DIGITAL LANDSCAPE DESIGN AS AN EXTENSION OF ARCHITECTURAL DESIGN:
A CONTEXTUAL FRAMEWORK FOR SUSTAINABLE ENVIRONMENTS IN NEPAL

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Abstract: *The integration of landscape and architectural design has become increasingly important in addressing environmental sustainability, climate responsiveness, and the quality of contemporary built environments. However, landscape design is often treated as a complementary component of architecture rather than as an integral extension of the architectural design process. In Nepal, this separation is particularly relevant because diverse topography, climatic conditions, ecological characteristics, and cultural landscapes require context-sensitive design approaches. This study aims to develop a contextual framework that positions digital landscape design as an extension of architectural design for creating sustainable environments in Nepal. The research employed a qualitative design-research approach combining literature review, contextual site analysis, digital mapping, and comparative analysis of landscape and architectural design strategies. Digital design methods were examined in relation to site characteristics, vegetation, topography, solar exposure, water management, circulation, and spatial relationships between buildings and landscape. The results indicate that integrating digital landscape design into the architectural workflow can improve environmental responsiveness, spatial continuity, and design coordination. The proposed framework identifies four interconnected stages: contextual data acquisition, digital analysis, integrated architectural-landscape modelling, and environmental performance evaluation. The framework demonstrates that digital technologies can support context-sensitive landscape decisions while strengthening the relationship between architecture, ecology, and local environmental conditions. The study contributes a contextual design framework for sustainable architectural and landscape integration in Nepal.*

Keywords: *Digital Landscape Design; Architectural Design; Computational Design; Sustainable Environment; Nepal.*

1. Introduction

The relationship between architecture and landscape has traditionally been understood as a continuous interaction between buildings, open spaces, vegetation, topography, water, climate, and human activities. In contemporary architectural practice, however, landscape is frequently considered after the building has already been conceived, rather than being developed simultaneously with the architectural form. This separation is increasingly problematic as buildings and urban areas are expected not only to provide functional space but also to respond to climate change, ecological pressures, resource limitations, and changing patterns of public life. Landscape therefore needs to be understood not simply as the space surrounding architecture, but as an active environmental system that contributes to the performance and identity of the built environment.

This issue is particularly important in Nepal, where environmental and cultural conditions vary considerably across relatively short geographical distances. Nepal's built environments are shaped by mountainous terrain, changing climatic conditions, monsoon rainfall, vegetation systems, water resources, and long-established traditions of settlement. Research on Nepalese vernacular architecture has demonstrated that traditional buildings developed numerous climate-responsive strategies, including orientation, shading, ventilation, thermal mass, and protection from rain [1]. These strategies indicate that the relationship between building and its surrounding environment was historically embedded in the design process rather than treated as a separate discipline. The challenge today is how such contextual knowledge can be translated into contemporary design processes without reducing it to superficial visual references.

Rapid urbanization has made this challenge more urgent in the Kathmandu Valley. Previous research has identified substantial changes in neighbourhood morphology and a reduction in the quality and availability of public open spaces associated with rapid and poorly controlled urban development [2]. More recent research has further emphasized the limited availability and uneven distribution of urban green spaces in Kathmandu, particularly in relation to air pollution and urban heat [3]. These conditions demonstrate that landscape design in Nepal has consequences extending beyond visual quality. The location, configuration, vegetation, surface materials, and connectivity of landscape spaces can influence environmental performance, public life, and urban resilience.

Recent evidence also shows that blue-green infrastructure can provide measurable environmental benefits in Kathmandu Valley. Bhattarai et al. found that urban forests, parks, and ponds produce different cooling effects and that their effectiveness depends strongly on surrounding urban conditions [4]. Such findings are important for architectural and landscape design because they demonstrate that environmental performance cannot be separated from spatial configuration. A landscape intervention that performs effectively in one location may not produce the same result elsewhere. Consequently, landscape design requires a process capable of incorporating site-specific environmental information into design decisions.

Figure 1. Urban landscape conditions in Kathmandu illustrating the interaction between dense development, public open space, vegetation, and surrounding environmental systems.

The need for contextual landscape design is also reflected in Nepal's climate-adaptation agenda. Sherpa reported that ecosystem-based adaptation has increasingly been recognized within Nepalese policies, but its integration into urban planning remains incomplete, particularly in relation to information, implementation, budgeting, and institutional coordination [5]. This suggests that the challenge is not simply a lack of environmental knowledge. There is also a methodological gap between environmental information and the actual design process. Digital landscape design provides an opportunity to address this gap by enabling designers to collect, organize, visualize, analyse, simulate, and integrate multiple layers of site information before making design decisions.

Digital technologies have significantly transformed architectural design through computer-aided design, parametric modelling, Building Information Modelling (BIM), environmental simulation, geographic information systems (GIS), remote sensing, and increasingly data-driven and computational methods. Nevertheless, the digital transformation of landscape architecture has developed more slowly and remains fragmented. Klemm, Lenzholzer, and van den Brink demonstrated the importance of connecting environmental evidence with landscape design practice, particularly for climate-responsive green infrastructure [6]. Their research showed that design guidelines can help translate scientific knowledge about microclimate into practical landscape decisions.

Within digital landscape architecture, computational approaches have expanded the ability to manipulate complex spatial and environmental variables. Yoffe et al. developed a computational framework that evaluates landscape sustainability indicators during early-stage design, demonstrating how parameters related to biomass, precipitation management, and urban heat can be incorporated into a parametric design process [7]. This represents an important shift from using digital tools merely for representation toward using them as instruments for design reasoning and environmental evaluation.

BIM has similarly created opportunities to connect architectural information with landscape systems. Nikologianni, Mayouf, and Gullino identified that BIM research has predominantly concentrated on buildings, planning, and smaller-scale applications, while the integration of landscape design, climate change, and environmental performance remains comparatively limited [8]. Their findings are particularly relevant to the present study because they indicate that digital integration between architecture and landscape is still insufficiently developed.

More recent studies have explored more sophisticated digital workflows. Ludwig et al. proposed a digital workflow for urban green systems involving 3D scanning, data-driven modelling, simulation, computer-aided design, information modelling, and decision-support systems [9]. Melsom and Hurkxkens similarly demonstrated how computational modelling can be used to simulate landscape erosion and connect site investigation with interactive design processes [10]. These studies indicate that computational tools can move landscape architecture beyond static representation toward dynamic environmental analysis.

At a broader scale, Dreksler et al.'s scoping review of digital technologies in landscape planning identified a wide range of emerging technologies, including remote sensing, machine learning, BIM, and virtual or augmented reality. However, the authors also noted that relatively few technologies are yet widely embedded in landscape planning workflows and that further work is required to understand how digital technologies can be effectively associated with different phases of the planning and design process [11]. Similarly, Petschek et al. demonstrated the potential of linking BIM with stormwater modelling to evaluate nature-based solutions and improve landscape performance [12].

These developments establish a clear state of the art: digital tools are increasingly capable of analysing environmental conditions, generating design alternatives, and evaluating landscape performance. Yet most existing studies focus on individual technologies or particular environmental problems. There remains a need for a more integrated framework that explains how digital landscape design can become part of the architectural design process itself, particularly within contextually complex environments such as Nepal.

The principal research gap is therefore not the absence of digital technologies. Rather, it is the limited integration of these technologies into a coherent architectural-landscape workflow that begins with contextual understanding and continues through analysis, design generation, coordination, and environmental evaluation. Existing research has demonstrated the value of computational design, BIM, GIS, environmental simulation, and data-driven landscape planning, but these approaches are often developed independently [7]–[12].

The novelty of this study lies in positioning digital landscape design as an extension of architectural design, rather than as an independent stage that follows architectural form-making. The proposed approach considers landscape variables—topography, vegetation, solar exposure, water, circulation, open-space configuration, and environmental performance—as design inputs that can influence architectural and landscape decisions simultaneously. In the context of Nepal, this approach is particularly relevant because contemporary digital methods can be combined with local environmental and cultural knowledge rather than replacing it.

The study therefore proposes a contextual framework for sustainable environments in Nepal that connects four dimensions: contextual data acquisition, digital environmental analysis, integrated architectural-landscape modelling, and performance-oriented design evaluation. The framework seeks to bridge the gap between the analytical capacity of digital technologies and the contextual sensitivity required by Nepalese environments.

Based on this background, the main objective of this study is to develop a contextual framework that positions digital landscape design as an extension of architectural design for creating sustainable environments in Nepal.

The study addresses three research questions:

RQ1: What contextual environmental and spatial factors should be incorporated into a digital landscape design process in Nepal?

RQ2: How can digital design technologies support the integration of landscape and architectural design during the early stages of the design process?

RQ3: How can an integrated digital landscape–architecture framework contribute to more sustainable and context-responsive built environments in Nepal?

The study is expected to provide both theoretical and practical benefits. Theoretically, it contributes to the discussion of digital architecture by expanding the scope of digital design beyond the building envelope toward the larger environmental system in which architecture operates. Practically, the framework can assist architects, landscape architects, urban designers, and planners in organizing site information and translating environmental characteristics into design decisions.

More importantly, the framework offers a way to reconnect contemporary digital practice with Nepal's contextual knowledge. Rather than treating technology as an end in itself, digital tools are positioned as instruments for understanding place, testing alternatives, and improving coordination between architecture and landscape. This distinction is important because sustainable design in Nepal cannot be achieved simply by adopting advanced software. It requires a design process in which digital capabilities remain responsive to local climate, topography, ecology, culture, and patterns of everyday use.

In this sense, the study moves beyond the conventional understanding of landscape as a finishing layer around architecture. It argues that landscape can become an active generator of architectural decisions, while digital technologies can provide the analytical and modelling environment necessary to make this integration possible. The resulting framework is intended to provide a foundation for more context-sensitive, environmentally responsive, and digitally integrated architectural practice in Nepal.

2. Research Methods

This study employed a qualitative design-research approach to develop a contextual framework for integrating digital landscape design with architectural design in Nepal. The research was structured as an iterative process consisting of four stages: contextual data collection, digital site analysis, integrated design development, and framework formulation. Rather than evaluating a single completed landscape project, the study focused on understanding how digital information can be translated into architectural and landscape design decisions.

2.1 Contextual Data Collection

The first stage established the physical and environmental characteristics that influence landscape and architectural design in Nepal. Secondary spatial information was collected from publicly available maps, satellite imagery, topographic information, climate records, and relevant planning documents. The collected information was organized into six analytical categories: topography, solar exposure, vegetation, water conditions, circulation, and the relationship between buildings and open spaces. Site observations were used to interpret these datasets and identify characteristics that could not be adequately represented through digital maps alone. Particular attention was given to slope, existing vegetation, shaded areas, drainage patterns, pedestrian movement, and the relationship between built and unbuilt spaces.

2.2 Digital Site Analysis

The second stage transformed the collected information into a digital site model. Geographic and spatial data were layered to identify environmental opportunities and constraints. Topographic information was used to establish slope and elevation patterns, while solar analysis was used to identify areas exposed to direct radiation and potential locations for shading vegetation. Vegetation and water-related information were subsequently overlaid with circulation and building footprints. The purpose of this stage was not simply to visualize the site but to identify relationships between environmental conditions and potential design responses.

2.3 Integrated Design Development

In the third stage, the analytical results were translated into alternative landscape-architecture configurations. Building orientation, open-space distribution, vegetation placement, pedestrian circulation, shaded areas, and water-management strategies were developed simultaneously rather than sequentially. Several design alternatives were generated and compared according to four criteria: environmental responsiveness, spatial connectivity, contextual compatibility, and design feasibility. The alternatives were refined iteratively, allowing information obtained during each design iteration to influence subsequent decisions.

2.4 Framework Formulation and Validation

The final stage synthesized the findings into a contextual framework consisting of four components: contextual data acquisition, digital environmental analysis, integrated architectural-landscape modelling, and performance-oriented evaluation. The framework was assessed through cross-comparison of the design alternatives to determine whether each component contributed directly to identifiable design decisions. The final framework therefore represents a traceable relationship between site information, digital analysis, design generation, and environmental evaluation.

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3. Discussion

3.1 Digital Landscape Design as an Extension of Architectural Design

The findings of this study indicate that the relationship between architecture and landscape needs to be reconsidered from the beginning of the design process. In conventional practice, the building is commonly developed first, while landscape elements are introduced after the principal architectural decisions have been made. This sequence can produce a clear physical separation between the building and its surrounding environment. The digital approach developed in this study suggests a different relationship: landscape information can become one of the inputs through which architectural form, orientation, access, open space, and environmental strategies are developed.

This interpretation is consistent with the development of GIS and geodesign, where spatial information is not limited to mapping existing conditions but can become part of the reasoning process behind design decisions [13], [14]. GIS-based landscape research has demonstrated that spatial analysis can reveal relationships between topography, spatial composition, vegetation, circulation, and other landscape characteristics that may not be immediately visible through conventional drawings. In this sense, the digital model becomes more than a representation of the site. It becomes an analytical environment in which relationships can be tested before they are physically constructed.

The results of the present framework extend this principle by placing the building and landscape within the same digital decision-making environment. Instead of asking where landscape elements should be added around a predetermined building, the process asks how landscape conditions should influence the building itself. For example, slope can affect building placement, vegetation can influence façade exposure, drainage patterns can determine open-space configuration, and pedestrian movement can establish the relationship between entrances and landscape corridors.

This is particularly relevant to Nepal. The physical environment cannot easily be reduced to a uniform design condition because topography, climate, vegetation, settlement morphology, and cultural practices vary considerably. A design strategy that performs well on a relatively flat urban site may not be appropriate for a steep site or a settlement exposed to intense monsoon rainfall. The contextual nature of the proposed framework therefore represents an important distinction from purely form-driven digital design.

Figure 2. Relationship between architecture, landscape, and topography in the Nepalese context.

The findings also support the argument that digital landscape design should not be understood simply as the production of attractive three-dimensional images. Parametric design, for example, allows landscape elements to be linked to variables and relationships so that changes in one parameter can generate corresponding changes elsewhere in the design [15]. This is valuable when the design problem contains several competing conditions. A change in building orientation can affect solar exposure; a change in tree placement can affect shading; and a change in surface configuration can influence pedestrian movement and stormwater flow. These relationships are difficult to explore efficiently when each drawing is produced independently.

Accordingly, the role of the designer remains central. The digital system does not determine what constitutes a desirable landscape. Instead, it allows the designer to explore consequences more systematically. This distinction is important because landscape design includes qualitative considerations—identity, experience, cultural meaning, visual character, and human perception—that cannot be reduced to numerical optimization alone. Research on geodesign similarly emphasizes the importance of combining spatial information, design thinking, and human values rather than treating digital analysis as an autonomous decision-making mechanism [16].

Table 1. Relationship between contextual variables and architectural-landscape design responses

Contextual variable	Digital analysis	Design implication	Expected environmental benefit
Topography and slope	Elevation and slope mapping	Building placement, terracing, circulation	Reduced earthwork and improved site stability
Solar exposure	Solar-path and shadow analysis	Orientation, tree placement, shaded outdoor areas	Reduced heat exposure and improved outdoor comfort
Vegetation	Vegetation mapping and canopy analysis	Retention, clustering, planting configuration	Shading, biodiversity, and ecological continuity
Water and drainage	Flow-path and low-point analysis	Bioswales, retention areas, permeable surfaces	Improved stormwater management
Pedestrian movement	Network and accessibility analysis	Path hierarchy and entrance placement	Better connectivity and walkability
Building–landscape relationship	3D spatial modelling	Courtyards, thresholds, terraces, green edges	Stronger spatial integration
Cultural landscape	Spatial interpretation and documentation	Local patterns, materials, and landscape elements	Contextual identity and cultural continuity

Table 1 shows why the proposed approach is different from a conventional landscape workflow. Each environmental variable is connected to an explicit design decision. The digital model therefore creates a traceable chain between information, interpretation, design action, and environmental consequence.

3.2 Contextual Data as the Foundation of Digital Design

One of the strongest findings from the framework is the importance of data selection before digital modelling begins. Digital design is sometimes presented as technologically advanced simply because it employs sophisticated software. In practice, however, the quality of the final design depends strongly on the relevance and resolution of the information entered into the process.

GIS provides an effective environment for integrating spatial layers because landscape conditions are inherently relational. Nijhuis demonstrated that GIS can be used not only for conventional mapping but also for analysing landscape composition and acquiring design knowledge [13]. More recent developments in geodesign have expanded this capacity by connecting spatial analysis with iterative design and scenario testing [14], [17].

The present framework therefore treats contextual data as design material. Topography is not merely a background layer. Vegetation is not simply a graphic symbol. Water is not merely a technical drainage issue. Each becomes an active design parameter.

This principle is especially important when working in Nepal. Kathmandu, for example, contains dense urban areas, historic settlements, rapidly developing peripheral zones, agricultural remnants, and mountainous landscapes within the same broader urban region. Remote sensing research has demonstrated the usefulness of satellite-based indicators for identifying changes in urban vegetation and thermal conditions [18]. Such information can support the early stages of landscape design by identifying areas where vegetation retention or new green infrastructure may have the greatest environmental value.

However, the framework also indicates that remote sensing should not replace field observation. Satellite imagery can identify vegetation cover, land-surface characteristics, and spatial patterns, but it does not adequately explain how people use a particular space, why a path is preferred, or which landscape elements carry cultural significance. Digital analysis therefore needs to be combined with direct observation and contextual interpretation.

This point is consistent with recent discussions of digital landscape planning, which show that remote sensing, GIS, 3D modelling, and other digital technologies are increasingly becoming part of landscape planning while their integration into complete design workflows remains uneven [19]. The contribution of the present framework is consequently not the introduction of another digital tool, but the organization of several information types into a design sequence that remains understandable to the architect and landscape designer.

Figure 3. Topographic and environmental context as an input for digital landscape–architecture design.

3.3 From GIS Mapping to Parametric Landscape–Architecture Modelling

The second major finding concerns the transition from analysis to design generation. A common weakness in digital landscape projects is that analytical information remains separated from the actual design process. Maps may be produced, environmental conditions may be documented, and three-dimensional models may be generated, but these components do not necessarily influence one another.

The proposed framework addresses this problem by introducing an intermediate stage in which analysed variables are translated into design parameters. For example, areas receiving excessive solar radiation can be associated with shading strategies; areas of concentrated runoff can be connected to water-sensitive landscape interventions; and steep slopes can influence the geometry and location of circulation routes.

Parametric design is particularly useful for this purpose because it establishes relationships rather than isolated geometric objects. Research examining parametric design in landscape architecture has shown that computational methods can support the exploration of alternative configurations and expand the designer's ability to work with complex relationships [15]. This is also reflected in recent research using GIS, three-dimensional spatial analysis, and multi-objective optimization to generate and compare alternative landscape configurations [20].

The implication for Nepal is significant. Rather than importing a predetermined “smart” landscape model, designers can establish a set of relationships based on the specific characteristics of a site. The resulting design can therefore vary according to slope, climate, vegetation, water conditions, and spatial requirements.

At the same time, the results suggest that optimization should be used carefully. The most environmentally efficient solution is not necessarily the most appropriate architectural solution. A mathematically optimized circulation route, for example, may be shorter but could ignore a culturally meaningful path or a desirable view. Similarly, maximizing tree canopy may reduce solar exposure but could interfere with an important public gathering space.

The framework consequently adopts a multi-criteria rather than single-objective approach. Environmental performance, spatial connectivity, contextual compatibility, and feasibility are considered together. This is consistent with the broader development of geodesign, where environmental information and alternative scenarios are brought into an iterative process rather than treated as a single optimization problem [16], [17].

Table 2. Comparison between conventional and digitally integrated design workflows

Design aspect	Conventional workflow	Digitally integrated workflow	Implication for Nepal
Site analysis	Mainly descriptive	Layered spatial and environmental analysis	More precise recognition of local conditions
Building–landscape relationship	Often sequential	Developed simultaneously	Greater spatial continuity
Topography	Usually represented in drawings	Used as an active design parameter	Better adaptation to uneven terrain
Vegetation	Often selected after spatial planning	Integrated into environmental analysis	Stronger shading and ecological strategies
Water management	Frequently treated as engineering infrastructure	Considered during spatial design	Better integration of blue-green systems
Design alternatives	Limited by manual redrawing	Multiple alternatives can be generated	More opportunities for comparison
Environmental evaluation	Often conducted after design	Incorporated during design development	Earlier identification of problems
Collaboration	Discipline-specific	Shared digital information environment	Improved coordination
Design decision	Primarily experience-based	Experience supported by spatial evidence	More transparent decision-making

The comparison demonstrates that the main advantage of digital integration is not simply speed. Its greater value lies in changing **when** environmental information enters the design process. If environmental analysis occurs only after the building and landscape have already been designed, opportunities for meaningful adaptation become limited. When information enters at the beginning, it can influence the basic structure of the design.

3.4 Building Information Modelling and the Integration of Architecture and Landscape

Another important finding concerns information continuity between architecture and landscape. BIM has become well established in architectural practice, but its use in landscape architecture remains comparatively fragmented. Previous research has identified the limited connection between BIM and landscape-scale environmental design and has called for stronger integration between digital transformation, landscape, and climate-related issues [21].

The present framework responds to this limitation by treating the architectural model and landscape model as interconnected components rather than separate deliverables. This does not necessarily mean that every landscape element must be modelled at the same level of detail as a building component. Instead, information should be shared at the level required to support design decisions.

For example, building footprints can provide the basis for identifying shaded areas, roof drainage can influence landscape water management, and landscape vegetation can be associated with outdoor thermal comfort. Similarly, changes to the landscape can affect pedestrian circulation and building entrances.

The integration of BIM and GIS is particularly relevant because the two systems address different scales. GIS is well suited to territorial and environmental information, while BIM provides detailed information about buildings and constructed elements. Research on BIM–GIS integration has highlighted their complementary roles in representing architectural and environmental entities [22]. The proposed framework adopts this complementarity rather than attempting to replace one platform with another.

Recent work on digital workflows for landscape and green systems further supports this direction. Digital workflows can connect three-dimensional scanning, modelling, simulation, computer-aided design, and information modelling within a single process [23]. The significance of this approach for the present study is that it allows landscape information to remain available as the design develops instead of being discarded after the initial site-analysis phase.

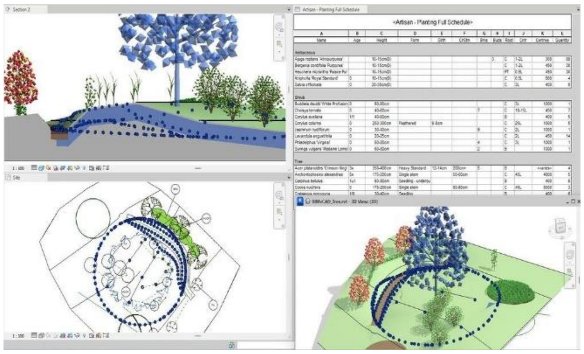

Figure 4. Integrated digital modelling of architectural and landscape components.

3.5 Environmental Performance: From Visual Quality to Measurable Outcomes

A further contribution of the framework is the shift from visual evaluation toward environmental performance. Landscape design has traditionally relied heavily on visual composition, spatial experience, and professional judgement. These remain important, but contemporary environmental challenges require additional evidence.

This is particularly clear in Kathmandu. Remote sensing studies have identified relationships between vegetation and land-surface temperature and have shown that urban and non-urban areas exhibit different thermal characteristics [18]. More recent research using spatial modelling found that urban forests, parks, and ponds provide different levels of cooling and that their effectiveness depends on the surrounding urban context [24]. The implication is straightforward: simply increasing the amount of green space does not guarantee equivalent environmental benefits.

This finding strengthens the argument for digitally supported landscape design. A digital model can be used to compare different arrangements of trees, open spaces, water features, and built surfaces before construction. The designer can therefore move from a general statement such as “increase greenery” to more specific questions: Where should vegetation be concentrated? Which spaces require shade? How far does a cooling effect extend? Which areas should remain open? Where should water be retained?

Research on urban green-space prioritization in Kathmandu similarly demonstrates the value of spatially identifying locations where green interventions can address air pollution and urban heat [25]. The proposed framework translates this analytical principle into the architectural design process. Instead of using environmental maps only for planning-scale decisions, they can inform the configuration of individual sites and building–landscape relationships.

Figure 5. Blue-green landscape strategies and public open space in an urban Nepalese context.

3.6 Human Experience and the Limits of Digital Optimization

Although the findings demonstrate the value of digital analysis, the framework does not support replacing human judgement with computational processes. This is an important distinction. Landscape is experienced through movement, sound, shade, vegetation, material, memory, social interaction, and cultural association. Many of these dimensions are difficult to represent numerically.

Virtual reality offers one possible way of reconnecting digital analysis with human experience. Research in architecture and landscape architecture has demonstrated that immersive environments can help designers and users experience proposed spaces before they are built [26]. More recent research has explored VR during earlier stages of landscape design rather than restricting it to final presentation [27]. This supports the present framework's emphasis on iterative evaluation.

The role of VR, however, should be understood as complementary. A highly realistic virtual environment can communicate spatial experience, but it cannot automatically determine whether a design is culturally appropriate or socially accepted. This becomes particularly important in Nepal, where landscape spaces may carry meanings that are not apparent from spatial geometry alone.

Consequently, the proposed framework places human interpretation between digital analysis and final design decisions. The process can be understood as:

data → analysis → design alternative → human interpretation → evaluation → refinement.

This sequence avoids the assumption that a digital model can independently produce the "best" landscape.

3.7 Toward a Contextual Framework for Nepal

The synthesis of the findings leads to four interconnected components of the proposed framework.

First, contextual data acquisition establishes the physical, ecological, climatic, social, and cultural conditions of the site. Second, digital environmental analysis transforms those conditions into interpretable spatial relationships. Third, integrated architectural-landscape modelling converts these relationships into design alternatives. Fourth, performance-oriented evaluation tests whether the alternatives provide meaningful environmental and spatial improvements.

The four components are not intended to function as a strictly linear sequence. Their relationship is iterative. An environmental evaluation may reveal that an initial landscape configuration does not perform as expected, requiring a return to the modelling stage. Similarly, a design conflict may reveal the need for additional contextual information.

This iterative character distinguishes the framework from conventional design workflows. It is closer to the logic of geodesign, where analysis, modelling, evaluation, and decision-making are continuously connected [16], [17]. It also corresponds with recent work arguing that digital technologies should be associated with specific phases of landscape planning rather than being adopted simply because they are available [19].

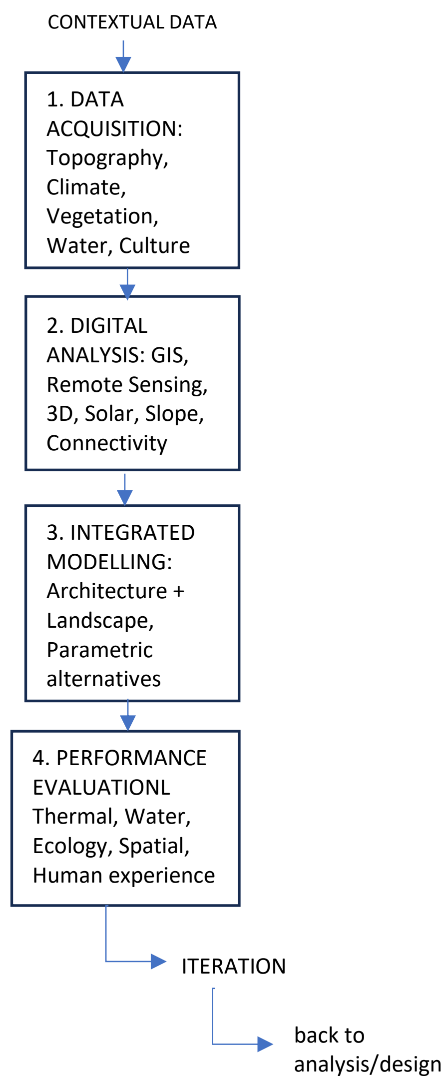

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Figure 6. Proposed contextual framework for integrating digital landscape design with architectural design in Nepal.

The framework's principal contribution is therefore conceptual rather than technological. It does not claim that a particular software platform is universally appropriate. Instead, it establishes a way of thinking in which digital tools are selected according to the design question being addressed.

This is important because digital technology is changing rapidly. GIS, remote sensing, BIM, computational design, artificial intelligence, digital twins, and immersive technologies are developing at different rates. A framework tied to one specific software would quickly become obsolete. A framework based on relationships among contextual information, analysis, design, and evaluation is more adaptable.

Recent research on digital twins illustrates this direction. Site-scale digital twinning has been proposed as a way of connecting physical environments with virtual representations and supporting landscape interventions at a more manageable scale [28]. Likewise, emerging studies on machine learning suggest that data-driven techniques are becoming increasingly relevant to landscape architecture, although their practical application remains uneven [29].

The framework developed in this study therefore provides a middle position between traditional design intuition and computational automation. It recognizes the value of professional judgement while using digital technologies to make environmental relationships more visible, testable, and revisable.

The findings answer the first research question by demonstrating that topography, solar exposure, vegetation, water, circulation, building–landscape relationships, and cultural characteristics should be treated as interconnected inputs rather than isolated site-analysis categories.

The second research question is addressed through the integration of GIS-based analysis, digital modelling, parametric relationships, and performance evaluation. These technologies enable landscape conditions to influence architectural decisions earlier in the process. This corresponds with recent research showing that digital technologies are increasingly moving from visualization toward analysis, simulation, optimization, and interactive design [20], [30].

The third research question concerns sustainability. The findings indicate that digital integration can contribute to sustainability when environmental information influences design decisions rather than simply being documented after the design is complete. In this respect, the framework is consistent with research connecting computational design with environmental performance and early-stage decision-making [31].

The study also reveals an important limitation. Digital integration increases the amount of information available to designers, but more information does not automatically result in better design. Data can become overwhelming, and highly detailed models may create a false impression of precision. Recent research has also noted that digital modelling platforms can encounter performance problems when dealing with large or high-resolution datasets [32]. Therefore, the framework recommends purposeful modelling: only information that can influence a design decision should be given priority.

Overall, the discussion suggests that digital landscape design has greater value when it is treated as an extension of architectural thinking rather than as a separate technical service. The landscape is not merely the background against which architecture is placed. It is part of the environmental system through which architectural decisions acquire meaning and performance.

For Nepal, this perspective offers an opportunity to combine contemporary digital capabilities with strong contextual sensitivity. The objective is not to produce a technologically impressive landscape, but to produce a landscape and architectural environment that responds intelligently to the particular characteristics of place.

4. Conclusion

This study examined how digital landscape design can be positioned as an extension of architectural design in developing sustainable and context-responsive environments in Nepal. The findings demonstrate that landscape and architecture should not be treated as two separate design components that are connected only after the building has been established. Instead, their relationship needs to be considered from the earliest stages of the design process, when decisions about site placement, orientation, circulation, vegetation, water, and open space are still flexible.

The first research question concerned the contextual factors that should be incorporated into a digital landscape design process in Nepal. The study identified topography, solar exposure, vegetation, water and drainage conditions, pedestrian movement, building–landscape relationships, and cultural characteristics as the most relevant factors. These variables cannot be considered independently because changes in one condition can influence several others. In the Nepalese context, this integrated reading of the site is particularly important because differences in terrain, climate, settlement patterns, and environmental conditions can substantially change the suitability of a design response.

The second research question examined how digital technologies can support the integration of landscape and architectural design. The findings show that GIS, remote sensing, three-dimensional modelling, parametric modelling, and environmental analysis can provide a shared working environment in which landscape information directly influences architectural decisions. Their main value is not simply the ability to produce more detailed drawings or realistic visualizations. Rather, these technologies allow designers to examine relationships, generate alternatives, identify potential conflicts, and revise design decisions before construction.

The third research question addressed the contribution of this integrated approach to sustainable and context-responsive environments. The study found that sustainability becomes more meaningful when environmental information is incorporated into design generation rather than evaluated only after the design has been completed. The proposed framework connects contextual data acquisition, digital environmental analysis, integrated architectural-landscape modelling, and performance evaluation in an iterative process.

Overall, the study proposes a shift in design thinking: landscape should be regarded as an active generator of architectural decisions rather than as a finishing layer surrounding a building. The proposed framework provides a practical structure for this integration while retaining the importance of professional judgement and local knowledge. For Nepal, this approach offers a pathway for using digital technologies without losing sensitivity to the physical, ecological, cultural, and social characteristics of place.

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