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Cartography and 3D Modeling as Tools of Applied Geography Landscaping

Cartography and 3D Modeling as Tools of Geography Applied to Landscaping

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Summary

This research analyzes the role of cartography and three-dimensional modeling in the context of geography applied to landscaping. The integration of geotechnological tools and landscape planning practices has promoted more sustainable, efficient, and accurate solutions for spatial planning and the requalification of urban and rural spaces. The article is based on an interdisciplinary approach, articulating concepts of physical geography, geoprocessing, and landscape architecture. Technical and methodological aspects of digital cartographic production, the use of geographic information systems (GIS), and advances in 3D modeling of terrains and buildings are discussed. The analysis is based on case studies and specialized literature to demonstrate how geotechnology has revolutionized spatial planning and landscape design.

Keywords: Digital cartography, 3D modeling, Applied geography, Landscaping, Geotechnologies.

Abstract

This research analyzes the role of cartography and three-dimensional modeling within the context of geography applied to landscaping. The integration between geotechnological tools and landscape planning practices has promoted more sustainable, efficient, and accurate solutions for land use planning and the redevelopment of urban and rural spaces. The article takes an interdisciplinary approach, articulating concepts from physical geography, geoprocessing, and landscape architecture. Technical and methodological aspects of digital cartographic production, the use of geographic information systems (GIS), and advances in 3D terrain and building modeling are discussed. The analysis is supported by case studies and specialized literature to highlight how spatial geotechnology has revolutionized planning and landscape design.

Keywords: Digital Cartography, 3D Modeling, Applied Geography, Landscaping, Geotechnologies.

1. Fundamentals of modern cartography and its relationship with geographic space

Cartography is a science traditionally linked to the representation of terrestrial space, having evolved over the centuries in line with technological and scientific advances. With the digitalization of spatial data and the consolidation of geoinformation,

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Cartography began to play an essential role in the analysis and interpretation of the territory.
Its application goes beyond basic mapping, contributing to urban planning, environmental management and the development of engineering and landscape architecture projects (MONMONIER, 1996).

The concept of geographic space, according to Milton Santos (2006), involves the materiality of the territory and its social, economic and natural dynamics. Modern cartography, in this sense, enables the critical and systematic analysis of this space, enabling simulations and forecasts based on empirical data. Maps, which were once static, have now become interactive platforms for consulting and managing georeferenced data.

The development of spatial databases integrated with GIS (Geographic Information Systems) has significantly expanded the capacity for cartographic analysis. This allows complex cross-referencing of information — such as relief, hydrography, land use and climate — essential for landscape interventions guided by technical and

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sustainable (LOCH, 2013).

In landscaping projects, digital cartography is often used to precisely delimit intervention areas, model the terrain and assess visual impact. Through satellite images, topographic data and digital elevation models, it is possible to anticipate scenarios and guide the best decisions in the field.

The use of drones and remote sensors for cartographic surveys has also become an indispensable tool. These resources increase data accuracy and reduce project costs compared to conventional methods. In this context, cartography ceases to be merely representational and assumes an operational and design-based character.

It is worth noting that the integration between cartography and geographic knowledge contributes to the construction of more robust spatial diagnoses. Understanding the landscape as a multifaceted system, composed of natural and cultural elements, is essential for the technical and ethical performance of professionals involved in territorial interventions.

2. Three-dimensional modeling of the territory: techniques, applications and challenges

Three-dimensional (3D) land modeling is a technological aspect that has been gaining prominence in the field of geotechnology, especially due to its ability to faithfully represent shapes, volumes and surfaces of geographic space. It is widely used in environmental studies, civil engineering works and landscaping projects, where accurate spatial visualization is essential for assertive decisions.

Among the main technical resources used in 3D modeling are Digital Elevation Models (DEM), Digital Surface Models (DSM) and Terrain Models (DTM).
These data are extracted by LiDAR sensors, photogrammetry or orbital images, and processed in specialized software such as AutoCAD Civil 3D, ArcGIS Pro, SketchUp and QGIS (NETELER et al., 2008).

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In landscaping, 3D modeling is useful for simulating landscape interventions before they are even implemented. It is possible to predict how vegetation, buildings, furniture and natural elements will integrate with the existing terrain, providing planners with greater aesthetic and functional control over projects (RIBEIRO; CÂMARA, 2000).

Another important aspect is the hydrological modeling of the terrain, which allows the identification of areas at risk of erosion, surface runoff and flooding. This is essential in defining drainage and revegetation strategies, especially on slopes and impermeable urban areas.

The use of 3D modeling in geographic education and research has also expanded.
Universities use three-dimensional models to simulate landscapes and analyze future scenarios, facilitating spatial understanding by students and researchers.
This strengthens technical and critical training in the teaching of applied geography.

The challenges of 3D modeling include the high demand for graphic processing, the need for sophisticated equipment and trained professionals. Despite this, its use has become more accessible with the advancement of cloud computing and the popularization of open source software.
source.

In short, three-dimensional modeling is a strategic ally of contemporary spatial planning. When combined with digital cartography, it constitutes a solid basis for landscaping projects committed to sustainability and territorial aesthetics.

3. GIS and digital tools in the representation of space for landscaping

The use of Geographic Information Systems (GIS) has revolutionized the way geographic space is represented and analyzed in landscaping projects. These systems allow the integration of several layers of spatial information — such as topography, hydrography, vegetation, and infrastructure — into a single digital environment. This facilitates the visualization of complex interactions in the territory, allowing for more accurate diagnoses and decisions based on georeferenced data.

GIS has become an essential tool in the diagnostic and planning stages of landscape projects. It can be used to identify areas of environmental fragility, ecological potential, soil vocations and legal restrictions. These elements are essential for sustainable landscaping that respects the environmental and social conditions of the intervention site.

Another relevant aspect of using GIS in landscaping is the ability to simulate scenarios.
Spatial modeling tools allow predicting the effects of different intervention alternatives on the territory. This includes analyzing the shading of buildings, the visibility of landscape elements, and the hydrological behavior of the soil. Such simulations reduce risks and increase the efficiency of projects.

Digital tools integrated into GIS, such as ArcGIS, QGIS, gvSIG and others, offer a wide range of functionalities that assist in the development of thematic maps,

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geoprocessing and generation of digital terrain models. Furthermore, these platforms are increasingly accessible, with open source versions widely used in universities and design offices.

The compatibility of GIS with spatial databases and remote sensors also represents a significant advance. This makes it possible to constantly update project data, monitor changes in the territory and adapt landscape interventions in real time. This dynamism is a strategic advantage for long-term projects or those subject to climate and urban variability.

GIS has also contributed to the democratization of spatial information. Through participatory platforms, it is possible to involve local communities in the landscape planning process, promoting more inclusive and collaborative territorial management.
This approach is consistent with the principles of critical geography and participatory planning.

Finally, training professionals in GIS is both a challenge and an opportunity. As these technologies become standard in environmental and urban projects, the demand for specialists who are proficient not only in the technical use of the tools, but also in the critical and ethical reading of spatial data grows. Training in geography, architecture and engineering needs to incorporate these contents into their curricula.

4. Cartography applied to urban planning and environmental management in landscaping

Digital cartography plays a fundamental role in contemporary urban planning, especially when integrated with environmental management and landscaping practices. The spatial interpretation and representation of the natural and anthropogenic elements of the territory enable the development of master plans, zoning and public policies with greater precision and socio-environmental responsibility.

In urban contexts, mapping can identify areas of environmental vulnerability, such as geological risk zones, floods and heat islands. This information is essential for guiding land use, creating green areas and implementing nature-based solutions. Integrating land use and land cover maps with socioeconomic data increases the analytical capacity of project teams.

Furthermore, digitally produced maps help with communication between the various stakeholders involved in urban planning: public managers, technicians, communities and investors. Thematic maps, three-dimensional models and infographics facilitate the understanding of projects and promote social engagement, an essential aspect for the effectiveness of urban policies.

In environmental management, cartography is an ally in monitoring conservation units, ecological corridors and river basins. Through satellite images, remote sensors and drones, it is possible to monitor deforestation, soil degradation and urban expansion.
This information supports environmental inspection and recovery actions.

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Urban landscaping projects also benefit from mapping by planning the insertion of green elements in densely populated areas. Spatial analysis makes it possible to identify priority locations for planting trees, installing parks, green roofs and vertical gardens. Such initiatives contribute to improving environmental quality and thermal comfort in cities.

It is worth noting that cartography applied to urban planning requires constant updating of data and articulation between different scales of analysis — from the lot to the metropolis. This multi-scale nature is essential for the coherence and integration of landscape projects with territorial planning instruments.

Finally, strengthening institutional capacities and training urban cartography technicians are essential for the consolidation of sustainable landscape policies. The articulation between universities, the public sector and the private sector can enhance the generation and use of cartographic data in favor of greener, more inclusive and resilient cities.

5. Integration between 3D modeling and cartographic data for sustainable projects

The combination of three-dimensional modeling and cartographic data has proven essential for the development of sustainable landscaping projects. This integration allows for detailed visualization of the territory, combining quantitative and qualitative aspects of the landscape with the aim of improving the functionality and aesthetics of spaces.

3D modeling based on georeferenced data offers a level of realism that makes it easier for everyone involved to understand projects. From decision-makers to local residents, the three-dimensional visualization of urban and landscape proposals makes participatory processes more effective and transparent.

Another relevant benefit is the possibility of integrated analysis between environmental and morphological variables. The overlapping of information such as slope, land use, vegetation and water network with three-dimensional models favors the selection of solutions that are most appropriate for each territorial context. This reduces negative environmental impacts and increases the ecological efficiency of interventions.

3D modeling software—such as SketchUp, AutoCAD Civil 3D, and Lumion—has increasingly integrated with spatial databases, enabling models to be constantly updated as new data is collected in the field or through remote sensing.
This dynamic favors the adaptation of projects to natural and urban changes.

The integration of 3D modeling and mapping also strengthens the economic sustainability of landscaping projects, since accurate visualization prevents planning errors and reduces rework costs. In addition, it facilitates budget control, as it allows for more accurate estimates of excavation volumes, materials required and execution deadlines.

3D models have also been used as a tool for assessing environmental performance. The simulation of natural lighting, rainwater runoff and comfort

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The thermal analysis of the environments allows us to foresee the impacts of the landscaping proposal even before its implementation, increasing the margin of control over the results.

Finally, the combination of three-dimensional modeling and cartographic data represents a technical advance that brings landscaping closer to the demands of the 21st century. Projects that use this integration tend to be more resilient, innovative, and suited to the social and environmental needs of the communities that receive them.

6. Practical applications: case studies in landscaping projects with geotechnologies

Several case studies demonstrate how the application of geotechnologies — especially digital cartography and 3D modeling — has transformed landscaping practices in urban and rural contexts. Projects carried out in cities such as Curitiba (PR), Medellín (Colombia) and Copenhagen (Denmark) are references in this regard.

In Curitiba, the Barigui River revitalization project used cartographic data and 3D modeling to define intervention areas, predict flood risks, and plan green corridors. The use of geotechnologies allowed greater integration between public spaces, environmental recovery, and urban mobility.

In Medellín, the “Articulated Life Units” (UVA) program incorporated digital tools into the diagnosis and design of multifunctional public spaces. Three-dimensional representations contributed to the involvement of the population in decision-making and to the effectiveness of projects in contexts of social vulnerability.

In Europe, Copenhagen adopted interactive 3D models to plan the city’s adaptation to climate change, with a focus on green infrastructure. Integration with geographic information systems was essential to predict the behavior of rainwater and redesign leisure areas and urban circulation.

Academic studies also reinforce the importance of geotechnologies. According to Santos and Mendes (2020), three-dimensional modeling combined with digital cartography promotes gains in scale, precision, and interdisciplinarity. Oliveira (2019) highlights the improvement in communication between technical teams and local communities as one of the main benefits of digital graphic representation.

In rural environments, experiences of requalifying degraded areas based on GIS and 3D modeling have allowed the recovery of ecosystems and the promotion of ecological tourism. Three-dimensional models assist in land use planning and the reintroduction of native plant species.

These examples show that the practical application of geotechnologies in landscaping is not only feasible, but also necessary in view of contemporary challenges. Systematizing these experiences in public policies and professional training curricula is the next step towards consolidating this technical and conceptual revolution.

Conclusion

The evolution of cartography and three-dimensional modeling as instruments of geography applied to landscaping represents one of the greatest advances in spatial sciences in recent decades. By enabling a richer, more dynamic and precise understanding of the territory, these technological tools have redesigned planning and intervention practices in the space.

The contents discussed throughout this article demonstrate that the use of Geographic Information Systems, cartographic data and three-dimensional models promotes an integrated, sustainable and participatory approach to urban and environmental development.
The combination of these techniques favors not only the efficiency of projects, but also their social acceptance and ecological suitability.

Scientific literature reinforces this finding. Studies such as those by Goodchild (2007), Santos (2014) and Batty (2013) point to the importance of spatial representations in urban planning, territorial management and the promotion of collective well-being. Cartography and 3D modeling are not only technical resources, but also political and social instruments.

Furthermore, the inclusion of these tools in the training of geographers, architects and engineers is essential to prepare professionals capable of facing the environmental and urban challenges of the 21st century. Interdisciplinarity, technological mastery and socio-environmental responsibility must be at the center of professional practice.

With the consolidation of these technologies, new frontiers are opening up for applied research and innovation in the field of landscaping. The evolution of sensors, artificial intelligence and augmented reality tends to further expand the possibilities for representing and simulating space.

Finally, this work reaffirms the central role of geography as a science that articulates nature, society and technology. By incorporating the potential of digital cartography and 3D modeling, landscaping becomes a more technical field, sensitive and connected to contemporary demands, reaffirming its commitment to quality of life, environmental balance and spatial justice.

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