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Research Paper

Analytical Model of Landscape Architecture Planning Using GIS-Based Information Systems Based on Digital Visual and Analytical Models

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Abstract
This paper delves into the reciprocal relationship between Geographic Information System (GIS) and landscape architecture, with a specific focus on the utilization of digital landscape models and visualization for the acquisition of planning knowledge. Rooted in the seminal contributions of Ian McHarg and Jack Dangermond, who were instrumental in pioneering GIS and layer planning in architecture, the study aspires to formulate a novel procedural theory for knowledge acquisition in landscape architecture. The research methodology adopts a theoretical and developmental approach, employing a qualitative systematic review analysis method. The study proposes an innovative approach to planning knowledge acquisition for landscape architects through the utilization of GIS, placing particular emphasis on visual presentations facilitated by digital landscape models and visualization models. The establishment of theoretical foundations is achieved by introducing the hierarchy of data, information, and knowledge, with a specific emphasis on the crucial role of knowledge management systems and decision support systems in the context of landscape architecture. The paper introduces a conceptual model that delineates the subsystems of knowledge management and decision support within the architectural information system. The findings and subsequent discussions underscore the significance of GIS in the acquisition of planning knowledge, emphasizing the cyclic nature of the process involving the creation, development, and experimentation with diverse options to achieve novel landscape architecture compositions. The paper introduces the Digital Visualization Model (DVM) and Digital Landscape Model (DLM) within the GIS framework, elucidating their respective roles in the landscape architecture composition cycle. In conclusion, the paper highlights the potency of GIS in environmental recognition and knowledge acquisition for landscape architects. It identifies three distinct approaches – GIS modeling, GIS analysis, and GIS visual presentation – and elucidates their seamless integration into the landscape planning process. GIS is acknowledged as a transformative force, enriching the formal interpretation of landscape architecture and paving the way for interdisciplinary exploration.

Keywords: *Landscape architecture, Landscape programming, Analytical model, Landscape information system.*

1. INTRODUCTION

Ian McHarg and Jack Dangermond, credited as the pioneers of Geospatial Information System (GIS) and layer planning in architecture, laid the foundation for integrating human living environments with the natural world. McHarg, in his seminal work "Planning with Nature," advocated for aligning human life environments with the principles of nature. Drawing from his experiences in natural settings such as rivers and forests, McHarg introduced the concept of layer planning in landscape architecture. This concept establishes a harmonious relationship between landscape architecture and the layering logic inherent in GIS (McHarg, 2010).

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Conversely, Jack Dangermond, a landscape architect and the founder of "ESRI," incorporated GIS into landscape architecture planning as early as 1969 (Hana, 2014, p. 5). Building on prior research and the Aspinal Theory, which explores the utilization of new tools in various scientific disciplines, this study endeavors to formulate a novel procedural theory. Aspinal & Associates (2006) identified GIS's potential to carve out a niche by integrating and localizing it within "landscape planning knowledge," thus paving the way for the development of new procedural theories in the field.

The present study seeks to elucidate the role of GIS in acquiring planning knowledge for landscape architects, with a focus on visual presentations through digital landscape models and digital visualization models. By delving into this subject, the study aims to contribute a new procedure and theory to the knowledge acquisition domain. The central inquiry of this study revolves around how landscape architects can glean knowledge from planning through the utilization of digital landscape models or digital visualization models in GIS visual presentations. To address this question, the study conducts a thorough review of relevant literature, establishing a theoretical framework that aligns with the shared domain between GIS and landscape architecture. Following the identification of standard fields, the study explicates the position of GIS in acquiring planning knowledge for landscape architects, employing the qualitative systematic review analysis method.

2. LITERATURE REVIEW

The discourse addresses the intricate nature and expansive array of GIS-related software within the realm of landscape architecture studies. It provides an overview of prior research, with particular attention to the work of Steffen Nijhuis, who underscores the strategic application of GIS for knowledge planning in landscape architecture. Nijhuis's research explores the quantification of visual phenomena and the integration of GIS in visual analysis, taking into account physiological and psychological considerations in landscape planning.

Furthermore, the concerns expressed by Naha Adkar and colleagues shed light on the persisting limitations in GIS usage, despite the evolution of processes and changing requirements, specifically within the context of landscape architecture in India. Additionally, Shiaokesia's paper anticipates the visual ramifications of GIS in civil reproduction, exerting influence across a diverse spectrum of scenes. Lastly, Lin Kang's study underscores the pivotal role of GIS in the landscape planning of street architecture, leveraging the wireless Internet of Things. The emphasis lies in the potential to enhance perspectives in this field, creating a more nuanced understanding. Figure (1) accompanying this section visually encapsulates the generalities inherent in the intersection of landscape architecture and GIS.

The surveyed literature underscores the adaptability of Geographic Information Systems (GIS) in landscape planning, demonstrating its potential to enhance the efficacy, sustainability, and inclusiveness of planning procedures. With technological advancements, GIS is poised to assume an increasingly pivotal role in shaping the trajectory of landscape planning, furnishing planners with potent tools to tackle intricate spatial challenges and cultivate resilient, dynamic outdoor environments. This literature review amalgamates insights gleaned from recent studies, primarily conducted by Salehabadi, Ghoddusifar, and Mohammadpour in 2023, delving into various dimensions of urban parks in Region 1 of Tehran.

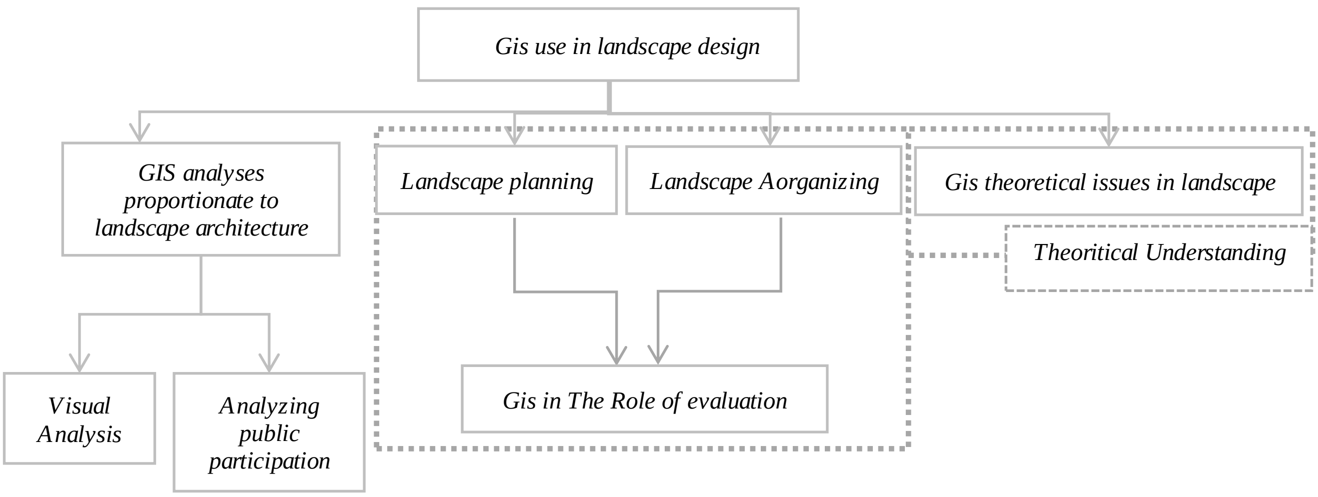

Fig 1. explaining the conceptual model of previous studies related to GIS and landscape architecture

"The Role of GIS in Landscape Design Knowledge Management" (Salehabadi et al., 2023):

In their initial exploration, Salehabadi, Ghoddusifar, and Mohammadpour investigate the integration of Geographic Information Systems (GIS) into the landscape design knowledge management process. The emphasis on digital visualization and digital mental perspectives signifies a forward-looking approach to park planning. This study contributes to the ongoing discourse surrounding the utilization of technology for informed decision-making in landscape design.

"Development of the Area of Supply and Demand of Urban Parks" (Salehabadi et al., 2023):

Salehabadi and colleagues delve into the evolution of the area encompassing the supply and demand for urban parks in Region 1 of Tehran. Their study introduces a spatial distribution coefficient, providing insights into the geographic dispersal of parks. Addressing the spatial dimensions of park planning, this research establishes a foundation for comprehending the local dynamics that influence the equilibrium between supply and demand.

"Measuring Distributive Justice of Urban Parks" (Salehabadi et al., 2023):

Salehabadi et al. scrutinize the distributive justice of urban parks in District 1 of Tehran, proposing a framework centered on citizens' services. This study assesses the equity in the allocation of park amenities, illuminating the social justice dimensions inherent in urban green spaces. The findings proffer valuable insights for policymakers endeavoring to cultivate inclusive and equitable urban park environments.

"Modeling Spatial Characteristics of City Parks" (Ghoddusifar et al., 2023):

Ghoddusifar, Salehabadi, and Mohammadpor employ Geographically Weighted Regression (GWR) analysis to model the spatial characteristics of city parks in the First Region of Tehran. By considering coefficients of General Performance of Park (GPP) and Area of Supply and Demand (ASD), the study furnishes a nuanced understanding of the localized factors influencing park features. This geospatial approach enhances the precision of planning interventions.

"Creation of an Urban Park New ASD Index" (Salehabadi et al., 2023):

In their final study, Salehabadi et al. introduce a novel ASD index incorporating a spatial distribution coefficient. Centered on Region 1 of Tehran, this research contributes to the ongoing discourse on formulating comprehensive indices for urban park planning. The study provides a pragmatic tool for assessing and enhancing the spatial distribution of amenities within urban parks.

In conclusion, the reviewed studies collectively contribute to the evolving field of urban park planning, underscoring the significance of spatial considerations, distributive justice, and the integration of GIS for informed decision-making. These findings hold implications for policymakers, urban planners, and researchers aiming to create sustainable and equitable urban park environments. The studies collectively emphasize the interconnected nature of various factors influencing urban parks, advocating for holistic and data-driven approaches in urban planning and management.

3. RESEARCH METHOD

The Geographic Information System (GIS) constitutes a convergence of four distinct computer programs, encompassing image processing, computer-aided design (CAD), surveying or mapping, and data management. Although diverse definitions exist for GIS, its application in landscape architecture aligns closely with the concept of an integrated system for spatial analysis. In this context, GIS is characterized as a tool that enables individuals to gain insights into a study sample, such as a landscape, by simplifying and summarizing spatial and non-spatial features into digital data. This intricate process is facilitated by specialized software, hardware, and the informed judgment of landscape planners (Chang, 2021).

The current research adopts a theoretical and developmental approach, seeking to elucidate the pivotal role of GIS in the acquisition of planning knowledge for landscape architects. The central focus lies on visual presentation within GIS, achieved through the creation of a digital landscape model and a digital visualization model. Through a comprehensive examination of the concept of obtaining planning knowledge through GIS, this research delineates the profound significance of GIS in the knowledge acquisition process for landscape planners. Additionally, it introduces a model for digital visualization and digital landscape modeling.

The primary objective of the research is to propose a novel approach to planning knowledge tailored for landscape architects and planners. Utilizing library methods, the study extensively explores sources and delves into the theoretical framework specific to this subject. The data analysis employs a systematic qualitative review, employing reasoned analysis, culminating in a comprehensive conclusion and evaluation derived from the transformation of data into information. Ultimately, this research contributes to the advancement of understanding in the realm of planning knowledge acquisition within the context of GIS for landscape architecture professionals.

4. THEORETICAL FOUNDATIONS

4.1. Data, Information, and Knowledge Hierarchy

To comprehend the essence of knowledge, it becomes imperative to acknowledge the hierarchical relationship existing among data, information, and knowledge, commonly referred to as the "knowledge hierarchy" (see Diagram 2). In the context of landscape studies, the process of acquiring knowledge commences with the collection and recording of data. Data serves as a concise representation of environmental elements that encapsulate both tangible and intangible facets of landscape architecture composition (Nijhuis and Bobbink 2012). Crucial sources of data encompass measurements, 2D and 3D site records, maps delineating physical, biological, and cultural features, contemporary documented sources (such as writings, images, drawings, etc.), aerial photographs, geographical bases, and contemporary studies involving investigations, interviews, and questionnaires concerning spatial composition.

The researchers, who are landscape architects, intend to extract information pertaining to landscape architecture composition from curated datasets to address specific research inquiries or fulfill predefined research criteria. Information, in this context, is endowed with interpretable meaning. On the other hand, data possesses inherent meaning within itself and necessitates exploration by the audience to transform into information (Balram & Fernoux, 2010). The process of forming or shaping data to derive information is crucial in addressing research questions or criteria, with the analysis of data serving to enhance perception and understanding of spatial relationships, structures, and patterns.

As articulated by DiBiase (2007), exploration involves unveiling related questions, thereby endowing intended meaning to the search for what is observed, whether anticipated or unforeseen. The analysis of apparent relationships in data is guided by a hypothesis, turning meaningful inferences into data. Planninged data, in this context, reveals relationships between variables at a specific time, with these relationships themselves validating hierarchies, associations, opportunities, and challenges.

4.2. The structure of the information system based on MLM and MVM

The Information System comprises four integral components: task, people, structure (or roles), and technology (O'Hara et al. 1999). Contrary to being merely a database, software, and hardware, an Information System is conceptualized as a comprehensive system. Its utility extends beyond the management of devices, encompassing the interpretation of communication systems as required. Importantly, the term goes beyond denoting individual tools and pertains to the broader landscape of scientific communication. It becomes an intermediary between people, forming an integral part of networks employed in scientific studies.

Within the realm of scientific inquiry, the set of information systems is constituted by networks and the hardware and software utilized by individuals and organizations for the collection, creation, and dissemination of information. The overarching goal of communication systems is to facilitate operations, aid managers, and enable decision-making processes efficiently through the integration of information and communication technology within an organization. Various types of information systems exist, including Shared Processing Systems, Decision Support Systems, Knowledge Management Systems, Learning Management Systems, and Database Management Systems.

Most communication systems are designed to execute computations that are cognitively challenging for humans, such as handling vast amounts of information, performing intricate calculations, and exerting control. The present research concentrates on Decision Support Systems and Knowledge Management Systems, with the objective of offering a practical model for the problem-solving process tailored for designers and programmers. Figure 3 in the analysis of findings provides a visual representation of information based on systematic analysis. Subsequently, the paper will expound on the two aforementioned concepts: Decision Support Systems and Knowledge Management Systems.

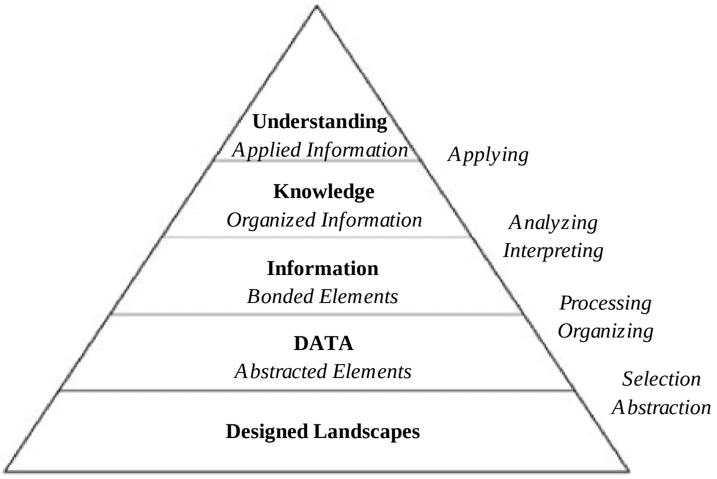

Fig 2. explaining the conceptual model of previous studies related to GIS and landscape architecture

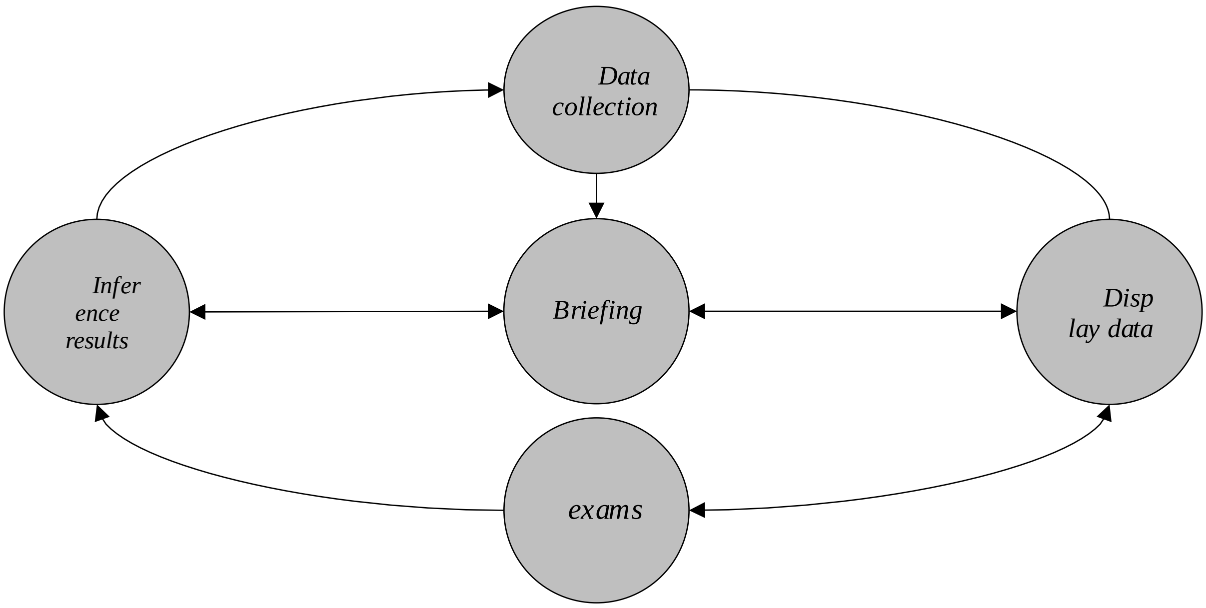

Fig 3. Macro cycle of data analysis in information systems

5. DECISION SUPPORT SYSTEMS

Decision Support Systems (DSS) constitute a category of information systems that provide support for decision-making and organizational activities. These systems operate at various levels within an organization, spanning management, operations, and organizational programs, typically offering assistance to higher-middle management personnel. Their primary objective is to aid individuals in addressing unstructured and semi-structured decision problems that may undergo rapid changes. Decision Support Systems prove particularly beneficial in situations where decisions are not easily predetermined.

In the context of both Turkish citizens and universities, Decision Support Systems serve as invaluable tools to enhance decision-making processes. For individuals, whether citizens or organizational entities like universities, these systems act as facilitators, assisting in navigating complex and dynamic decision scenarios (Taticchi et al. 2014).

5.1. Information system in landscape architecture

Computer-based methods have been utilized in the landscape design and planning processes for Rasht since 1991. Despite their increased use, their role in project execution remains at 50%, primarily involving drawings and similar representations for the three-dimensional depiction of the environment, which holds a pivotal role in design and planning comprehension.

Several reasons drive the development of an information system in landscape architecture:

1. Non-systematic calculations are time-consuming.
2. Cognitive limitations in analysis and memory affect efficiency.
3. Individual problem-solving capabilities are constrained.
4. Group decision-making, especially among experts, faces criticism.
5. Complex landscape decisions involve intricate calculations.
6. Over time, decisions without an information system may lack desired quality.
7. Competitive pressures on designers and planners are escalating.

The architectural information system, on its own, does not inherently enhance the capabilities of a designer or programmer. However, when integrated with subsystems like knowledge management systems and decision support systems based on GIS, it offers a model that serves as a platform for processing and calculating data and information. This integrated system provides essential elements for projects.

The key components of information systems include computer hardware, software, and communication infrastructure. Additionally, components such as remote communication, databases, analog resources, methods, and information technology (IT) play pivotal roles in the operation and management of organizations. Figure 4 illustrates the conceptual model that governs the interactions among these constituent elements within an information system.

5.2. Subsystem of knowledge management in the information system of Landscape architecture

Information processing in landscaping, design, and landscape maintenance invariably requires a certain volume of data. Even in relatively small projects or privately formed companies, there is a need for information creation and modeling to retrieve, store, process, present, and archive data. As projects grow in complexity, the demand for data and its organization increases, making the utilization of digital platforms especially noteworthy.

Despite the initial constraints on data access, prior research indicates that knowledge management systems (KMS) are valuable in enhancing knowledge and awareness in architectural plans. The KMS subsystem emerges as a potent tool for environmental awareness, providing support to environmental design researchers by mediating and facilitating the knowledge processes inherent in design. This underscores the mutual dependence between the KMS and the design researcher, particularly the landscape architect, in tasks such as identification, acquisition, extraction, retrieval, evaluation, and sharing of various resources. This necessity prompts designers to plan and design in ways that align with project goals. The overarching aim of knowledge management is to establish connections between experts and individuals seeking knowledge, fostering a collaborative environment, especially in the realm of landscape architecture.

5.3. Decision support subsystem in the architectural information system

Decision support systems are rooted in information systems and offer designers a problem-solving perspective by assisting in their decision-making processes. They enable designers to extract relevant portions of information, allowing for its utilization in areas that serve as the exclusive recipients of straightforward data, creating a circular process.

Within the realm of Landscape Architectural Information Systems (LAIS), GIS-based spatial decision support systems constitute a fundamental component that involves multiple spatial analyses. Computational machines, such as computers, integrate and analyze alternative models, displaying various states. These systems leverage principles akin to personal finance to ascertain scenarios for sub-programs, utilizing the criteria and standards outlined in expert-developed programs and decision-making methodologies. The case is subsequently analyzed through a process involving assessment and acceptability.

Figure 5 illustrates the stages of decision-making facilitated by decision support systems. The sequential, hierarchical, and linear nature of the steps in this system is evident in the figure, showcasing the systematic progression inherent in the decision-making process.

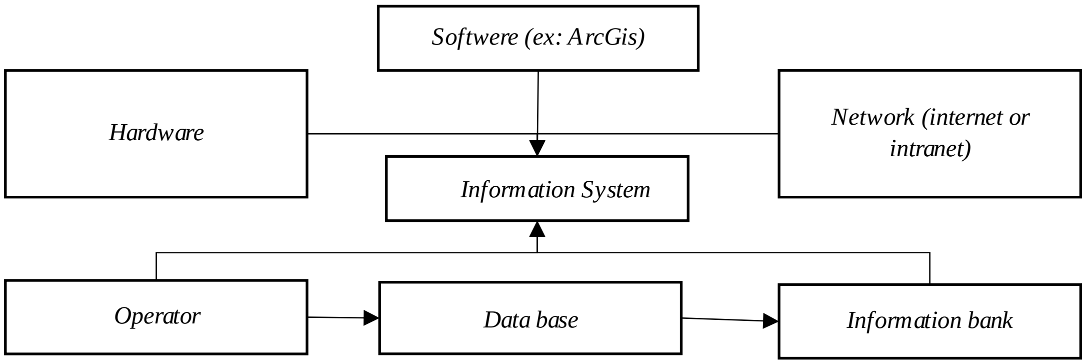

Fig 4. Main components of information systems

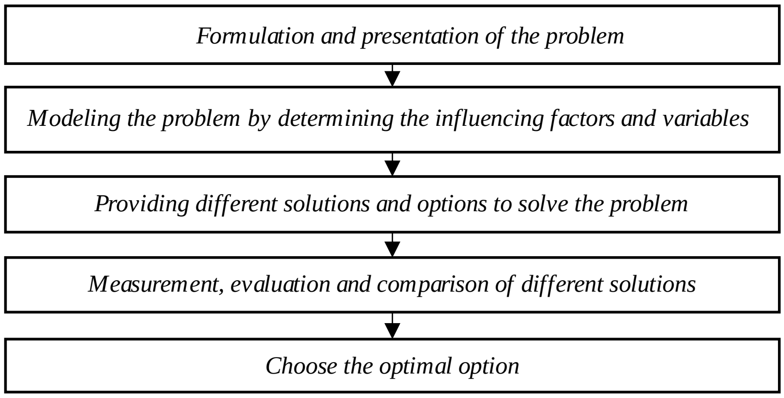

Fig 5. Decision-making steps through decision-making support systems

5.4. Application of spatial decision support system in planning

In landscape architecture, the complexity of problem-solving and the interaction of various phenomena necessitate the utilization of decision support systems and knowledge management systems. Comprehensive information is required during a program's strategic planning in landscape architecture, encompassing social, economic, land use, transport, and transportation data. This includes information based on social structure, age-sex population, people, work interactions, information flows, and data related to hydrometry, ecology, and climatology. Physical data, covering landscape quality, topography, soil composition, land use, and the structure of both artificial and natural elements, is also an integral part of this extensive information set.

The use of decision support systems in spatial decision-making allows for the simultaneous consideration of various data types, models, and predicted goals. This process provides essential components for urban and regional landscape planning programs. Within a landscape planning process, a capable spatial decision support system manages the storage, maintenance, and retrieval of data and related information. The analytical subsystem enables detailed analysis of variables influencing the problem, understanding their spatial relations through various analytical tools and techniques, and employing different methods of mathematical and statistical analysis.

A spatial decision support system facilitates a more accurate, faster, and efficient exploration of the problem and the factors affecting it. Through analytical tools and modeling capabilities, different scenarios can be developed as potential solutions to the problem. Moreover, the system allows for the determination of indicators and components for evaluation, the comparison and ranking of action options, and the extraction of the most desirable option among alternatives. Following the selection of the optimal solution, the spatial decision support system can prioritize, schedule actions, and even determine allocation methods.

6. FINDINGS & DISCUSSION

6.1. Acquiring Planning Knowledge using GIS

Landscape planning is fundamentally rooted in understanding and advancing the compositions of landscape architecture planning (Nijhuis, 2015). The process of acquiring planning knowledge involves delving into the thoughts and insights of planners, focusing on the subject of planning, and utilizing Geographic Information System (GIS) to transform these insights into novel landscape architecture compositions. This production cycle of planning is characterized by a repetitive thought process that encompasses the creation, development, and experimentation with various options to attain a fresh landscape architecture composition.

The initial ideas formulated during planning become tangible within the planning knowledge cycle. This initial planning is articulated in a developmental cycle, aiming for integration, perfection, and additional features. This cycle serves as a crucial testing ground, wherein planning is experimented with based on criteria and standards set by the planning experiment. In each iteration of this cycle, GIS plays a pivotal role in processing data through preprocessing and modeling, generating knowledge through analysis, description, and visualization, and producing planning through previous analyses, experiments, and simulations of planning suggestions.

6.2. GIS in the Process of Acquiring Planning Knowledge using Visual Presentation

The understanding of GIS's role in landscape architecture can be gleaned by examining the dialogues between landscape architecture and GIS researchers, particularly in evaluating the effectiveness of previous landscape planning efforts. The analysis involves two facets: assessing the efficiency of planned landscape compositions and refining these prior plans. While both types of analysis may be integral to the planning process, the emphasis here is on acquiring landscape planning knowledge. Typically, literature on the use of GIS for acquiring planning knowledge highlights technical aspects and advancements. However, limited attention has been given to interactive analysis processes where users, specifically landscape architects, contribute information to the information flow (Van der Schans, 1990).

Van der Schans (1990) introduced the Landscape Model (LM) and Visualization Model (VM) to evaluate the interaction between humans, computers, and the landscape. This framework provides insights into the role of GIS in acquiring planning knowledge. According to this framework, the expression of the landscape is equivalent to the "planned landscape" and "landscape architecture composition." The interaction process involves a dialogue among the planned landscape, Mental Landscape Model (MLM), and Digital Landscape Model (DLM), with potential interactions occurring along different paths (see Figure 6). This framework serves to describe the process of data and information management and is not intended for content analysis or information structure (Bertin, 2010, 60).

6.3. Acquiring Knowledge from Visual Presentation

Analysis differs from visual presentation as it generates substantial information, whereas visual presentations only reflect the outcomes of image presentations. Acquiring knowledge through analytical tools facilitates extracting data from information, a process achievable through graphic presentations. To comprehend the role of visual presentation in knowledge development, it is essential to consider the distinction between content (mental model) and how to express it (mental visualization). Specifically, two mental models play a crucial role in interacting with visual presentations: the Cognitive Landscape Model (MLM) and the Mental Visualization Model (MVM) (see Figure 6).

MLM represents mental content that conceptualizes landscape planning architecture composition independently of its visual presentation. On the other hand, MVM establishes the connection between landscape architecture composition and visual presentation by addressing cognitive content and its expressive methods. In essence, when analyzing landscape architecture composition, a researcher develops an MLM, externalizes mental content through MVM, and presents it visually (Van der Schans, 1990).

The resulting visual presentation is then compared with the planned landscape, leading to changes or corrections in mental content (e.g., acquiring planning knowledge) through a cyclical process. Conversely, the visual presentation can be the starting point for creating MLM by interpreting and analyzing MVM. Figure 7 illustrates the trajectory from visual representation to MVM and from there to MLM towards planning landscape; in both paths, visual presentation facilitates the understanding of landscape architecture composition.

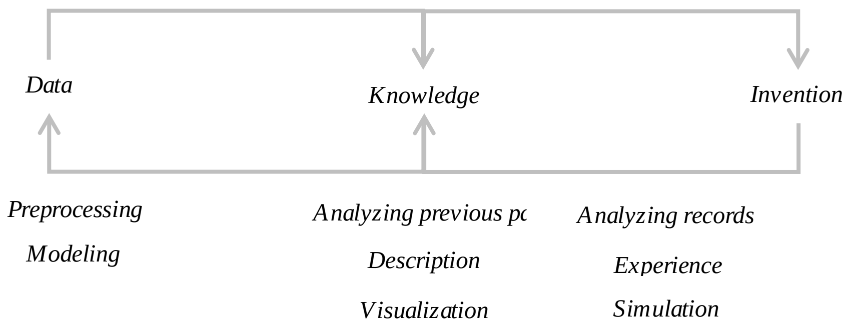

Fig 6. GIS as a facilitator and intermediate knowledge formation cycle and design production cycle: a repetitive process from data to knowledge, from knowledge to the invention

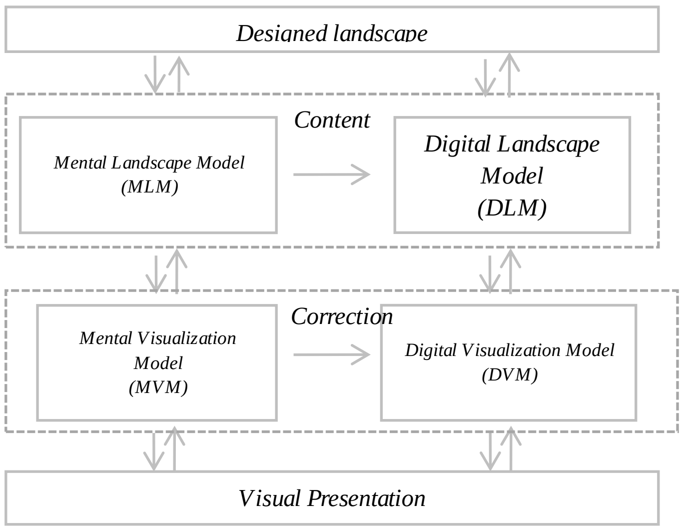

Fig 7. acquiring knowledge as an interactive process among designed landscape, mental models, digital models, and graphic presentations

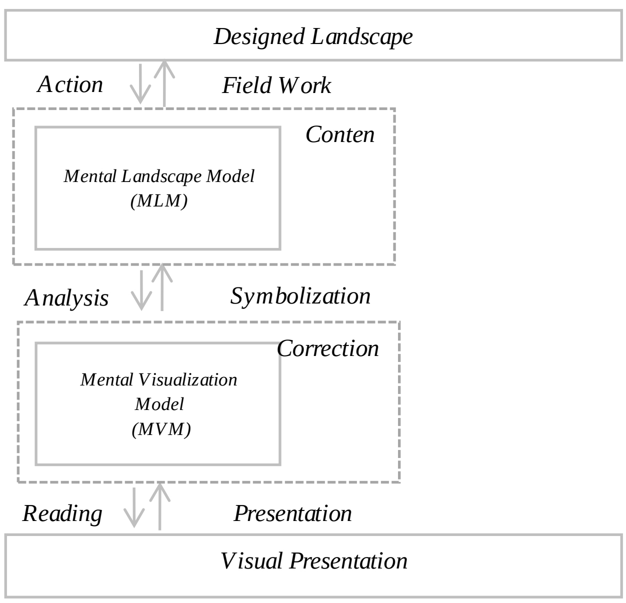

Fig 8. Interpreting the composition of landscape architecture through mental content (MLM) and expression (MVM) into a visual representation and vice versa

6.4. Digital Visualization Model (DVM)

GIS empowers landscape researchers to electronically articulate and translate the Mental Visualization Model (MVM) into a Digital Visualization Model (DVM) (Ormeling & Van der Schans, 1997). GIS is intricately linked to MVM, and the integration of image processing, computer-aided design (CAD), and surveying into a diverse, interactive, and dynamic presentation can serve as a potent DVM (Conceptual Model 5). GIS is instrumental in creating virtual 3D landscapes, computer graphics, and Computer-Aided Planning (CAD), which are then transformed into DVM.

DVM relies on both software capabilities and operator skills. Graphic variables such as size, value, color, texture, direction, shape, and symbols like points, lines, and areas are determined and manipulated using DVM. Therefore, GIS functions as a tool for digitally visualizing MVM. Figure 8 illustrates the trajectory from landscape architecture composition to MLM, from MVM to DVM, and from there to visual presentation.

6.5. Digital Landscape Model (DLM)

In addition to the Digital Visualization Model (DVM), GIS employs a Digital Landscape Model (DLM). The DLM involves summarizing the components and features of landscape planning based on predetermined criteria, creating a digital structure, and storing it as data within the GIS. Furthermore, the DLM can simulate certain aspects of composition in cases where data is insufficient or unmeasured (Maantay & Ziegler, 2006, 46). Unlike the Cognitive Landscape Model (MLM), the DLM is a digital representation or description of landscape architecture composition, irrespective of its graphic representation. In contrast to the MLM, the DLM is a digital presentation of a subject and can be independently considered as a foundation for analysis and visual presentation.

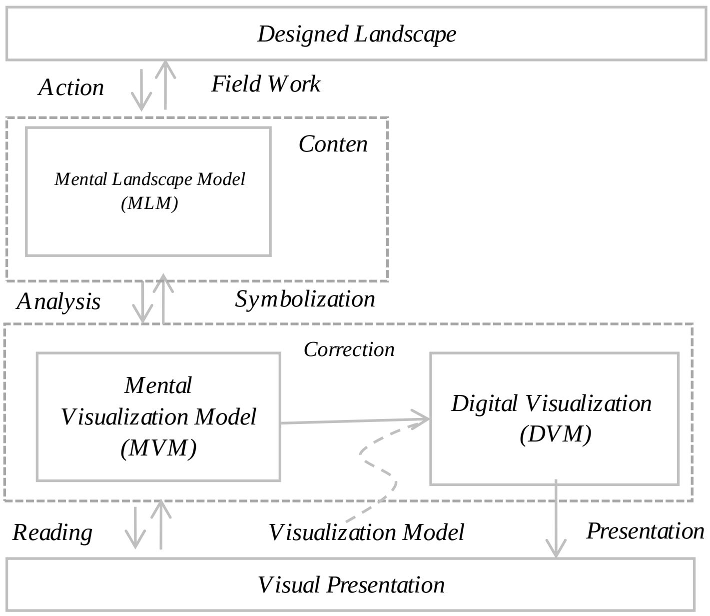

Fig 9. Landscape interpretation designed through mental content (MLM) and mode of expression (MVM) is enhanced into a visual representation and vice versa, using the Digital Visualization (DVM) model

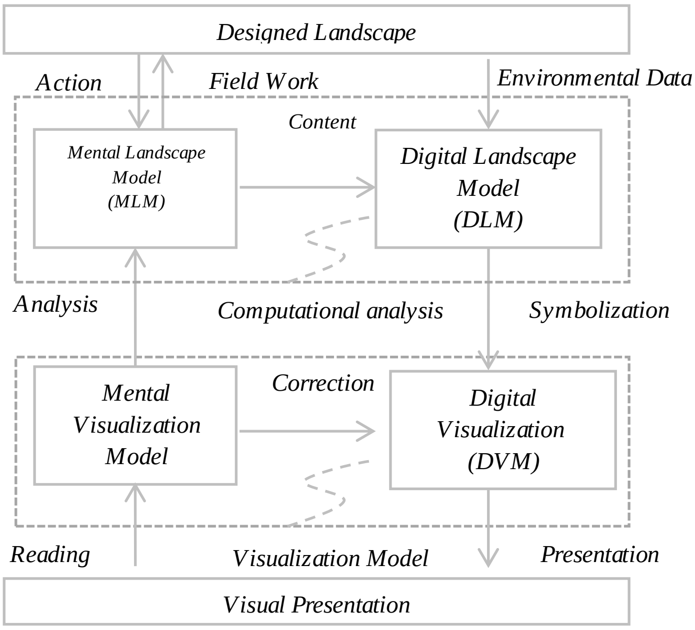

Fig 10. interpreting landscape architecture through MLM and MVM to a visual presentation and vice versa

7. CONCLUSION

This study highlights the effectiveness of Geographic Information System (GIS) as a powerful tool for environmental recognition, providing environment planning researchers with the means to mediate and facilitate the acquisition of planning knowledge. The symbiotic relationship between GIS and planning researchers, especially landscape architects, plays a crucial role. GIS operates meaningfully through user interaction, revealing novel insights and knowledge about planning through the computational capabilities of computers and interactive exploration, modeling, and visualization techniques.

At the core of the environmental construction process, GIS applications play a significant role. Addressing the research question regarding how landscape architects can acquire planning knowledge through Digital Landscape Modeling (DLM) and Digital Visualization Model (DVM) in GIS visual presentations reveals three distinct approaches:

1. **GIS Modeling:** Involves digitally delineating compositions of current and future landscape architecture, providing a comprehensive representation.
2. **GIS Analysis:** Encompasses the exploration, analysis, and synthesis of landscape architecture compositions to uncover new or concealed architectural relationships. This process utilizes computers for simulation and evaluation both before and after planning.
3. **GIS Visual Presentation:** Focuses on presenting virtual landscape architecture compositions in both place and time, facilitating the retrieval and transfer of landscape planning information and knowledge.

The seamless integration of GIS modeling, analysis, and visual presentation into the environmental planning process allows for the reflection and evaluation of landscape-planned interventions. This integration ensures efficiency through periodic and repetitive simulations to investigate their effects. To optimize the benefits of the planning cycle, the links between planning and modeling must align with the specific needs of landscape planners.

To accomplish the objectives of this study, GIS performance functions as an interpretational instrument across all three operational fields, contributing to the generalization and expansion of landscape architecture planning knowledge in two key ways:

1. **Precision in Knowledge:** GIS refines and quantifies "the same type of knowledge," improving the understanding of order and developing specific aspects more accurately. Through the reproduction and transfer of methodologies, GIS enables an integrated, clear, and systematic approach to analyzing landscape architecture compositions, leading to advanced spatial analyses over time.
2. **Incorporation of Specialized Knowledge:** GIS encompasses the measurement of values, experimentation, and validation of specialized knowledge or architectural phenomena known in landscape architecture. This comprehensive approach fosters a deeper understanding of the field, enhancing the quality and depth of planning knowledge.

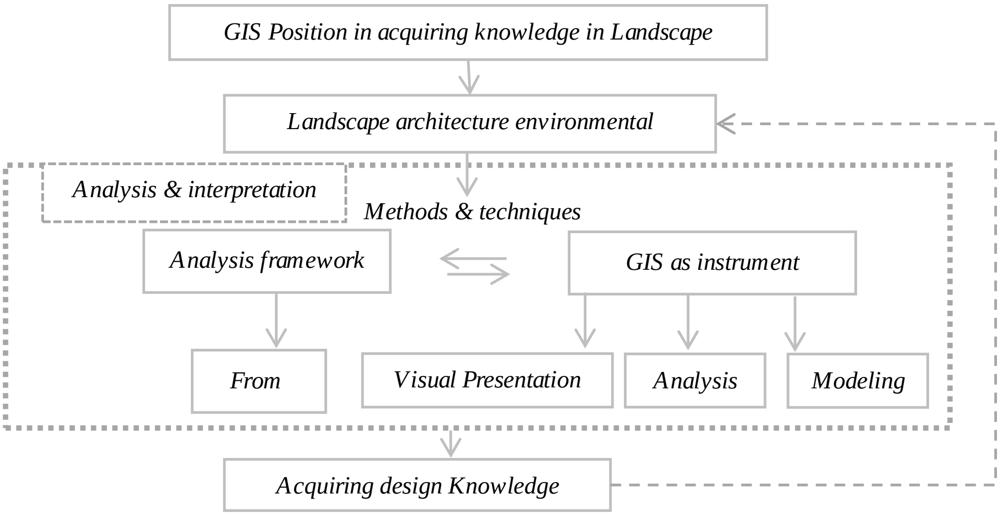

Fig 11. A framework for the role of GIS in acquiring architecture design knowledge

Furthermore, the progress in this field, driven by the fundamental evolution through Geographic Information System (GIS), lays the foundation for the emergence of "new types of knowledge." This entails the seamless integration of additional information layers, scientific disciplines, and diverse data sources. As a result, GIS becomes a transformative force in landscape architecture studies, introducing alternative methodologies to comprehend landscape architecture compositions, particularly visual form, temporal progressions, and dynamics such as movement and development (e.g., vegetation growth and human changes).

GIS-driven landscape studies have the potential to intersect with and delve into other scientific fields, including visual perfection and navigation studies. By engaging with complexity and involving more variables, GIS not only enriches the formal interpretation of landscape architecture but also opens avenues to uncover the tactile and sensory dimensions of planning—a feat that was historically challenging. Moreover, it expands the analytical scope by incorporating data obtained from psychological and phenomenological approaches, providing insights into the intricacies of planning subjects. This integration broadens the horizons of landscape architecture studies, encouraging interdisciplinary exploration and fostering a deeper understanding of the multifaceted aspects of planning.

8. ACKNOWLEDGMENT

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