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Sustainable Urbanization in a Medium-Sized City in Southern Brazil

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Abstract: Urbanization in Brazil is increasing, mainly in medium-sized cities. This expansion causes varying degrees of environmental impact. The general objective of this manuscript is to analyze the resultant impacts that urbanization has had on soil morphology in and around developing areas of the Brazilian city of Passo Fundo/RS. Implementation of the methodology laid out in the Leopold Matrix allowed the location of data for the analysis of the characteristics present in the use of the soil of the study area. Results showed high levels of vegetative loss around the City of Passo Fundo, due to a high degree of urban expansion driven by real estate speculation. The research suggests monitoring the degree of pollution of water resources in addition to regional air quality due to the marked intensity of vehicular flow.

Key words: Urban design, environmental impacts, environmental analysis, public policies.

1. Introduction

Urbanization, or the accelerated growth of cities, first arose at a somewhat modern pace during a period of industrial development in the mid-13th century resulting from the disintegration of the feudal system. This pattern greatly intensified throughout the 19th and 20th centuries with the progression of the Industrial Revolution [1, 2]. The expansion of cities has not always progressed in an orderly manner, resulting at times in a limit to the amount and frequency of green space in many Brazilian municipalities [3]. One resulting trend in this lack of planning is the decreasing quality of life of the population living in urban areas. Landscape morphology is also impacted, causing decreases in urban vegetation responsible for the regulation of the local microclimate [4].

The expansion of cities is an international act fueled by population growth and increased demands for space. Resulting horizontal urbanization expands the outer limits of the city as it grows [5, 6]. While it may not be possible to prevent changes in land use from occurring in the coming decades, it is certainly possible to protect the environment through information and sustainable planning [7, 8]. The importance of this is paramount on the outer edge of a city as areas which are the closest to the urban/rural divide may maintain healthy natural vegetative communities and in general have higher quality environmental conditions than areas within the urban landscape being redeveloped [9].

For this reason [4, 6], the authors highlight the importance of research conducted in urban areas

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seeking to highlight the consequences of urban expansion, in an effort to facilitate the formation of public policies that ensure this expansion based on population growth is done sustainably. Another factor is the importance of discussing problems encountered in different locations and examining the results of unsustainable urbanization in order to strengthen our theoretical understanding of the issues at hand, bolstering broader sustainability initiatives [10, 11].

In this context, the area chosen for this study was located on the urban/rural divide of the City of Passo Fundo/RS, Brazil, currently under threat of urbanization as the city expands. The study site is in close proximity to highway RS-324, which serves as a main artery to and from the City of Passo Fundo and experiences significant traffic flow.

The applicability of the research lies in the relevance of the problem of real estate speculation carried out in the study area, thus initiating the process of dividing lots and commencing development of the land. We posit that this is the stage in which issues related to the environmental and morphological aspects of the site must be taken into account, as careless development now can limit the impact of future intervention; whereas, responsible and sustainable development now may likely negate the need for future intervention.

A firm understanding of the relationship between economic growth and its potential impact on the environment, the responsible use of resources, and adequate access to information on sustainability is crucial in order to avoid environmental degradation when planning the expansion of city [12].

The general objective of this manuscript is to analyze the impacts that can cause changes to a site's morphology through development, comparing the degree of environmental degradation in the City of Passo Fundo in relation to the urban expansion process. However, in order to carry out the research, specific objectives were developed, such as identification of the environmental impacts present in the area and the differences in the form of urban development.

2. Materials and Methods

The City of Passo Fundo is located in the State of Rio Grande do Sul (southern Brazil) and has an estimated population of roughly 203,000 inhabitants [7]. The study area is located adjacent to an industrial zone on the outskirts of the city. This close proximity to an industrial zone drives real estate speculation in the area. Prior to development, the entire area was under agricultural cultivation (Fig. 1).

The research was based on bibliographic surveys related to the topic addressed [8], with environmental issues involving Permanent Preservation Areas (PPAs), such as riparian forests and wetlands, in addition to erosive processes of the soil that degrade the quality of local water bodies. The Leopold Matrix methodology, established and assigned three degrees of environmental impact (low, medium and high) through a combination of photographic records and field study, which are together fundamental for the physical recognition of the place of study [9, 10]. The goal of this is to propose necessary improvements for maintaining or improving the environmental quality of an area both during and following development.

The present research analyzes the study area, which is slated for development for residential purposes. The area currently exhibits considerable environmental degradation through soil erosion, chemical and solid waste pollution, and noise pollution due to its proximity to the highway. These issues, if not addressed and remedied during development, would negate the possibility of a wholesome housing environment following construction.

The technical and theoretical bases for such impact analyses were laid out through the Environmental Impact Assessment, configured by the Brazilian National Environment Policy, governed by Law No. 6,938/81. This legislation regulates the environmental quality conditions of urban and rural areas under the

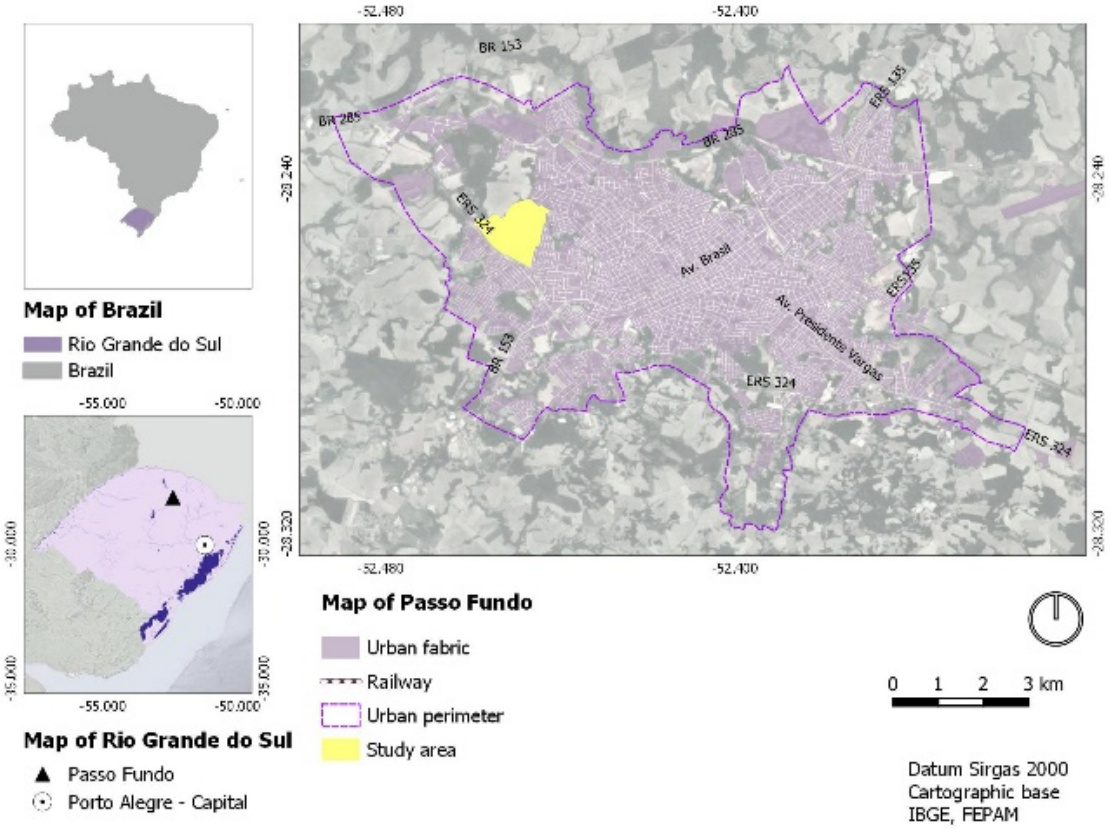

Fig. 1 Map of the city of Passo Fundo. The implementation of the city of Passo Fundo.

premise of guaranteeing the right to an ecologically balanced environment, as well as decreeing environmental preservation as a responsibility of the state government [11].

3. Results and Discussion

The ecology of the area that now makes up the City of Passo Fundo has been drastically altered through development of the city itself. Native plant communities have been lost through the land's conversion to urban uses and urban expansion. This first began as deforestation carried out in the late twentieth century removed the natural forest cover in order to convert the land to agriculture (Fig. 2) Agricultural areas are now being consumed by housing developments, industrial areas, and urban infrastructure [11, 12].

Initial deforestation and subsequent agricultural activities left the soil unprotected and vulnerable to aeolian and water driven erosion, leading to the siltation of the Pinheiro Torto River and wetlands in the study area's vicinity. The lack of protective vegetative cover in the area, coupled with the steep slope of the terrain, ranging from 602 to 644 m in altitude, accentuated the problem of erosion.

The siltation of the Pinheiro Torto River caused by sediment transport through the study site during periods of intense precipitation clearly demonstrate that the 30 m of riparian APP required by the New Brazilian Forest Code, approved by Law No. 12,651, on May 25, 2012 is either not present or is not adequately functional in the study site.

The Leopold Matrix made it possible to analyze the environmental conditions and environmental impacts present in the study area [13, 14]. Results of the analysis showed medium and high environmental impact in the area. This rating was driven largely by water pollution from solid waste and land surface soil

Fig. 2 Representation of agricultural activities and natural resources in the study area.

erosion. Erosion and soil degradation can be aggravated by improper land use and management [15]. Lack of adequate vegetative cover leads to the formation of channels and gullies on the soil surface that speed erosion. This is particularly acute in areas with steep slopes. Furthermore, the site's close proximity to a major highway leads to aquatic pollution from hydrocarbons, road dust, and heavy metals caused by vehicular traffic.

Fig. 3 shows current land use in the analyzed area and outlines in red the proposed boundaries of a housing development. A private enterprise has proposed a commercial strategy focused on local sustainable development. The project's goals include preserving the area's aquatic and riparian environment and habitat, while conforming to Brazilian federal legislation by maintaining the 30 m of APPs on the river's shore. This will be achieved by constructing a linear park along the water resource, which not only protects and preserves aquatic and riparian habitat, but also enhances the quality of life of the area's future residents. According to Maculan [11], this proposal by the private enterprise would be characterized as a morphological transformation, consisting of a change in the use and occupation of the land from agropastoral production to urban land.

Ecological relationships exhibit a low degree of negative Leopold impact on the environment. The native forest identified in Fig. 3 formed due to the presence of water resources, and provides a natural form of protection for those same water bodies.

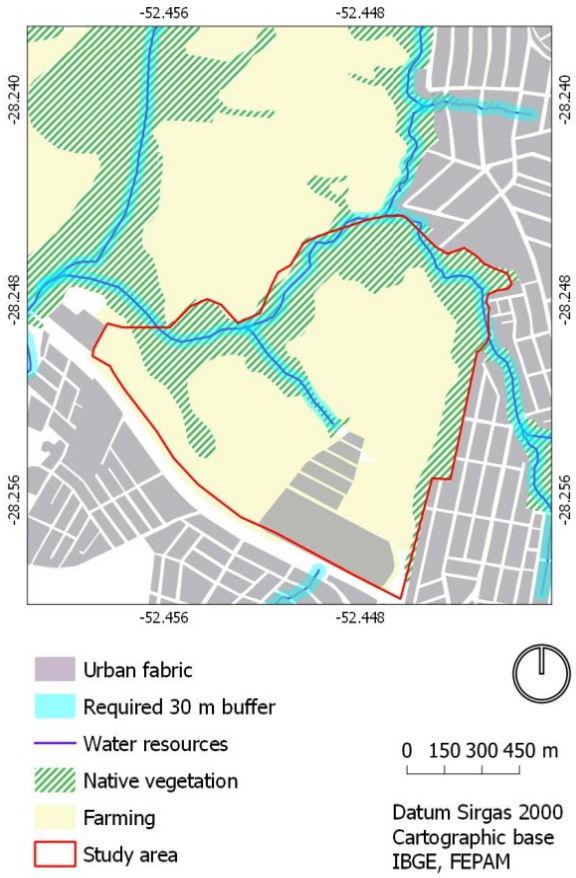

Fig. 3 Land use in the study area.

Adequately addressing the needs of man, environmentally and economically, is necessary in order to replace unsustainable methodologies of development of the past with behaviors that minimize negative impacts on the environment [13]. An important tool in recognizing these potential negative impacts is the environmental impact assessment, used in many studies, as well as to support practical initiatives and decision making [10, 11]. Ensuring adequate environmental education of the local population also contributes to the minimization of environmental impacts, fostering people's commitment not only to the local environment, but also to the global environment [14, 16]. The sustainability of the proposed development is anticipated to be a large marketing factor once complete. Knowledge of the importance of sustainability drives consumer demand for sustainable products and services.

4. Conclusion

This research made it possible to report the importance of an analysis of environmental impacts, highlighting the environmental concerns in an effort to create future public policies policing urban expansion of the City of Passo Fundo; demonstrating that it is possible to stimulate housing projects and sustainable development in a controlled manner which respects existing Brazilian federal legislation.

The study area, on the edge of the existing city, is certain to one day undergo urbanization, but by doing so utilizing a plan that incorporates the preservation of existing water resources and riparian habitat, the overall impact on the environment can be limited. In addition to this, the authors suggest monitoring of atmospheric pollution is the vicinity due to its proximity to a major highway.

Anthropogenic actions often result in environmental impacts; however, environmental damage does not necessarily have to be the result. Accurate planning and designs that incorporate sustainability into development can minimize environmental impact overall.

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