perceived that in all maps there is a significant change in behavior in the southern portion of the road, since there it meets the BR-101, in which a synergistic effect occurs, where BR exerts a certain influence on the activities analyzed at the its around.

The importance of transport infrastructure for the development of the economy, where good quality roads imply a reduction in the cost of transport, and, consequently, the final price of products, making them more accessible to the competitive to competitors. They also allow each region to specialize in economic activities for which they have the highest vocation, such as agriculture, livestock, services, among others, generating gains in productivity and quality for the economy. The reduction of travel time between the two cities allows, over the years, to increase economic and social ties, in addition to the universe of choice of housing and investment of the population where the highway is located, but, like any public investment in infrastructure, to achieve beneficial potential, the state needs the technical capacity to plan and monitor emerging areas.

Conclusion

The results obtained by mapping the classes of dense forest, urban infrastructure and agriculture and pasture allowed, at the end of this study, to outline an analysis on the impact of the highway between the municipalities of Içara and Criciúma, where it is inserted . Furthermore, it was indicated the feasibility of using object-oriented classification in mapping urbanized areas from high spatial resolution images. With regard to the mapping process, carried out between the images through the technique used, it was satisfactory regarding the ability to transfer details, enhancing the exploration of the data necessary for proposed discussion and favoring the speed and agility of work.

In the application of the classification performed, it is noted that the implementation of highways implies, in the long term, a change in the landscape to which it was inserted. The greatest impact occurred with agriculture and pasture sectors, while deforestation, when observed in the 8-year period, decreased. With the new forms of urbanization that are taking place, through the formation of dispersed nuclei, the need for updated data arises, on the spatial distribution of these areas, for the orientation of public policies, especially focused on planning towards intelligent urban growth and in balance with the natural environment. This data can be obtained at first from the object-oriented classification of satellite images, as presented in the work developed, and refined through field verification.

Finally, considering the results of this study, it was concluded that road works, such as *via-Rápida*, have significant impacts over the years in urban space, and may be positive or negative to the environment. The research seeks to show, that as much as the highway has approximately 2 years of inauguration, over time it exerts great influence on the transformations around the environment. With this, it is of paramount importance to analyze these impacts constantly for the improvement of projects, both along the same and in subsequent areas, always aiming at minimizing negative impacts and maximizing positives, in addition to predicting the control of expansion and environmental areas on the impacts that a highway can bring to its surroundings.

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