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MANAGEMENT MODEL FOR CONSERVATION CONDITIONS OF INFRASTRUCTURE AT UNIVERSITY USING GEOGRAPHICAL INFORMATION SYSTEM

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Abstract: Public or private built heritage requires the conservation of infrastructure, and it is up to the responsible managers to survey, analyze and make decisions for the maintenance of heritage conservation. The Geographic Information System (GIS) presents itself as a tool to support decision-making by management bodies as it enables the visualization, analysis, correlation and integration of data and information in a geospatial environment. In this study, it is proposed to present the model elaborated for the investigation of the conservation of infrastructure of didactic environments at the State University of Maringá, Pr, using GIS environment. The main campus of the State University of Maringá was used as an area for applying the model. This article addresses only the investigations carried out for classrooms and didactic secretariats. As an investigative tool, a checklist was drawn up, with indications of the presence or absence, quantity and conservation conditions of infrastructure due to pathological manifestations (painting, mold, efflorescence, spalling, fissures, medium cracks and large cracks) on walls and ceilings. Inspections were carried out in order to identify and classify possible manifestations divided into 5 levels ranging from (1) to the worst conditions or non-existence; (2) for insufficiency; (3) for sufficiency; (4) for good condition and; (5) for excellent conditions. Through spatial and statistical analysis, it was possible to show which percentages and where the classrooms and secretariats are in good or excellent condition, not requiring priority maintenance, and the didactic rooms and secretariats that deserve special attention in terms of maintaining the infrastructure. With the spatial analyzes it was possible to evidence a prevalence of similar conditions for environments of the same building. It was concluded that the model contributes to decision-making by highlighting the conditions of the environments, the prioritization when interventions are necessary, as well as the organization regarding the forecast of the number of employees needed, their specialties and optimization of time and displacement to attend to occurrences of maintenance in nearby locations.

Keywords: Spatial Analysis, university infrastructure, GIS.

INTRODUCTION

In any school environment, there must be a harmonious interaction between physical space and pedagogical activities to provide a comfortable feeling to all those who develop activities there. Thus, the infrastructure of didactic environments is essential for the best performance of the academic community. In this way, the maintenance of buildings both in terms of aesthetics and structure is necessary because, in addition to contributing to environmental comfort for pedagogical development, it guarantees safety in cases of unsatisfactory performance of elements that make up the building.

The periodic inspection of buildings together with the creation of a bank of information on the inspected aspects helps public or private managers in decisions regarding the need for interventions (preventive or corrective maintenance), general renovation or even demolition in extreme cases.

Understanding that the government is responsible for an educational network composed of buildings spatially distributed in neighborhoods, municipalities and states, the GIS comes in handy for managers since it allows the integration of data and information stored in a database with the spatial location of these. Through GIS information and the spatial context in which it is inserted can be analyzed.

Just like municipal, state or even federal school buildings, the State University of Maringá (UEM) is an educational environment that has more than 220,000 square meters of built area, more than 23,000 enrolled students (including undergraduate and postgraduate students) and more than 4 thousand employees (adding professors and university agents). In this way, in order to guarantee the appropriate conditions of the environments for the development of the activities carried out at the University, there is a supplementary management body called the university campus prefecture (PCU), linked to the rectory, and whose purpose is to execute and/or supervise the execution of works, carrying out physical planning, scheduling and carrying out preservation, maintenance and operation work on the university campus, as well as maintenance of equipment and materials.

Linked to the PCU is the Services and Works Sector, which receives numerous requests for services directed to different locations on the campus and with the most varied types of execution, from small to large repairs or even renovations. Currently, these services are registered in order of entry and the teams are then sent depending on the date of the document and availability, both of personnel and financial resources.

This procedure does not become optimized, since the same location, or nearby locations may need the same service, but be executed with a time difference given the input date of the request. Thus, a team that could serve service orders to those locations in a single trip ends up having to travel a greater number of times, increasing operating costs.

Another factor is the types of procedures to be performed. There is no ordering by type of execution or priority in services. Small and medium repairs, whose execution takes little time and low cost, often spend months or years waiting in the queue of many requests.

Periodic surveys aimed at specific purposes of analyzing the conditions of the University's physical environments could contribute to the ordering and management of works and maintenance services. However, information cannot be treated as a set of isolated data without integration, systematization and standardization. Research models for specific purposes are necessary for effective interpretation and analysis for decision making.

However, in addition to the information regarding the conditions of the environments, it is necessary to have spatial knowledge of the information collected, thus enabling the ordering, organization, integration and consequent optimization in the management of requests for services and works

In this context, this article aims to present the results obtained in the elaboration of the investigation model of the infrastructure conditions (pathological manifestations) of didactic environments at the State University of Maringá, Paraná, Brazil using GIS as a tool for geospatial analysis. The model was designed to investigate pathological manifestations (painting, mold, efflorescence, peeling, fissures, cracks and cracks) on walls and ceilings of didactic rooms that serve graduation.

MATERIAL & METHODS

OBJECT OF THE STUDY

The State University of Maringá was created in 1970 and is located in the Northwest of the state of Paraná, Brazil. It comprises the campi of Maringá (headquarters), Umuarama, Cianorte, Goioerê, Diamante do Norte and Cidade Gaúcha.

In search of excellence, the State University of Maringá (UEM), created in 1970, is in constant development, in teaching, research or extension, being necessary that its physical structure accompany this development, so that not only the expansions are evident, but also the conservation and maintenance services. In this scenario, implementing a GIS with the managing body (PCU) meets the demands of the University regarding the management of its physical structure. Thus, to start the implementation of the GIS, a test area located on the UEM headquarters campus, in Zone 07 of the municipality of Maringá-PR, Southern Brazil, was used. For this study, it was delimited only the analysis of the buildings, defined by the institution as "blocks", with didactic classrooms.

In this study, 139 classrooms distributed in 16 buildings (blocks) were analyzed. Each block at the University has an identification designated by an entire numeral or by the composition of a letter and an entire numeral. Classrooms are also identified by entire numerals. (Figure 1).

METHODOLOGICAL PROCEDURES

The methodological procedures were divided into three stages: updating and georeferencing the cartographic base made available by the PCU, and studying the representation of didactic classrooms; definition of the domains and subdomains to be studied, as well as the indicators, criteria of the indicators, and elaboration of the checklist; and structuring of GIS and analysis of the infrastructure of the environments (classrooms).

The cartographic base used in GIS was initially obtained from PCU, however, it was in the Local Reference System and needed updates. The procedures for georeferencing and updating the database have been performed, however, they are not dealt with in this article.

Regarding the representation of the classrooms, since UEM has blocks with more than one floor, it was decided, for the development of this model of implantation of GIS, to represent the rooms in a single floor without taking into account the real location, but the number of rooms per block. In this way, didactic rooms distributed on more than one floor, per block, were represented on a single floor. This procedure meant that the classrooms were not represented in their real dimensions, however, such information was inserted in the database together with the information regarding the floor in which they are contained.

The investigated domains were divided into Environmental Aspects and Pathological Aspects, which were subdivided into subdomains (lighting, ventilation, noise, equipment, convenience and conservation). The conservation subdomain was subdivided into research groups and subgroups (Figure 2). This article deals only with the pathological aspect domain.

The checklist was elaborated with indications of presence or absence for each subdomain, group and subgroup investigated. In the case of presence, criteria to evaluate the quantity and/or quality of the groups and/or subgroups investigated were established.

The quantification and qualification indicators were based on the indicators that the Ministry of Education (MEC) of Brazil uses for the evaluation of higher education institutions regarding the infrastructure of the environments (BRASIL, 2017). They are divided into five levels, ranging from (1), for bad conditions or nonexistence; (2) for insufficiency; (3) for sufficiency; (4) for good conditions; (5) for excellent conditions.

Pathology is the study of situations of occurrence of problems, failures or defects that unbalance the function for which the building was created (Verçoza, 1991). The author comments that this knowledge is as important as the professional responsibility

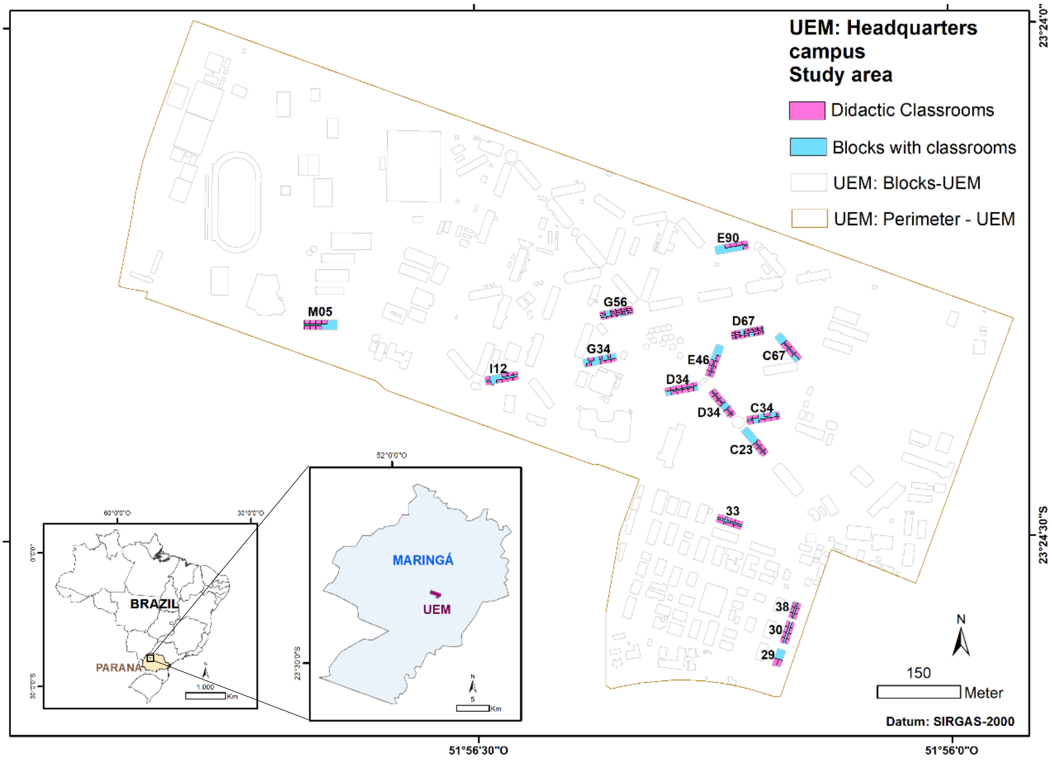

Figure 1. Location of the test area in the context of the Municipality of Maringá, Paraná State, Brazil

Source: Cartographic Base (Brazil and Municipality of Maringá), provided by the Brazilian Institute of Geography and Statistics (IBGE), 2019; Cartographic Base of the University made available by the University City Hall (PCU) and adapted by the authors in 2019.

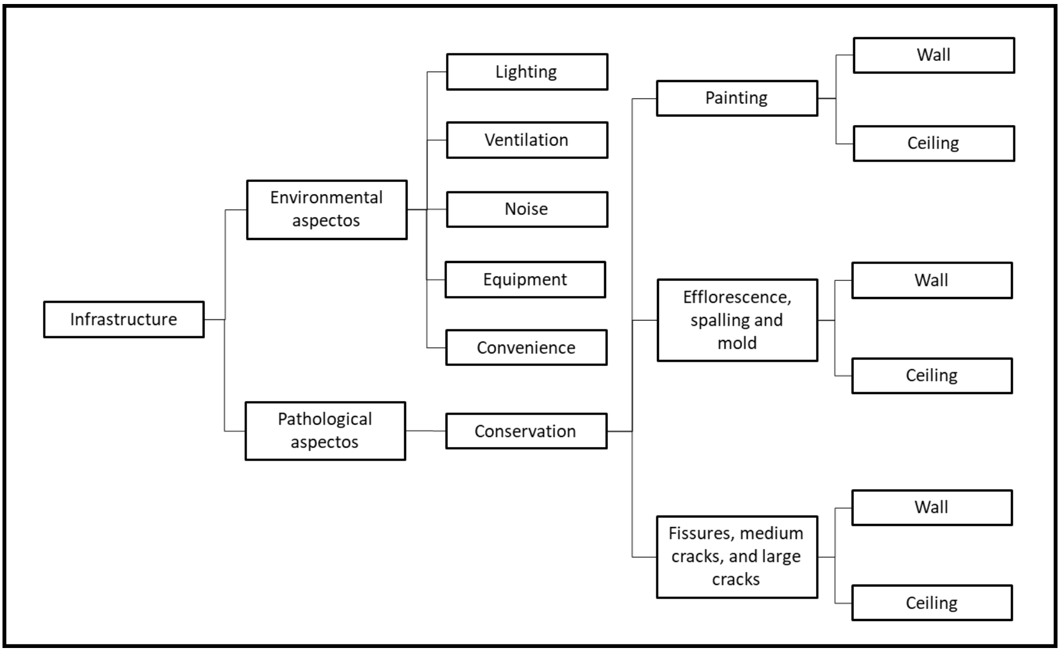

Figure 2. Domains, subdomains, groups and subgroups that compose the investigation of the infrastructure conditions of the didactic classrooms in UEM

Source: own elaboration, 2019.

in the execution of the work. A pathological manifestation in this work is understood to be the result of a degradation mechanism. Such manifestations were identified through an on-site visit and classified according to authors and norms that deal with pathology. (ABNT NBR 15775, 2013; ABNT NBR 6118, 2003; ABNT NBR 9575, 2010; ASTM E632, 1998; Bauer, 1997; Cechinel et al., 2009; Ferreira & Lobão, 2018; Lersch, 2003 C.E.; Oliveira, 2018; Verçoza, 1991).

Once the manifestations of infiltration (classified in efflorescence, mold and corrosion/spalling), as well as cracks (classified in fissures, medium cracks, and large cracks), have been identified, the groups were investigated individually in order to enable managers to diagnose each pathology identified, per room.

Such pathologies were classified as punctual manifestation (a single occurrence in the entire area analyzed), and non-punctual manifestation (more than one occurrence in the entire area analyzed). This criterion was adopted because, once these pathologies are identified, they require an inspection for technical analysis of their real condition and the priorities for interventions.

The indexes and indicators of the group were established from the surveys of each item in the group, taking into account the classification of the type of occurrence (punctual or non-punctual manifestation), and the number of different manifestations in the same environment.

For the painting group, the qualitative aspects of the painting status (cracks, dirt and peeling) were analyzed. The criteria, indexes and indicators for the Conservation subdomain are shown in Board 1.

Finally, the third stage dealt with the elaboration of the database and the structuring of GIS (Software ArcGIS 10.7.1®), as well as the performance of statistical analysis, the elaboration of thematic maps for each group of the subdomain and correlations and analysis of spatial patterns of the results.

GROUPS AND CRITERIA	INDEXES/INDICATORS				
	1	2	3	4	5
Group -Painting; **Criteria** -Qualitative aspect	Nonexistent	Peeled off	Whole, but cracked and dirty	Whole, no cracks and little dirty	New painting
Group -Efflorescence, mold and Spalling **Criteria** Number of manifestation and occurrence	Two or more distinct non-punctual manifestations	One non-punctual manifestation	Two or more specific punctual manifestations	One punctual manifestation	No manifestation
Group – Fissures, Medium Cracks and Large Cracks **Criteria** Number of manifestation and occurrence	Two or more distinct non-punctual manifestations	One non-punctual manifestation	Two or more punctual manifestations	One punctual manifestation	No manifestation

Board 1. Conservation subdomain: groups, criteria, indicators and indexes.

Source: Own elaboration, 2019.

RESULTS AND DISCUSSIONS

The first analysis was carried out for each group in the conservation subdomain, individually. The painting was analyzed both on the walls and on the ceiling.

Regarding the painting, it was observed that the University has managed to keep most of its didactic rooms in excellent or good conditions, whether on the ceiling, wall or window frames. In 18% of the rooms, the walls were in excellent conditions, 70.5% were good and in 11.5%, they were sufficient (16 of the 139 didactic rooms investigated). Regarding the ceiling, in 12.9% (18 didactic rooms), the painting was in sufficient conditions, in 63.3% the painting was good, and it was excellent in 23.7%. In order to analyze which rooms were in sufficient conditions and to verify if there is a pattern of approximation between them, the maps of Figures 3 and 4 were elaborated, showing the spatialization of the conditions of the didactic rooms regarding, respectively, the painting of the walls and the ceiling.

It can be observed that, for the painting of the walls, there was a pattern of approximation depending on the rooms contained in the same block for the same conditions. It was observed that Blocks D34, E46 and 30 presented excellent conditions regarding the painting of the walls, in all didactic rooms. In contrast, Block M05 and C23 presented more than 60% of the rooms in sufficient conditions, *i.e.*, painting the entire wall, but with cracks and dirt. For ceiling painting, the pattern of rooms contained in the same block having most rooms in the same conditions is noticeable, however, for ceiling painting, only Block 30 presented excellent conditions in all its rooms. The blocks with most rooms in sufficient conditions for ceiling painting were G56 and D67.

As for the verification of the group (efflorescence, mold and spalling), for both walls and ceilings, it can be observed that more than 85% of the walls and more than 65% of the ceilings are in excellent conditions, with no pathology), as can be seen in the Graph of Figure 5.

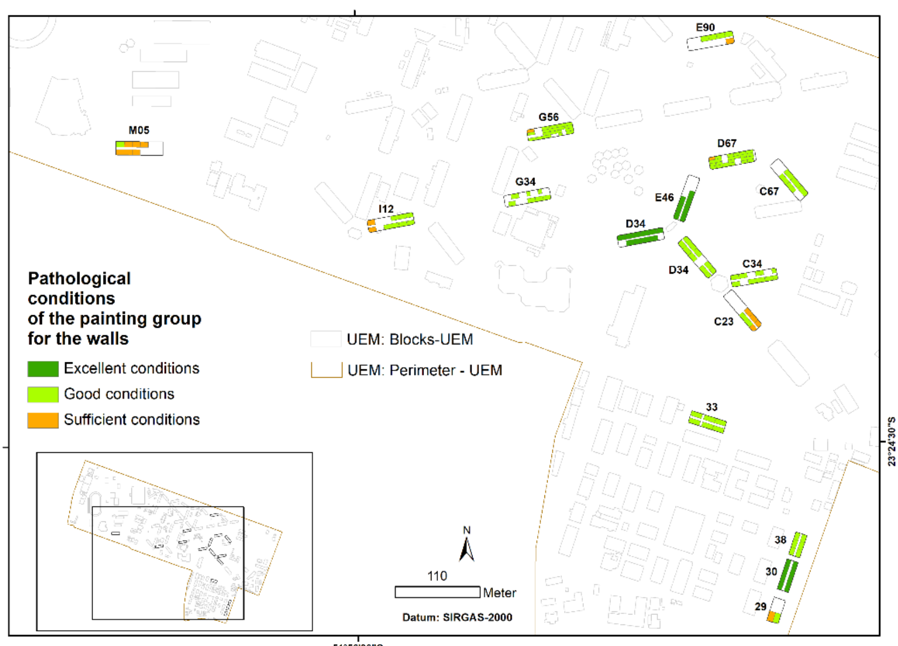

Figure 3. Pathological conditions of the painting group of the classrooms for the walls.

Source: Base adapted from PCU-UEM, 2018; own elaboration, 2019.

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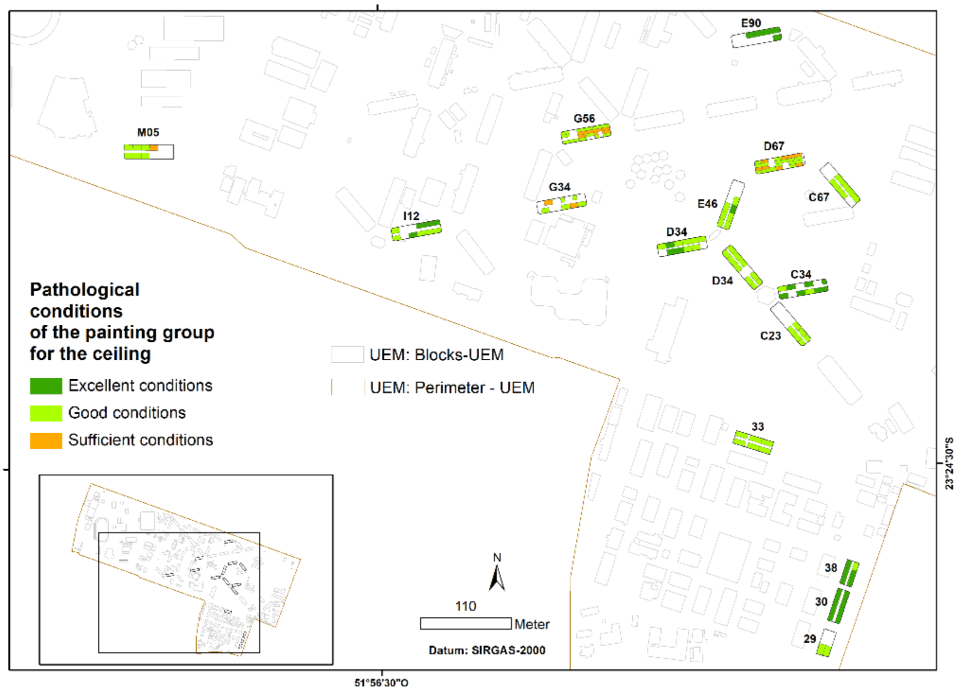

Figure 4. Pathological conditions of the painting group of the classrooms for the ceiling.

Source: Base adapted from PCU-UEM, 2018; own elaboration, 2019.

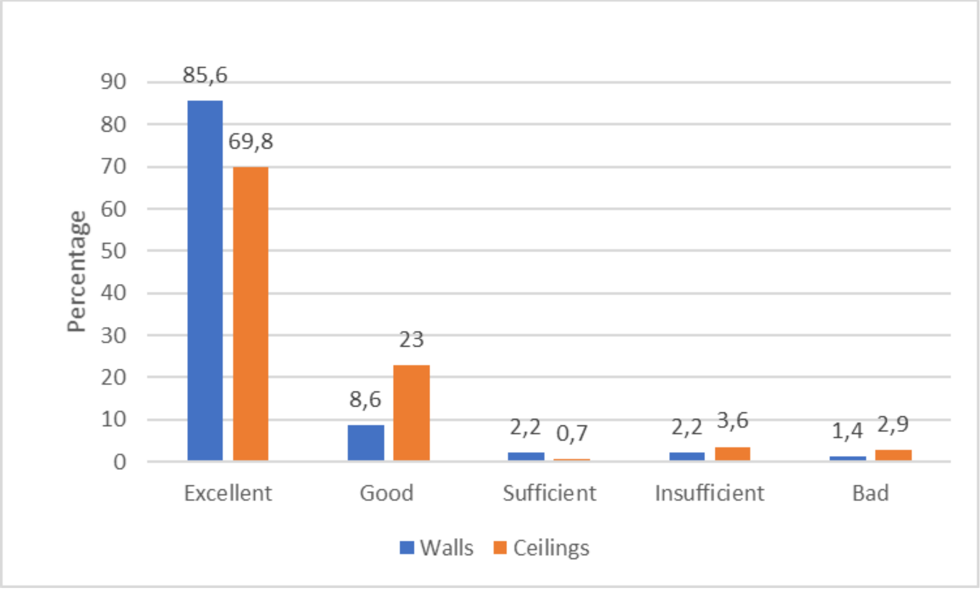

Figure 5. Percentage of the pathological conditions of the classrooms regarding to the efflorescence, mold and spallings group for the walls and ceilings.

Source: Own elaboration, 2019.

Since most of the classrooms were in excellent or good conditions, we elaborated maps with the rooms in which the conditions of sufficiency, insufficiency, and the bad pathological conditions (efflorescence, mold and spallings) were observed, respectively, in the walls and ceiling (Figures 6 and 7).

It can be observed in the maps in Figure 6 and Figure 7 that blocks M05 (regarding the walls) and G56 (regarding the ceiling) are in conditions of insufficiency or bad conditions in relation to the other blocks, *i.e.*, they present two or more punctual or non-punctual manifestations. Of the seven rooms in M05, four of them were in conditions of insufficiency or bad conditions (more than 50% of the rooms), two in conditions of insufficiency and two were in the bad conditions.

In block G56, of the nineteen rooms, eight were in a situation of sufficiency, insufficiency or worse conditions (just over 40%), with one room being in sufficient conditions, four were in insufficient conditions and three were in the bad conditions. Thus, it is understood that such rooms need urgent attention on the part of managers. Again, it is observed that there is a prevalence of equal conditions in the rooms in the same block.

It is noteworthy that classrooms such as the rooms in block 33 were not considered in the evaluation, regarding painting criteria such as efflorescence, stains and spalling of the ceiling, since they have a Styrofoam lining. However, these linings are mostly in need of maintenance.

In relation to the investigation regarding fissures, medium cracks and large cracks on the walls and ceilings, it can be observed from the results presented in the Graph of Figure 8 that the majority (more than 80%) of the rooms were in excellent or good conditions.

Just as it was done for the efflorescence, mold, stains and spalling pathologies, we sought to spatially represent the conditions of sufficiency, insufficiency and bad conditions of fissures, medium cracks and large cracks in order to observe in which rooms and blocks such manifestations were found. The maps in Figures 9 and 10 show the pathological conditions for the walls and ceilings of the classrooms, respectively.

From the Maps in Figures 9 and 10, it can be observed that the events that led to the sufficiency and insufficiency classifications occur concentrated in Blocks M05 and D67, with two rooms in conditions of insufficiency and three rooms in conditions of sufficiency in the walls, and in blocks G34 (3 rooms) and C23 (2 rooms), respectively, in the ceilings. As well as the pathologies regarding efflorescence, mold, stains and spalling, the pathologies of fissures, medium cracks and large cracks must be inspected and analyzed technically.

Finally, the map in Figure 11 presents a synthesis of the rooms that obtained the lowest index in the average of the conservation groups (less than or equal to 3) and the highest indexes (greater than 4) in order to analyze which rooms need maintenance priority and which do not need.

It can be observed that the university has mostly (more than 95%) of the didactic rooms in good or excellent conservation conditions. However, it is worth mentioning that the rooms in the M05 block and a room in the G34 block, obtained indexes lower than or equal to 3, for the average of the items investigated. In this way, it is understood that such rooms are a priority for the realization of maintenance and should be inspected by the managers.

CONCLUSION

This study presented a part of the results obtained in a project using the Geographic Information System that is being developed at the State University of Maringá, aiming to assist the management bodies in decision

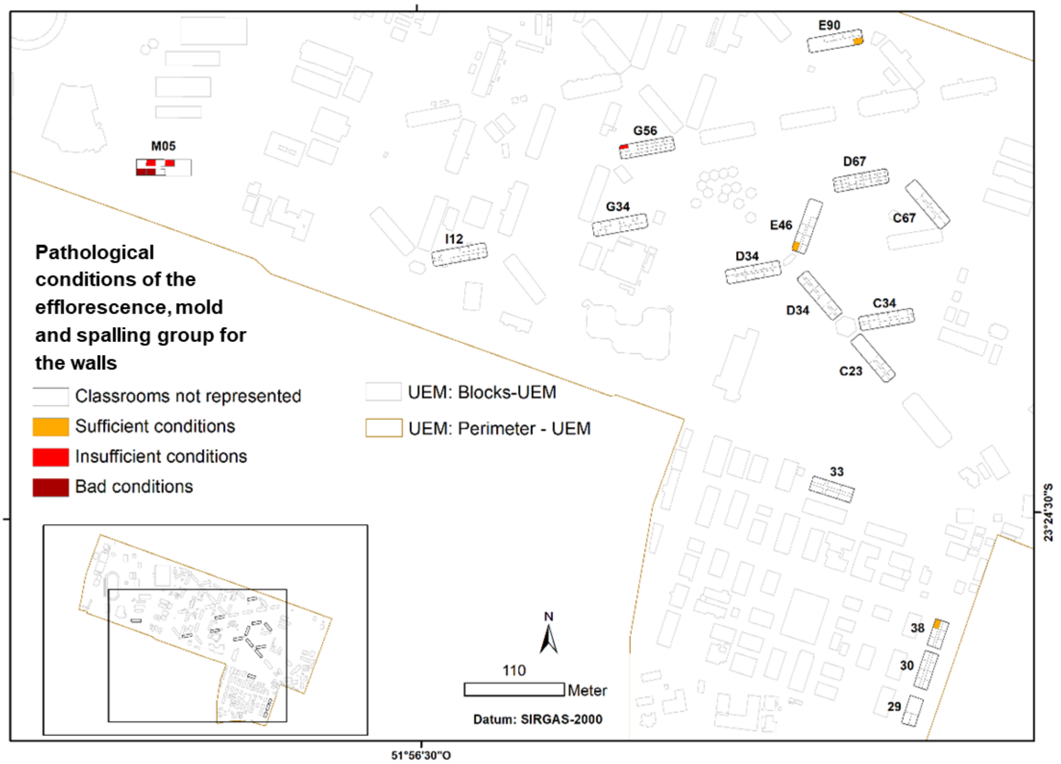

Figure 6. Pathological conditions of the efflorescence, mold and spalling group of the classrooms for the walls.

Source: Base adapted from PCU-UEM, 2018; own elaboration, 2019.

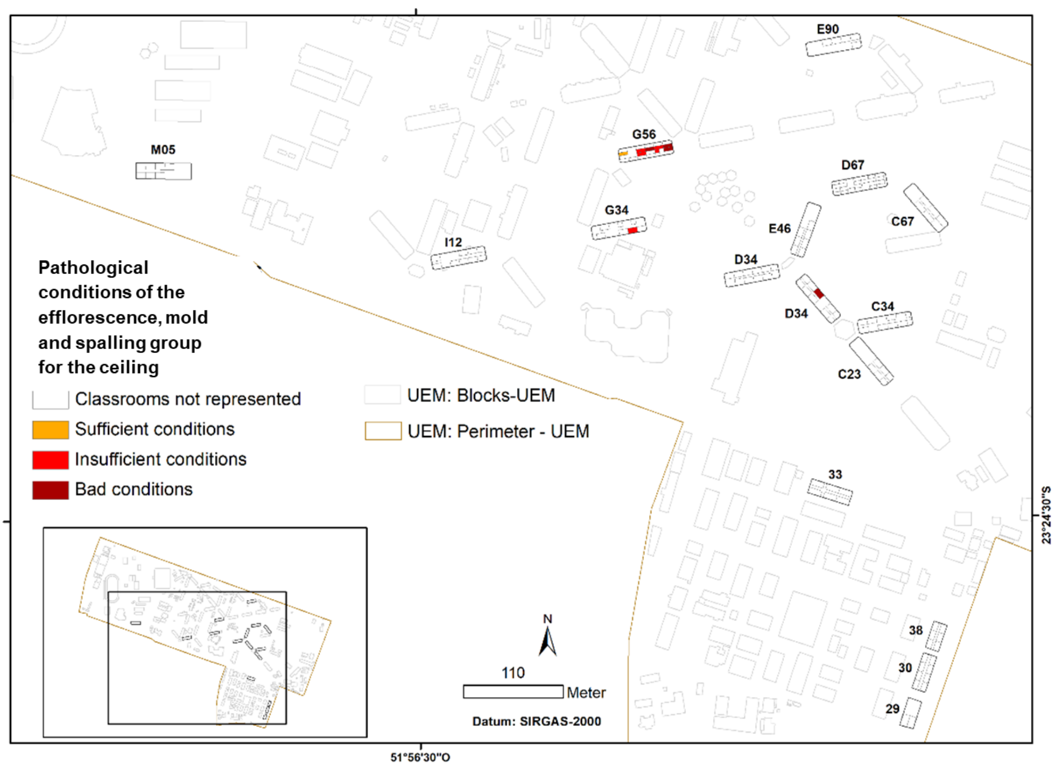

Figure 7. Pathological conditions of the efflorescence, mold and spalling group of the classrooms for the ceilings.

Source: Base adapted from PCU-UEM, 2018; own elaboration, 2019.

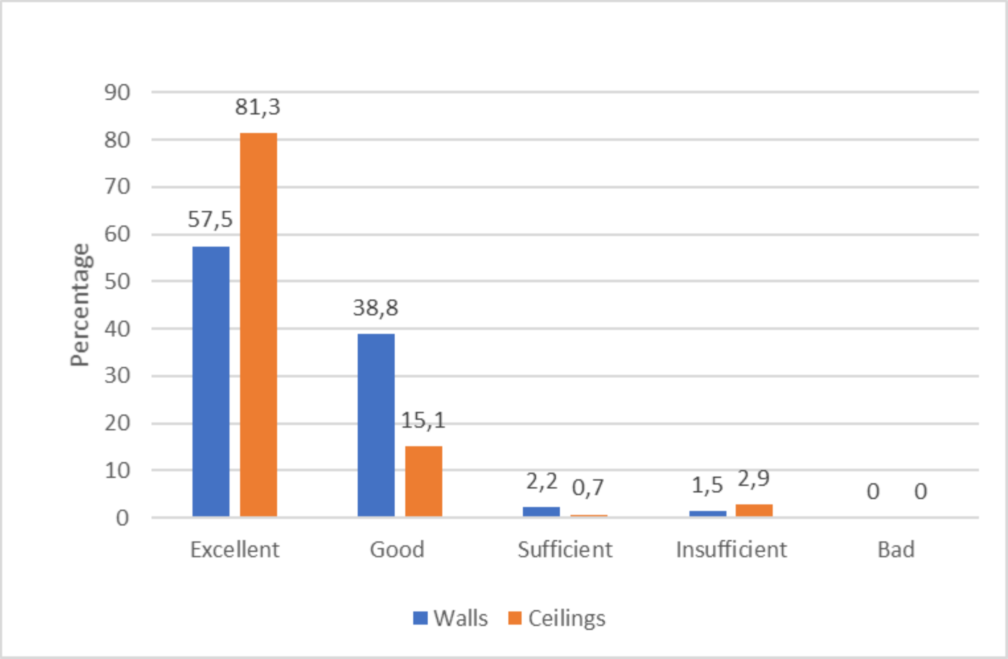

Figure 8. Percentage of the pathological conditions of the classrooms regarding to the fissures, medium cracks and large cracks group for the walls and ceilings.

Source: Own elaboration, 2019.

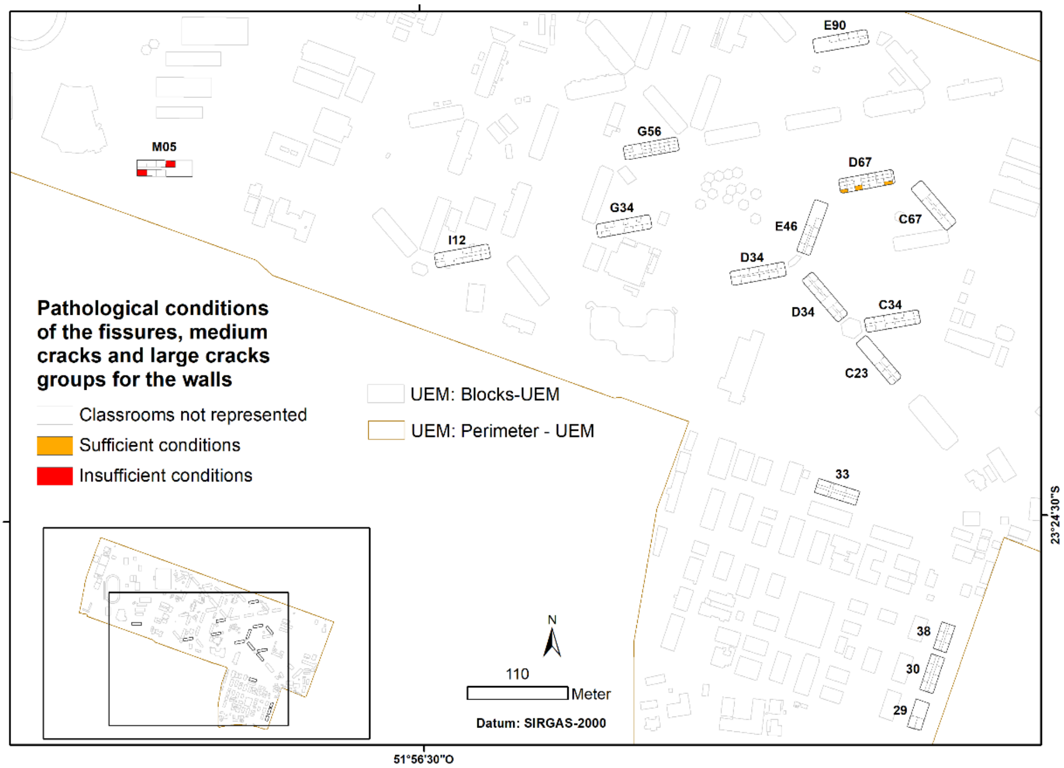

Figure 9. Pathological conditions of Fissures, Medium Cracks or Large Cracks group of the classrooms for the walls.

Source: Base adapted from PCU-UEM, 2018; own elaboration, 2019.

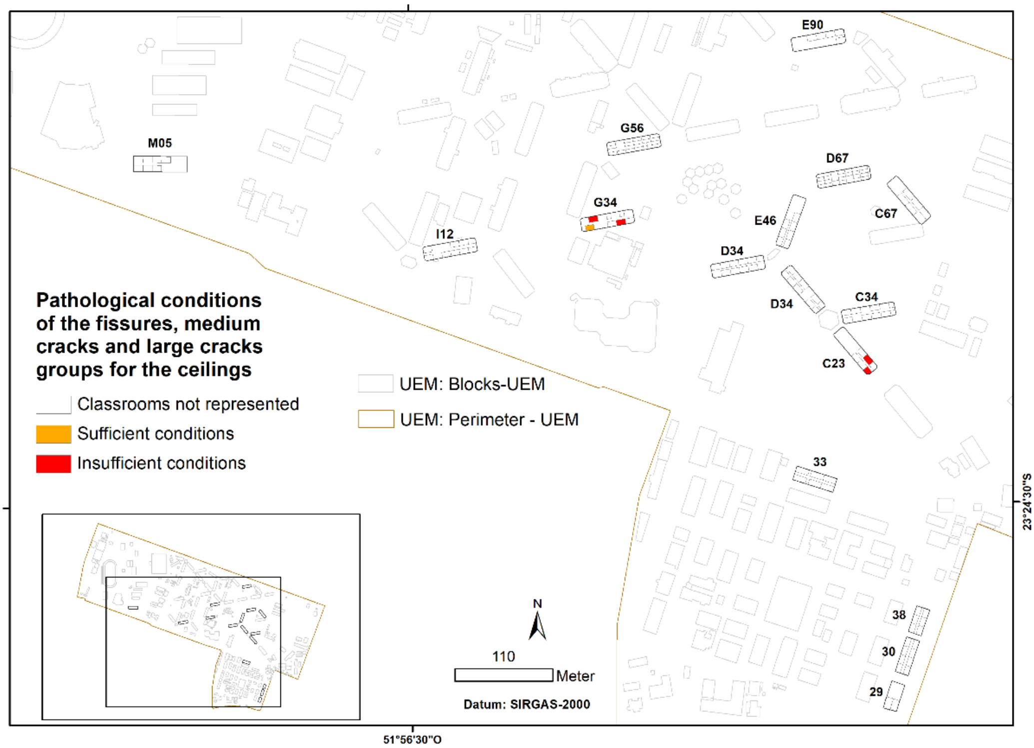

Figure 10. Pathological conditions of Fissures, Medium Cracks or Large Cracks group of the classrooms for the ceilings

Source: Base adapted from PCU-UEM, 2018; own elaboration, 2019

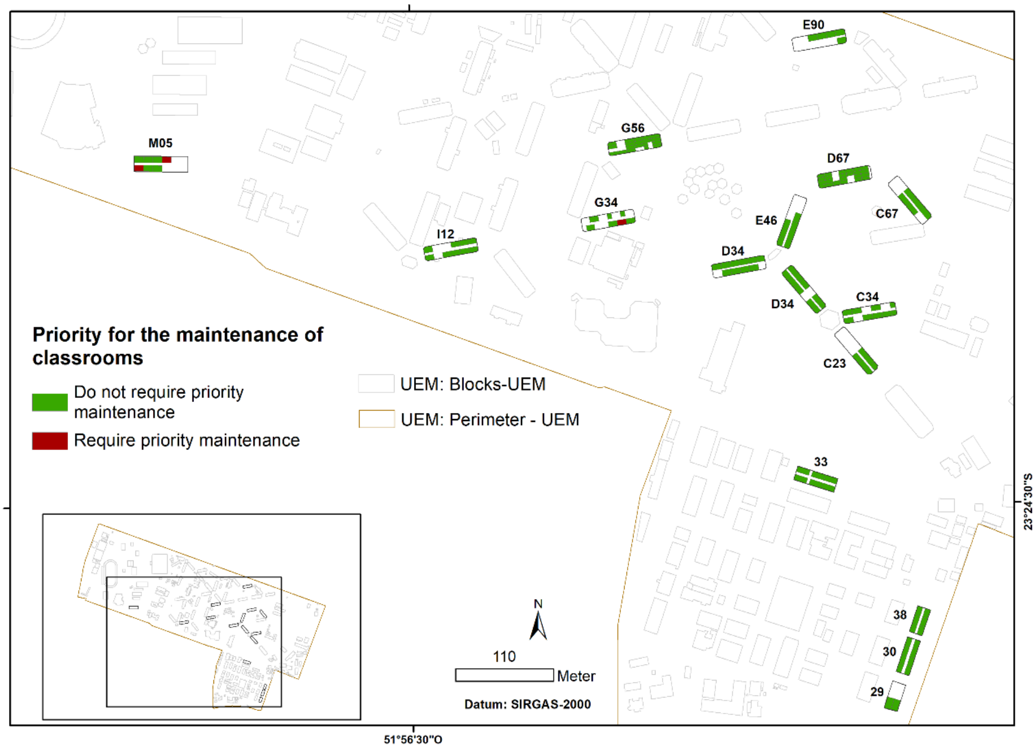

Figure 11. Classrooms that require priority maintenance by UEM managers.

Source: Base adapted from PCU-UEM, 2089; own elaboration, 2019.

making. For the conservation subdomain presented here, it can be observed that the use of GIS meets the interests of the managers of the educational institution, since it allowed not only to statistically obtain the conservation status of the investigated environments (classrooms) but also allowed to analyze spatially the distribution of the best and bad conditions.

It was possible to observe that some blocks have problems, mainly regarding pathologies, requiring inspections and urgent actions. It was also observed that the majority of the classrooms concerning the conservation were in good or excellent conditions. It was possible to present a synthesis of the rooms that obtained the highest and lowest rates in all the items investigated in order to signal to the University managers which are the environments that need maintenance priority. As spatialization also allows the verification of the same occurrences in several rooms in the same block, the use of GIS also helps the manager to predict the number of employees needed and their specialties, to attend maintenance occurrences.

Thus, GIS proved to be an extremely important tool in prioritizing the environments to receive intervention and in the organization of the operational teams that perform the maintenance. The entire result of this research was shared with the managing body of UEM (University City Hall), making the actions of the managers more effective.

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