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EVALUATION OF NEIGHBORHOOD IMPACTS CAUSED BY COMPANIES OF THE HIGH-TECH INDUSTRIAL CLUSTER OF SÃO CARLOS, SP, BRAZIL

José A. de Lollo[1*], Sergio Antonio Röhm[2], Thais H. Martinetti[2]

[1]*Urban Engineering Post-graduation Program, São Paulo State University at Ilha Solteira, Brazil*
[2]*Urban Engineering Post-graduation Program, São Carlos University, Brazil*

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Abstract: The purpose of this study was to develop a methodology for evaluating neighborhood impacts using a Geographic Information System (GIS) and to apply the procedures to the companies of the High-Technology Industrial Cluster of São Carlos. To this end, an evaluation was made of the neighborhood impacts on the physical environment, urban components, quality of life, and urban infrastructure using impact matrices, and the impacts were assigned scores according to type, order, magnitude and duration. Fifty-one companies were examined based on data provided by the companies themselves and on field surveys. The impacts are represented spatially in proportional symbols maps, based on the spatial distribution of the companies in the urban area of the city of São Carlos and the areas of influence of each company. The application of the proposed methodology served to validate it and indicated that the neighborhood impacts caused by the companies of this study are related to each company's type of activity, its size, and its occupation of the area.

Keywords: Urban planning; Law 10257/01; neighborhood impacts; industry impacts; high-tech cluster

* Correspondence to: José Augusto Lollo. E-mail: lolloja@dec.feis.unesp.br.

INTRODUCTION

Disregard for proper technical criteria has caused innumerable conflicts concerning the use of urban land as well as major impacts on the population, leading to serious social and economic losses and major obstacles to new proposals for land use. Studies involving impact identification and assessment in land use proposals for civil engineer works and projects have become increasingly common in Brazil. However, there are no specific methodologies or techniques to assess impacts in urban areas, a situation that can be considered to result from the following factors: lack of specific legislation, little technical experience in such activities, and lack of data for such analyses.

The term Neighborhood Impact was created to describe a specific set of environmental impacts that can occur in urban areas as a result of the establishment and operation of a given company, and which are manifested in the area of influence of that company.

The need to define a new class of impacts emerged because the Brazilian environmental legislation that deals with environmental impacts limits the obligation of carrying out Environmental Impact Studies and writing Environmental Impact Reports to urban enterprises of significant dimensions (large housing complexes and airports, for instance), or to typical rural or suburban areas (highways, railroads, dams, mining projects).

Therefore, suitable alternatives are required to characterize and analyze the impacts resulting from urban land occupation of smaller spatial dimensions, but which represent significant modifications in the conditions of the urban environment (e.g., supermarkets, shopping centers, large commercial or residential buildings).

The legal gap concerning this subject was covered through the promulgation of Law 10257 of July 2001 (Brazil, 2001), which adopts the Neighborhood Impact Study as a mechanism of impact assessment.

Neighborhood impacts represent a Brazilian particular approach treating urban environmental impacts. In other countries this kind of environmental impacts hasn´t specific legal regulations or analysis procedures, being considered as common environmental impacts.

In these situations specific urban impacts related to Brazilian neighborhood impacts receive particular treatment only in limited situations as shopping centers (Ambience Developers Private Limited, 2006) and supermarkets (Friends of the Earth, 2005; City of Fairfield, 2008).

Although the Neighborhood Impact Study already existed as an instrument of analysis for over ten years prior to Law 10257 in Brazil, its use (with this or another name) has been restricted to large cities such as São Paulo, Porto Alegre, Campo Grande and Natal, characterize impacts resulting from the implementation of large projects such as shopping centers, commercial buildings, and hypermarkets.

Neighborhood Impact Studies involve the identification, appraisal (if possible) and analysis of neighborhood impacts foreseen for a given proposal for urban occupation. In the opinion of Moreira (1997), a Neighborhood Impact Study should contain: (a) a characterization of the enterprise, (b) a characterization of the neighborhood, and (c) an assessment of the impact of the enterprise on the neighborhood.

In a Neighborhood Impact Study for a private housing estate in Niterói, and considering the municipal legislation on the subject (Technical Instruction # 004/2003), it was proposed a three-level classification of impacts in the area: (a) based on consequences (positive or negative), (b) based on scope (direct or indirect), and (c) based on intensity (high, medium and low).

Moreira (1997) summarizes the factors considered in 26 neighborhood impact studies he analyzed in the city of São Paulo, describing impacts produced by the following factors: water, sewage, electric power, drainage, gas, telephony, roads, public transport, urban landscape, and natural resources. He also evaluates the urban transformations resulting from the establishment of the enterprise.

What can be observed in the great majority of cases is that neighborhood impact studies are restricted to legal aspects, and sometimes even those are not taken into account properly or completely. The characteristics of the company and the neighborhood in question are rarely taken into account.

In the opinion of Moreira (1997), “the imposition, on the entrepreneur, of corrective and/or compensatory measures to offset the impacts produced on the road system, urban infrastructure, urban landscape, and on the existing human activities” is one of the most important regulatory instruments in the struggle for locations in the urban space.

Moreira (1997) points out that the final product of a Neighborhood Impact Report should include: (a) a demonstration of the compatibility of the road and transport system with the enterprise; (b) a demonstration of the compatibility of the drainage system with the increase in the volume and rate of rainwater drainage resulting from paving the area of intervention of the enterprise; (c) a demonstration of the viability of water supply, sewage collection, and electric power supply; (d) an indication of the urban transformations caused by the enterprise; and (e) the insertion of the works in the landscape. He also points out that the reports he analyzed were deficient in that they failed to meet these requisites.

The deficiencies found in neighborhood impact studies usually carried out in Brazil can be divided into

and deficiencies resulting from the way in which the works are conducted (Lollo & Röhm, 2005a). The main legislation-related deficiency is the simple application, on the part of municipalities, of the content of Articles 36 and 37 of Law 10257/2001 without an analysis of the environmental components considered important for the municipality in question. Due to its generic nature, the content of the law is vague concerning several environmental factors such as "urban and community equipment", and "urban landscape and natural and cultural heritage".

With regard to "urban and community equipment", special attention should focus on the diversity of infrastructural devices that may suffer impacts, such as public roads, public services of garbage collection, treatment and disposal of solid and liquid wastes, public water supply systems and urban drainage and service networks. As for "urban landscape and natural and cultural heritage", it is common for municipal legislation and, hence, for the studies resulting therefrom to consider only aspects of the historical and artistic heritage and landscape, without due concern for the protection of the components of the physical environment.

The deficiencies in technical analyses consist of incorrect or incomplete assessment of the characteristics of the company and of the neighborhood in question. The company to be evaluated should be well characterized with respect to its nature, size, and proposed land occupation. As for the neighborhood, it is fundamental not only to characterize its current environmental conditions but also to properly outline its spatial dimensions as a function of the area of influence of the company. Thus, the neighborhood's dimensions should be suitable for the characteristics of the company according to the latter's size and nature, and especially to its foreseen impact.

Neighborhood Impact Studies that fail to adequately describe or assess the conditions of the enterprise, the neighborhood, or the components that may be subject to impact lead to negative consequences in four ambits, namely: for the environment, for the neighborhood population, for the population in general, and for government.

The adverse consequences for the environment include all forms of degradation, contamination or pollution that may impair the quality of the environmental components. These effects can be felt locally (in the neighborhood in question) or, if not properly monitored and treated, they can extend beyond the neighborhood, compromising the environmental quality of other areas. This is particularly true with regard to the contamination or pollution of air and water (underground and surface), since they circulate, transporting harmful substances to areas outside the neighborhood in which they were discharged.

This also applies to improperly discarded solid wastes, be it garbage, industrial waste, or construction waste. These wastes may be discarded in other areas, thus becoming an impact factor in areas beyond the neighborhood of the company. For the population of the neighborhood, the lack of previous detection of impacts precludes the adoption of control, mitigation or even compensatory measures, exposing the population to the harmful effects of the interventions of the enterprise in the environment.

In addition to the obvious inconveniences, this situation may lead the neighborhood's population to assume an attitude of animosity towards the enterprise and the public authorities, which makes the subsequent management of the problems more difficult and may even lead to legal action, further eroding the relations among the actors of the process.

When a parcel of the municipality's urban area is degraded, the neighborhood impacts are already, indirectly, a problem for the entire population. However, by extending beyond the boundaries of the area of influence of the enterprise, these impacts directly affect other portions of the municipality.

By demanding the prioritization of public resources for corrective activities, these effects reach the municipal budget, precluding other investments of interest to the general public. For the public authorities, in addition to the degradation and devaluation of parts of the municipality and the need for investments to correct these negative effects, the absence of previous identification of neighborhood impacts means the loss of a great opportunity for demanding investments in compensatory measures from the entrepreneur responsible for occupying the land.

Because of the normative and generic nature of Law 10257 and the meager efforts of municipalities to make advances in legislation on neighborhood impacts, a major obstacle in neighborhood impact studies is their subjective nature, which makes it difficult to establish clear criteria for impact appraisals and classification.

One way to reduce these problems would be the adoption of proper procedures and computerized techniques to collect and analyze information, which would allow for simplicity and precision in the collection and storage of information, as well as the possibility of objective analysis and the proposition of normative instruments for analyzing urban occupation, the standardization of a mechanism of analysis, at low costs and with operational simplicity. Based on this vision, we consider here the use of a geographic information system (GIS), which combines the precise definition and representation of the spatial distribution of impacts with flexible recording and analysis of data in a database. To test this system, the process was applied to the urban area of the city of São Carlos, analyzing areas surrounding the sites where companies of the High-Tech Cluster of São Carlos are established.

This city was chosen because its presents a significant occupation by high-tech companies with significant possibilities of transformation of the use of urban land resulting from the implementation of the High Technology Cluster. These companies were selected because they represent specific characteristics that highlight their importance in the urban area, such as their spatial dissemination, their size and the varied nature of their activities.

The activities developed in this study were aimed at achieving the following objectives: (a) develop a system of collection, treatment and representation of information concerning impacts in neighborhood impact studies; (b) propose mechanisms for recording, updating and analyzing information of interest for impact assessments, using GIS; (c) identify, evaluate and spatially represent the neighborhood impacts produced by companies of the High-Tech Cluster of São Carlos.

METHODS

Selection of Companies

The selection of the companies to be studied was based on three basic criteria: (a) the possibility of identifying neighborhood impacts occurring during their establishment or during the execution of their activities; (b) the companies should present characteristics that allow for their classification as technology-based companies; and (c) they should be located in an urban area.

Physical Environment Components

The starting point for the selection of the components to be considered was Law 10257/2001, but this law is quite limited in its definition of the environment to be evaluated, even more so when it comes to the physical environment. Therefore, generic terms of Law 10257/2001, such as “natural heritage”, needed to be detailed in order to describe environmental components that would allow for easy identification and evaluation. Thus, the factors foreseen in the law were expanded and detailed based on the literature dealing with environmental impacts and on experience with the reality analyzed, which resulted in the set of neighborhood impacts described below.

Soil Part of the activities of the establishment and operation of companies may be responsible for the occurrence of significant impacts on the soil, or may generate indirect impacts on other components (such as water), as a result of impacts on the soil. In the case of neighborhood impacts, this only makes sense if the building in which the company carries out its activities has been constructed for this particular purpose (so the impacts would have been generated during its construction) or if the renovations or adaptations the ground. With regard to the processes of physical degradation, surveys should include earthmoving activities (excavation and landfill), the need for auxiliary works or for their containment, erosion and silting processes and the effects of these interventions on the environmental quality.

Rock In this case, also, the process of land occupation (especially when it involves excavations for construction or to mining for rock as a raw material) may cause processes that directly degrade subsoil rock or, as a consequence of rock degradation, lead to indirect impacts on other components of the physical environment.

Relief Alterations in the local relief of the terrain may impair its visual quality and create secondary impacts on the circulation of surface and subsurface waters, since they alter the surface declivity and the thickness of materials in the subsoil (especially soils). This may lead to physical (erosion, silting and flooding) and chemical degradation (water contamination). The attributes to be surveyed include surface steepness, relative position in landform (top and middle of a hill, or floodplain, for instance) and its influence on processes that may cause neighborhood impacts.

Natural landscape In this case, the evaluation should focus on the impacts resulting from to the establishment of the company that have destroyed, degraded or altered the natural landscape, considering this as the composition of variables of the physical environment that are expressed in the form of visual landscape. The existence of natural landscapes of special interest should be checked through field surveys, as well as the effects of the establishment or expansion of the company on these landscapes.

Vegetation The conditions of implementation or of subsequent modifications of the company may be responsible for the degradation or elimination of vegetal species whose size, species or benefits justify their preservation. The surveys should identify the removal of vegetal species, their type and number, as well as identify initiatives for the reposition of the vegetal cover through reforesting, gardens, and other means.

Land use The presence of the enterprise may cause impacts on land use and occupation insofar as it introduces other occupations of various natures that are related with the enterprise. Surveys should consider the most common urban uses (residential, commercial or industrial), as well as other uses that may occur in areas of transition between urban and rural (natural vegetation, farming, grazing, reforestation) and the implications of these types of occupation on the

Surface water Water bodies in the proximities of the company in question may be affected by it in various ways: silting, discharge on rain drainage water from the company, discharge of sewage from the company, use of water bodies for the disposal of removed earth**,** pollution or contamination through contact with the company's industrial wastes. Surveys to identify the existence of such water bodies, their distance from the company, and the type of relation they have with the company's activities are fundamental in order to verify to what extent the existing losses in water quality are related to the company's activities.

Groundwater It is essential to characterize the effects on the local aquifer resulting from the company's activities, which involves the verification of signs of underground water contamination and pollution through the company's industrial activities and wastes. Information should be obtained about the local aquifer (depth and water quality data) and the company's potentially impacting activities for this aquifer. It should also be ascertained if the company has a well which draws from the aquifer in question and the operating conditions of that well.

Urban environment components

Population density With regard to densification of the population directly attributable to the company, we considered the number of people who moved to the neighborhood because they work in the company. As for the "indirect" densification of the population (people who moved into the area due to benefits resulting from the company's presence), we took into account the company's area of influence.

Urban density In this case, too, the definition of the area of influence is essential for new occupations related to the enterprise under analysis. With regard to the building in which the company is installed, one should consider the increase in constructed area that this occupation has occasioned, in terms of both occupied area and expanded area resulting from the establishment of the company.

Real estate valuation Increased or diminished interest in real estate properties in the neighborhood as a result of the establishment of the company should also be ascertained.

Natural ventilation and light Also to be evaluated are the construction characteristics of the building (construction or remodeling related to the company) and of the neighboring houses and their spatial relation to the company; the dimensions of the area of influence will depend on the number of floors of the company building and the number of floors of neighboring

Urban landscape This survey involves the identification of aspects of the urban landscape that may be affected by the occupation in question. Information should be collected to ascertain if the company building or its state of conservation causes partial or total obstruction of the urban landscape.

Cultural heritage This involves identifying the heritage of interest and ascertaining its relation with the company, or verifying if the building in which the company is installed should not be characterized as a cultural heritage, as well as ascertaining its state of conservation.

Urban transformations This subtitle should encompass transformations wrought on the urban landscape through the establishment of the company, but which are unrelated to urban infrastructure and services (these aspects will be discussed in another set of information). The transformations to be considered are: urban densification, land use and occupation, changes in the urban plan, and expansion of urban occupation.

Quality of life components

This aspect comprises a set of activities of the company, or which are related to it, which directly affect the quality of the environment's resources (water, air and soil) and which are especially related with process and waste management.

Noise emissions The purpose here is to identify the occurrence of noise emissions, their intensity, and measures of control or protection for people adopted to minimize their effects.

Garbage Information concerning the management of solid wastes not included in the company's list of industrial, harmful or pathogenic wastes. This includes, especially, wastes from office services and the company's kitchen, cafeteria or restaurant, and should include all the aspects of their management, from their generation to their final disposal.

Sewage Like garbage, another set of information to be evaluated concerns the impacts due to the management of organic liquid wastes (sewage). And, as in the case of garbage, these are attributes related to the company's waste management plan.

Industrial waste If the company's productive process generates any type of industrial waste, an evaluation should also be made of its management to verify if is treated, recycled or reused, and how it is disposed of.

Contamination and pollution Contamination or

actions presupposes that the company in some way disposes some type of waste on its property or in its surroundings. The data to be collected concerning this aspect involves information already garnered for the different types of wastes existing in or generated by the company, added to information about the possible emission of gases by the company.

Urban infrastructure components

This set of information evaluates the impacts that the presence of the company has exerted on the urban infrastructure and services. The following components were listed for the companies of the High-Tech Cluster of São Carlos.

Generation of traffic A description should be made of the traffic expected in the company's proximities due to its existence, comprising employees, clients and suppliers, taking into account the times of peak traffic in light of local conditions.

Demand for urban transportation The need for public transportation for the company's employees and the demand for urban transportation generated by the company for clients and suppliers should be evaluated.

Utility Systems This aspect involves ascertaining the past and current conditions of the supply systems of services such as water, sewage, rainwater drainage, electric power, telephony, and street lighting, as well as banks, post offices and other services. If changes have been required, it is essential to also determine if the costs of these adaptations were covered by the company in question or by the municipal administration, and what problems or advantages these changes represent for the population.

Parking The co8mpany's parking needs involve the vehicles of its employees, suppliers and clients. In the absence of such services, vehicles will be parked on the street, possibly hindering neighboring activities.

Security The establishment of the company may be a factor that causes security problems for the neighborhood. The region's public security needs should be identified, as well as their relation with the establishment of the company, the resources allocated to deal with the problem and the source of these resources.

Impact assessment

In this work, the impact matrix was chosen among the various available impact assessment techniques due to its agility, simplicity and flexibility, which allow for the survey and assessment of impacts. This technique was originally proposed by Leopold (1971) and is widely used for the rapid identification and evaluation of environmental impacts.

The basic proposal of an impact matrix consists of cross-checking proposed actions against environmental factors and of attributing values to these cross-checked actions (which characterize the environmental impacts) that represent the relative importance of the impacts.

In the present work, this structure was validated, although it was subjected to a few modifications due to the peculiarity of the neighborhood impacts. These modifications involve the classification of the impacts, the basic structure of the matrix, the phases of the enterprise and the correlated interventions, as well as the environmental components evaluated (Lollo & Röhm, 2005b).

The neighborhood impacts to be evaluated in the matrix were classified according to their nature, order, magnitude, and duration. The nature of the impacts was classified as positive (beneficial) or negative (deleterious). In terms of order, the impacts were divided into direct (causes clearly related to the company's actions), and indirect (causes not related solely to the company's interventions).

As for magnitude, the proposed classes were: high (alterations that change the characteristics of the environmental component); low (alterations of little significance, intensity, or complexity of the component in question), and medium (alterations of the environmental component of a magnitude such that they affect its function without changing its characteristics).

With regard to duration, the impacts were divided into permanent (indicating the absence of an end to the intervention or of a foreseen technology to control or remediate the impact), and temporary (a condition which involves a foreseen deadline for its end, either of the execution of the works or through the availability of a control technology).

In the present proposal, we have suggested as far as possible to avoid the definition of impacts as temporary ones, unless their temporariness is absolutely certain (e.g., interventions that occurred only during the construction of the company). In dubious situations, in which "there might be a solution within some time", the impact should be considered permanent.

In terms of its structure, the proposed matrix preserves Leopold's original idea, but with a few adaptations aimed at aligning the matrix to the reality of the proposed work.

Thus, the structure contains the categories of information (aspects of occupation, its consequences, the evaluated environmental components, and the foreseen mitigating and compensatory measures) in columns, while the actions themselves are described and their impacts evaluated on the lines of the matrix.

After the evaluation of the impacts, the next step consists of establishing the values for each consequence

indirect), magnitude (high, medium, low) and duration (temporary or permanent). For each of the described conditions, values (weights) were established that considered the relative importance of the impact, thus allowing the impacts to be appraised. The values adopted are presented in **Table 1**.

The definition of the value for each of the possible answers in the data survey questionnaire enabled us to establish a scale to quantify the surveyed data.

Influence areas definition

The delimitation of the area of influence of each company is crucial for the correct assessment of the effects resulting from the neighborhood impacts and their implications in the conflicts of urban land use. This delimitation depends on: (a) the conditions of the space under consideration; (b) the occupation in question; and (c) the impact analyzed.

Thus, an in-depth analysis is required of the interventions and the environment in question in order to establish specific criteria for the definition of the area of influence of each factor. In the case of this study, the determining factors for defining the area of influence are the one relating to traffic and parking, since they are aspects of a broader scope.

With this philosophy in mind, the areas of influence were defined based on the greatest distance from the central point facing the urban parcel where the company is located to the largest street or avenue offering adequate conditions to accommodate the traffic generated by the company, without significantly affecting on the local traffic.

The areas of influenced were then defined in Spring as circular “buffers’ with a radius of 50, 100 and 200 meters around the company, with 200 meters determined as the highest value of important area of influence. These “buffers” are distinguished not only by their dimensions but also by the following colors: 50 m - red, 100 m - blue, and 200 m - pink.

RESULTS

The quantification of the physical environment resulted in a set of values that, for the companies studied here, represent the influence each of them exert on the environmental quality of their neighborhoods and that indicate how the characteristics of the companies and the groups to which they belong affect the final result.

Table 1. Values adopted for impacts evaluation

	Classes	Values
Order	direct	3
	indirect	1
Magnitude	high	3
	medium	2
	low	1
Duration	permanent	3

Table 2. Neighborhood impacts assessed

Company	Physical	Urban	Quality	Infrastructure
IT-21	16	5	15	15
IT-1	18	9	15	8
IT-2	14	0	15	15
EL-1	35	63	74	42
IT-4	23	10	15	15
IT-6	23	33	15	1
IT-7	28	31	15	15
OT-1	34	46	72	23
CE-4	12	41	65	25
IT-11	17	0	15	1
MD-2	25	53	46	19
BI-1	19	23	63	25
EL-2	14	31	70	30
CE-5	16	67	45	39
MC-2	26	33	66	41
IT-17	25	5	15	1
OT-2	19	30	46	12
IT-19	23	25	15	15
IT-20	17	15	15	1
MD-5	33	11	73	26
IT-27	19	5	15	15
IT-25	17	0	15	1
IT-28	25	5	15	15
BI-3	10	33	63	25
MD-4	19	59	45	24
IN-4	46	44	63	42
IT -31	22	9	15	15
MT-2	14	36	73	19
IN-5	14	34	35	36
IT -35	14	30	15	14
IN-6	19	18	46	32
IT -36	13	26	15	15
EL-5	16	0	63	24
IT -34	20	32	15	1
IT -37	17	12	15	14
OT-3	29	47	64	42
PQ-1	33	38	63	35
MT-3	31	31	73	27
IT-41	19	5	15	15
IT-44	23	28	15	15
EL-6	16	5	34	46
IT-48	17	7	15	15
EL-7	14	23	63	26
MT-4	54	41	73	41
IT -50	22	11	15	15
IT -47	18	7	15	15
IT -49	25	10	15	15
CE-2	6	12	39	15
EL-8	24	25	66	16
EL-10	14	23	68	41

IT – information technology, EL – electronics, OT – optics, CE – ceramics, MD – medical and dental equipment, BI – biotechnology, IN – instrumentation; PQ – ParqTec Foundation (incubated companies in the Cluster).

These results are listed in **Table 2**, which shows the total of the values obtained for each class of attributes, while the companies are identified by codes that

attributed to them according to their listing in alphabetical order.

Spatial distribution of companies

An interesting aspect to note with respect to the companies of this study is that their distribution is not scattered throughout the urban area of São Carlos, but concentrated preferentially in certain regions of the urban area. This distribution is due basically to two factors:
(a) The larger and more recently established companies tend to be concentrated in areas destined specifically for this type of occupation, such as industrial districts. These concentrations are located in the northern and northwestern portions of the urban area.
(b) The smaller companies, especially those specializing in services (such as information technology firms) are concentrated in the central region of the urban area, where there is a greater commercial concentration.

The former case (companies located in industrial districts) comprises two groups of companies. The first group consists of twelve companies located in the region known as the "Santa Felicia High-Tech District", which concentrates companies that act mainly in the areas of ceramics, optics and electronics (**Fig. 1**). The second group, which consists of seven companies situated in the "Industrial District III" and its surroundings, comprises companies acting mainly in the areas of electronics and metallurgy (**Fig. 2**).

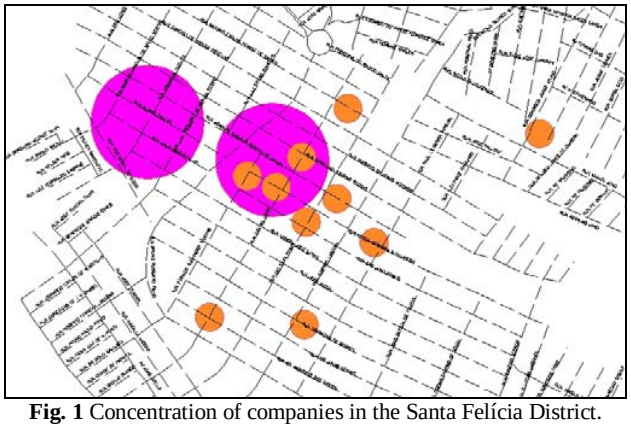

Fig. 1 Concentration of companies in the Santa Felícia District.

Fig. 3 Concentration of companies in the central region of São Carlos.

The latter case (companies concentrated in the city's central region) comprises a group of twenty-one companies, most of them acting in the field of information and instrumentation technology, all of them small to medium-sized (**Fig. 3**).

Another interesting point is the initiative of the ParqTec Foundation (which manages the High-Tech Cluster of São Carlos) to create the São Carlos Science Park, which will tend to attract new technology-based companies to establish themselves there and even companies already operating in other locations to move to the area. This will tend to reduce the neighborhood impacts in the urban portions of the area, since the Science Park's is slated to have its installations located in a region distant from the urban area and destined exclusively for industrial occupation.

Impacts Appraised

With respect to the impacts on the physical environment, it was found that the total values of these impacts are of little significance in relation to the total possible impacts and that some of the impacts evaluated occur on only a few of the companies analyzed. The components least affected by neighborhood impacts on the physical environment are soil, rock, natural landscape, and underground waters. This is due to the fact that the great majority of companies analyzed here is installed in previously constructed buildings, and have therefore not made significant modifications in the components of the environment.

Other neighborhood impacts on the physical environment, however, occur throughout the area, covering most if not all of the companies, and are related with alterations in the destination of urban land use, i.e., vegetation land occupation and use, and surface waters.

Some of the companies present a significantly greater set of neighborhood impacts on the physical environment than the majority. This is due to the fact that these companies are larger, thus generating more substantial neighborhood impacts. This finding is

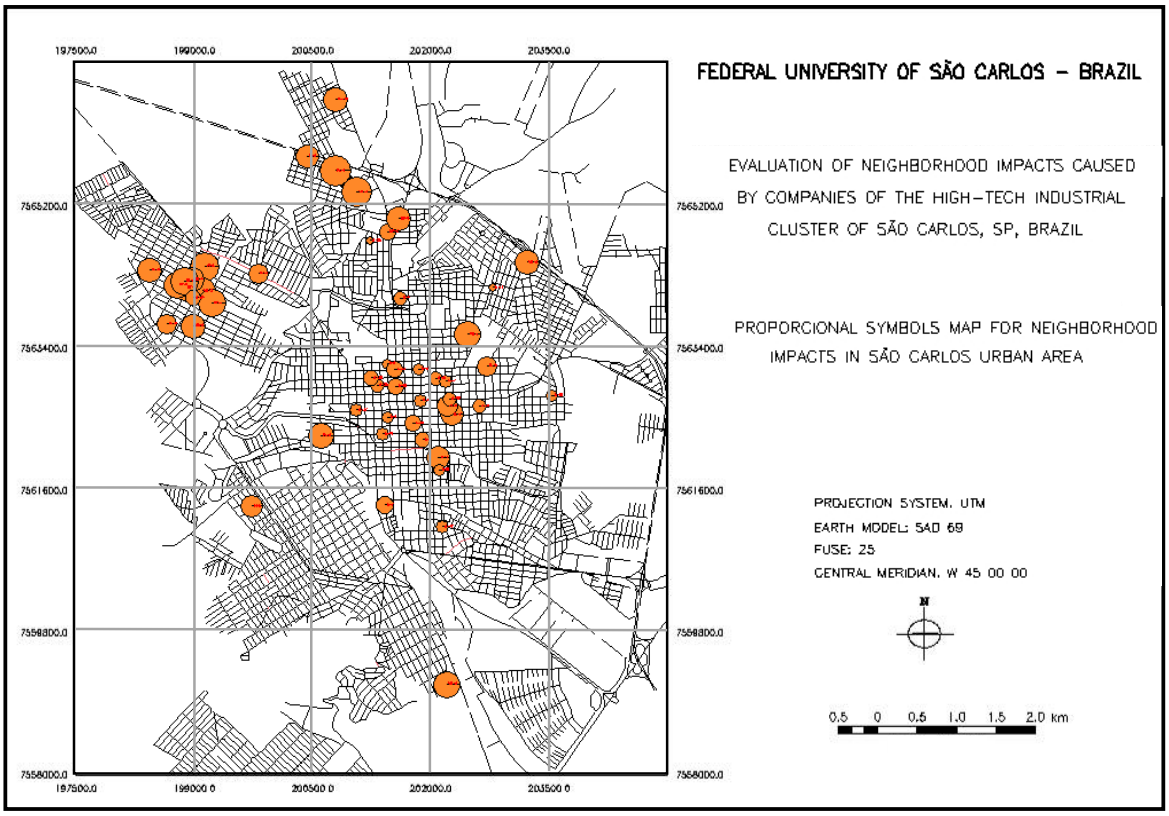

Fig. 4 Map showing proportional symbols representing impacts on the physical environment.

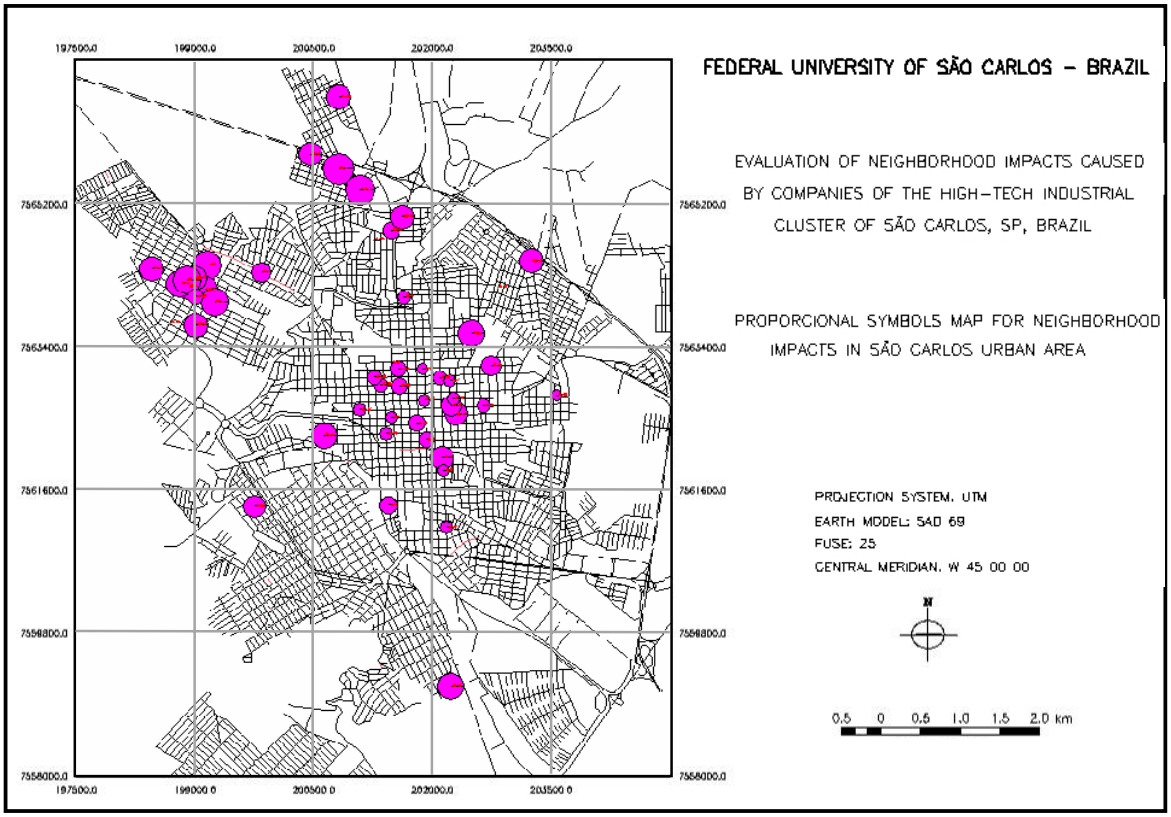

Fig. 5 Map showing proportional symbols representing impacts on the urban environment.

which represents each company's total impact on the physical environment, indicating the companies with the highest sum of impacts on the physical environment highlighted by larger circles. The companies that present the largest sum of neighborhood impacts on the physical environment are the ones whose buildings were constructed specifically for their industrial purposes and which are larger, in terms of both the number of employees and the nature of their activities. These companies operate in the areas of metallurgy and electronics.

The impacts on urban environment where another set of impacts of lesser importance in the general context. The impacts identified with the greatest frequency are urban densification and rising real estate values, which are results consistent with a set of companies whose highest concentration occurs in the central urban area of the city.

A second set of impacts in terms of frequency are the urban transformations and the impacts on the cultural heritage. These results also reflect the tendency for the occupation of more central regions of the urban area of São Carlos by most of the technology-based companies (particularly service providers). In this case, as well, one finds a close and direct correlation between the size of the company and the generation of neighborhood impacts, a situation that is illustrated in the map of proportional symbols in **Fig. 5**.

The set of impacts on the quality of life are strongly concentrated in certain types of impact, such as the generation of noise, solid (garbage) and liquid (sewage) wastes and, hence, impacts related with environmental contamination and pollution.

With regard to noise emissions, the location of these companies in the proximity of residential buildings is the most important factor in generating the impact. However, the intensity of these noise emissions is not very significant and the companies' working hours (daytime) contribute to diminish the problem.

As for garbage and sewage, the main problem is the demand the companies represent for such services from the municipal administration, since they all depend on the public management systems of such wastes. This is a common reality in Brazilian municipalities, which do not yet have a legal instrument to oblige companies to manage their nonindustrial wastes.

The risks for contamination and pollution occur as a consequence of problems in the management of the aforementioned wastes. **Figure 6** shows a map of proportional symbols for the impacts on the quality of life evaluated in the area.

In terms of impacts on the urban infrastructure there is too a strong concentration of certain types of impacts, especially in the generation of street traffic, a demand for water supply system, street lighting and services. There are two realities here: while the impacts on street

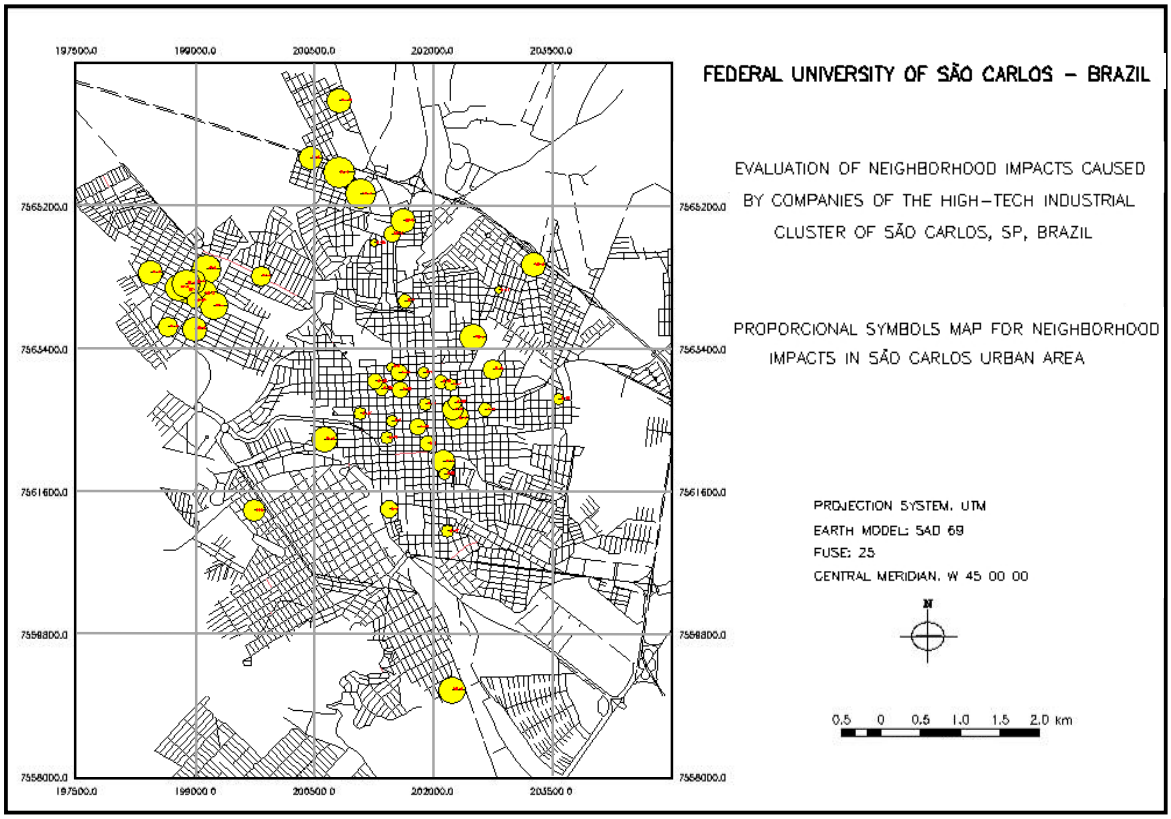

Fig. 6 Map showing proportional symbols representing impacts on quality of life.

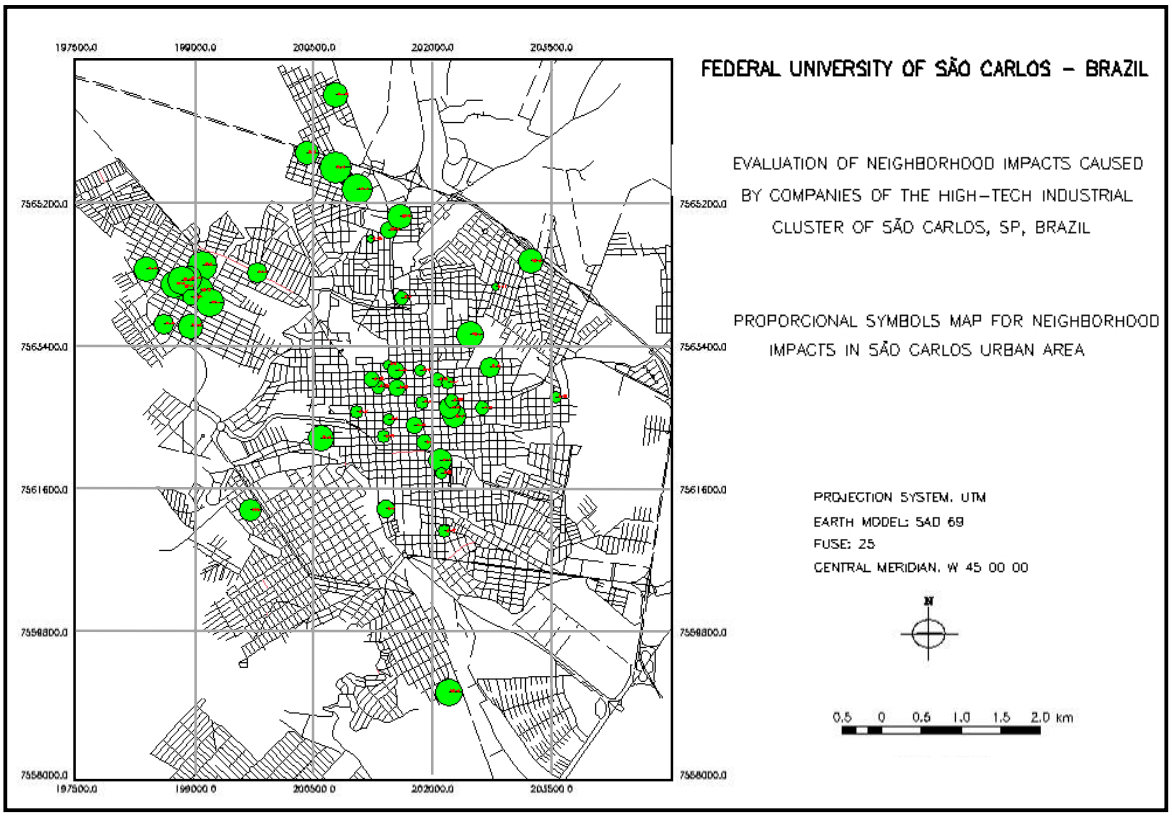

Fig. 7 Map showing proportional symbols representing impacts in urban infrastructure.

traffic and on the water supply system are the consequence of the central location of a good part of the companies of this study (especially the smaller ones, which provide services), the demand for street lighting and services are characteristics of the larger companies located in the industrial districts. The distribution of impacts on the urban infrastructure is illustrated in the map of proportional symbols in **Fig. 7**.

An aspect worth noting with regard to the neighborhood impacts detected in the area is that the impacts with the highest intensity and concentration occur at the companies situated in the two industrial districts that house technology-based companies, namely the Santa Felícia District and Industrial District III.

Although this situation is favorable inasmuch as it means fewer and lesser impacts on the city's more central and populated areas, it indicates the existence, in the city of São Carlos, of areas with greater needs for attention and investment by the local government in order to discipline urban occupation and reduce neighborhood impacts.

An interesting solution for this situation would be the occupation of the São Carlos Science Park, which was designed precisely to receive this type of company, but up to the time the survey for this study was made, most of the companies consulted showed no interest in moving to the Science Park.

FUTURE PERSPECTIVES

In terms of GIS application, neighborhood impacts evaluation is a recent and still simple procedure. In this paper, we only use circular buffers to characterize influence areas and proportional symbols maps to present neighborhood impacts magnitude. Obviously, GIS presents more complexes alternatives for studying neighborhood impacts.

In terms of influence area definition, other geometries (as squares, rectangles or ellipses) can be used beyond circles for representing uniform or non uniform impacts distribution in space. Its applications can be especially interesting when certain impacts (i.e. generation of traffic, parking, or noise) present spatial anisotropy.

Calculating neighborhood impacts also can be done in different ways which used in this article. Alternatives using different weights for impacts or impact groups can be useful when discussing costs or decision maker for impacts reduction alternatives.

Ways of impacts interactions, indirect or secondary impact assessment, influence areas overlap, artificial intelligence based analysis methods, and support decision systems represents a list of GIS applications to be tested.

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