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BIM and GIS Integration for Urban Revitalization Development in the Kumartuli Region, a Socio-Heritage Site

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Abstract: ***This study explores the use of Building Information Modeling (BIM) and Geographic Information Systems (GIS) in improving residents' livelihood and living conditions in Kumartuli, a socio-heritage site in North Kolkata, India. The present investigation aims to explore current problems and provide future direction for redeveloping existing workplaces and living units, including improvements in infrastructure such as roads, water supply, drainage, and sewerage systems. It also explores integrating bio-climate and biophilic design principles for sustainable neighborhood development in Kumartuli. GIS can enhance BIM function by providing a systematic platform for problem-solving, while BIM represents detailed community working space data. The output may provide a new venue for investigating urban planning, infrastructure management, and construction management to improve the quality of livelihood for the communities of idol makers.***

Keywords: BIM, GIS, Construction Project, Construction Management, Kumartuli, Culture Heritage

I. INTRODUCTION

India is a country with many different customs and cultures. Heritage refers to the things that come from our past and our forefathers. In our nation, there are people of many castes, faiths, and creeds. Every ethnic group in our nation has its history, customs, and culture. India is a unique geographical place due to its nature. The Bengali community of traditional idol builders and sculptors is known to call Kumartuli home. These highly trained craftspeople are referred to as kumars. For generations, these people have been creating clay idols of various deities, including the goddess Durga. Using BIM and GIS in construction, urban planning, and environmental protection is a real game changer. This enlightened mix helps project teams to arrive at sound decisions, increase productivity, and achieve sustainability.

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The merging of BIM and GIS technologies has a new impact on construction and urban planning, offering efficiency, accuracy, and sustainability. This integration of the planning and the development in the design and construction stages results in more sustainable and resilient infrastructure development. Construction and design firms gather useful and accurate data using GIS and BIM that allows them to obtain more precise and valuable data resulting in improved and efficient design project management., GIS data integration is crucial for many applications, such as land-use planning, emergency management, environmental analysis, and infrastructure planning. This endeavor aims to raise the quality of living conditions and means of subsistence for the inhabitants in Kumartuli, a socio-heritage site in North Kolkata, India. The central spot for clay artisans in West Bengal is Kumartuli. The primary objectives of Geographic Information Systems are to enhance decision-making efficiency, enable efficient data collection and dissemination, eliminate duplicate information, and consolidate data from multiple locations. The BIM capability highlights pivotal points for organizations and institutions incorporating BIM technologies, particularly within the field of urban planning, which is a substantial area of study. Using modern digital technology trends like BIM and GIS, the present article seeks to include contemporary data on Kumartuli, a historic heritage site at the edge of the Hooghly River. These tools will be utilized to accelerate the growth of the Kumartuli society enhancing quality of life while improving the beauty of the vicinity.

- **The Objective of Paper:** This paper aims to investigate current challenges and provide propositions for the possible future growth of work environments and dwellings with upgraded facilities such as streets, public restrooms, community centers, parks, water supply, sewerage, and drainage systems, light, and ventilation systems, etc., in along with accommodation for local artisans and communal workspaces.
- **The Rationale of the Study:** By examining the available research and analyzing the present circumstances and barriers to making the necessary modifications, the study will comprehend the process of incorporating bio-climate and biophilic design concepts for sustainable neighborhood advancement in Kumartuli. As GIS regulates construction project information resources and BIM reflects explained community working space figures, both of them may assist one another by offering a structured system for figuring out solutions.

- **The Expected Output of the Study:** The results may offer an entirely new perspective on this resurgent issue, permitting an examination of all of its aspects involving infrastructure management, urban planning, and construction management to improve the quality of living for the communities of idol makers. In addition, the research indicates that heritage and traditions are outcomes of regressive development, which requires more investigation.
- **Research Methodology theses:** This paper involves several modern works of literature. A review of the literature was conducted on the subject of integrating Building Information Modeling (BIM) with Geographic Information System (GIS) and urban planning, as well as potential applications for the improvement of the cultural assets of Kumartuli. Recent data was collected from various literature resources such as reputed journals, research papers, blogs/web, conference papers, thesis, books, magazines, reports, surveys, and general papers, etc. The case study was conducted from the point of view of urban development. The parameters studied in the case study were the existing conditions, the relationship between built and open spaces, streets, basic services, and public health. After identifying the problems, the BIM-GIS model was generated to provide solutions for infrastructure management, and construction management to improve the quality of livelihood.

II. LITERATURE REVIEW RESEARCH

A. Kumartuli [Year-Wise Evolution, 2014-2024]:

Intensive interviews, case studies, photography, some books, journals, administrative materials, and internet resources have also been utilized as secondary data for the present study. They emphasize the technique used by the idol manufacturers of Kumartuli in Kolkata and show how they have modified it to improve production in response to the shifting demands of the market. Table 1 unveils specifics regarding Kumartuli, such as the name of the author, the year the research paper was published, and each author's main conclusions. This illustrates that it requires a period for the Kumartuli cultural heritage to be accepted and recognized globally.

Table 1: Literature Review Research on Kumartuli During 2014-2024

Sr. No.	Author (year) [ ]	Key Findings for Kumartuli Region and Durga Puja Festival
1	Sarkar V. 2023 [1]	The government's efforts to improve living conditions for artisans have often been unfulfilled, causing them to rely on makeshift studios to preserve their heritage.
2	Banka, N. (2023) [2]	Stated that Kumartuli is evolving as the place where artists create enormous idols of deities, primarily goddess Durga. Men are no longer the only ones who can create idols of gods.
3	Sinha, et al. 2023 [3]	The Durga Puja festival has historical and social significance evolved from ancient times to the present, with economic impact in modern society due to class evidence among artisans, urbanization, labor migration, and environmental issues.
4	Chakrabarti, D. 2023 [4]	Researched on customs of community building for the adoption, production, appropriation, and reconfiguration of informal spaces in Kumartuli.
5	Du Beat,2023 [5]	The narrated tragic reality of Kumartuli potters which revealed unhealthy situations and unhygienic conditions on his recent visit to the place; needs to improve such problems
6	Chakrabarti, D., 2022 [6]	(i) Suggested for UNESCO's Intangible Cultural Heritage list; (ii) looks into the logistics and operations of idol-making within the tight alleys; (iii) showcases artisan techniques despite narrow lanes that are competitive and crowded.
7	Chakrabarti, D., 2021 [7]	This study explores idol-making as a culturally embedded, situated practice, examining its political economy in the context of spatial restructuring and shifting governance, and highlighting the need for its inclusion in cultural policy.
8	Agni Amrita, 2021 [8]	The author describes a traditional heritage site where God and Goddess makers bring them to earth, supporting the neighborhood and being the largest hub of Durga idols in Bengal.
9	Choudhary, S. (2021), [9]	Explores how caste affects people's perceptions of their background and values in daily life and how it functions as a type of capital, ancestry, and traditional knowledge.
10	Chakrabarti,D., 2020 [10]	Explores the evolving social, cultural, and built landscape of the idol-making neighborhood in Kumartuli through visual ethnographic fieldwork, focusing on residents' everyday practices.
11	Rout, A.D.2020. [11]	The first step towards recognizing the unique artistic talent of this social group of potters is to prevent their craft from disappearing into obscurity.
12	Paul, A., and Das, 2021 [12]	The impact of globalizing factors on urban tradition and the preservation of traditional practices by idol makers in a changing world.
13	Mazumdar, M., 2021. [13]	The strategy aims to identify Kumartuli as a distinctive urban cultural space.
14	Mukhopadhyay, R., 2019 [14]	North Kolkata, located near the serene Hooghly River, is closely linked to the initiation of Durga Puja in the city.
15	Biswas Sayeri (2023) [15]	(i) limited access to modern tools and technology (ii) Despite the undeniable artistic brilliance, financial instability. (iii)Irregular incomes and not having a secure consistent livelihood (iv) Working with clay, paint, and other materials can pose serious health risks. (vi) They face the threat of displacement from the spaces they've occupied for generations (vii) and do not even have access to social welfare programs or healthcare benefits.
16	Debnath Kashish (2017) [16]	By using qualitative data analysis to fill in historical gaps in the community, this report aims to increase awareness of the realities faced by Indian craftsmen and women in India and to foster appreciation for their beautiful art form, which demands a great deal of dedication and devotion.
17	Das, et al.,2019 [17]	The research design is focused on working with heritage-facing cultures and studying heritage's resilience in diverse contexts, especially in the context of the migration of Kumar's

18	Banerjee, D. (2017, [18]	Research to improve worker lifestyles and the preservation and upkeep of cultural heritage and aesthetics are required because of the absence of development initiatives, government policies, and supporting infrastructure.
19	Basu, and Ghosh, 2016, [19]	Both the urban design parameters and the visual communication design factors can be taken into consideration when analyzing the visual perception of an urban area.
20	Logothetis, S.et al., 2015 [20]	The evolution and advancements in BIM for cultural heritage documentation, highlight the challenges faced by the community and the historical background of BIM.
21	Sharma, A., 2015 [21]	Focuses on Kumartuli Craft Village and Biopara, College Street, highlighting the importance of art and cultural industries in the economy and emphasizing preserving and maintaining heritage and cultural features.

B. Introduction to Kumartuli

The Kumartuli area, one of Kolkata's most artistic settlement indicators, [22] has attempted to investigate the significant aspects of Kumartuli idol-making styles, their transforming presentations and fresh ideas, and how the community's past, customs, and folklore are still expressed through these advancing images. One such public event that happens in the autumn in Kolkata and its surrounding areas is Durga Puja. Every year, West Bengal`1, India celebrates Durga Puja, also known as Sharadotsav or Durgotsava. Innovative designers and architects create unique pandals with distinctive and inventive concepts to entice festival visitors. [23] The most significant festival, Durga Puja, has been observed, which encapsulates much about contemporary procedures. It is the sole occasion in the country that offers insight into the wider context of design and artistic techniques. [24] The celebration proposes multiple possibilities for temporary employment and craftsmanship. [25] Kumartuli Shilpa Kendra, which creates Durga and Kali idols, is situated within the city. Kumartuli is renowned for its traditional potters' cottages. Most Kumartuli idol designers are elderly, laboring in confined, and barely lit rooms. They've been producing idols for decades. An artisan's studio is a rectangular space with a doorway towards an alley or the street, with rows of idols on each side. [26] It is the residence of many exceptional artisans engaged relentlessly in crafting clay idols for years. [27] Tried to reflect on the design procedures that drive the creation of a spatiotemporal place, as well as its tangible and intangible perceptions and relationships. They also contribute to the survival of other intangible aspects such as a common ideology, visual appeal, cultural customs, ceremonial activities, holy insights, understanding, and a revitalized link to the environment. [28] Proposes a deliberate connection of historic protection to regional growth and extensive awareness of heritage's intangible benefits and their appropriate incorporation into current municipal governance methods. [29] Investigated the Kumartuli idol-making technique. For creating the idols, the Kumars have routinely used ecologically sensitive substances like clay, tamarind adhesive, and powder that allow them to maintain the hue. **[4]** Published a book on the topic, “Heritage, Crafting Communities and Urban Transformation Durga Puja Festival, Kolkata” in 2023. Her findings enable comprehension of the way conventional crafting community activities are being implemented, adopted, created, and altered in Kumartuli's informal spaces. Ghosh stated in 2023 that Kumartuli plans to distribute idols to numerous pandals across Kolkata and idols are being traded to other zones of the globe [30].

C. Consideration of Urban Threat Parameters of Kumartuli

Issue of Living cum Workshops and Storage Spaces*:* The sculpting of idols in Kumartuli, India, traditionally begins during the Rathyatra celebration in the monsoon season. As global demand for idols increases, the festival spectacle is changing Kumartuli's seasonal customs. Artisans live in deplorable conditions with inadequate sanitation and living resources but is the only space for idol-making practices. The design concepts to reside integrated workplace units are tailored to needs, which are 18-20 feet tall, and include a macha or mezzanine level composed of wooden panels. The units have brick walls, cement concrete plaster, and factory shed roofs made from galvanized steel, tin, asbestos, or PVC sheets. Figure 1 depicts the 3D model of the Kumartuli area, which is derived from the existing data. A typical section of the artist's house is shown in Figure 1(a), whereas, Figure 1(b) exhibits the roof light fitted and built from bamboo at Kumartuli, Kolkata.

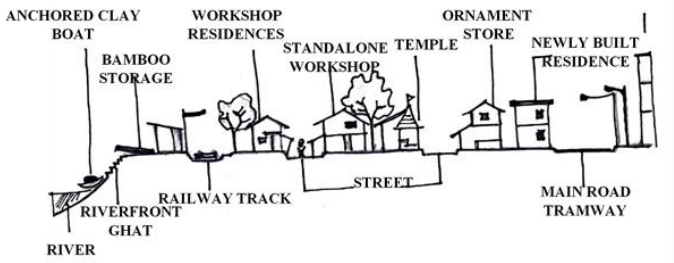

Figure 1(a): Typical Section of Artist's House

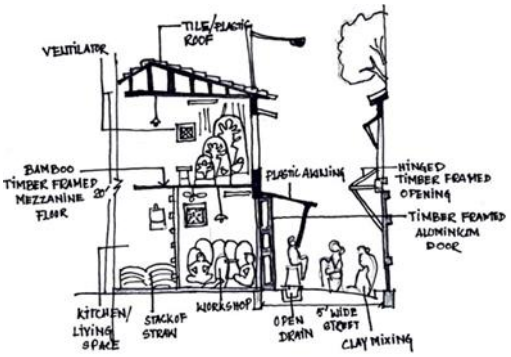

Figure 1(b): Roof Light Fitted and Built from Bamboo

The main issues faced by Idol artisans in Kumartuli include limited space and inadequate storage units for raw materials. There aren't many living quarters or workshops for them, so they have to work where they eat, cook, and rest. The lack of proper storage units hinders their efficiency. When it's raining, awnings, makeshift bamboo huts, and plastic sheets are utilized to cover streets and open areas that are used for storage.

Workshops in open, streets and public areas are occupied by idol-making activities, causing little privacy for residents. Improving infrastructure and living conditions is crucial for sustainability and well-being, as current dwelling conditions affect health and the quality of masterpieces.

Change in Space Requirement During off Season and Peak Season*:* Depending on the festival, different requirements for idol-making necessitate greater horizontal and vertical space. To meet this demand, during the busiest times of Durga Puja, artisans put in 24-hour shifts, extending studios, remodeling homes, and setting up open-air manufacturing lines. Despite these limitations, the creative use of open and shared areas enables artists to supply seasonal demand.

Issue of Light, Ventilation, and Open Spaces*:* Clay model makers can be found in Kolkata's Kumartuli alleys, but their workspace's inadequate lighting, ventilation, and exposed areas are a serious concern. The craftsmen's health and the caliber of their work are adversely affected by the claustrophobic conditions, which are characterized by poor illumination and airborne clay dust particles. Figure 1(b) shows a roof light fitted and built from bamboo that is around 40 years old. Similarly, low-lit roofs supported by a single bamboo pole, and units covered with PVC sheets can be seen throughout the neighborhood [18]. The neighborhood is busy with artisans crafting sculptures and feels the absence of refreshing patches of greenery. The lack of green spaces is not just an aesthetic concern but is associated with various health and environmental issues. BIM and GIS can help to replete the area with multiple open spaces, functioning as both, for community interaction and Idol making workshops.

Issue of Water Supply, Street, Garbage Disposal, Drainage, Street Lighting, Public toilets- Water Supply and Drainage: The water supply is intermittent and inadequate, forcing potters and residents to rely on tankers. Idol-making requires a lot of water, and the drainage system is inadequate, leading to frequent waterlogging and public health hazards.

Inadequate Public Toilets: The lack of public toilets in Kumartuli is causing distress for women and elderly residents, who lack clean and hygienic facilities. Overcrowded public toilets lack basic amenities like running water and sanitation. To address this issue, proper toilets, and clean water are needed, as well as infrastructure planning to prioritize water supply needs for artisans.

Inadequate Street Lights: Inadequate Street lighting in Kumartuli, particularly during peak season nights, is causing darkness and safety concerns. To improve safety, more street light positions should be identified, installed, and upgraded with energy-efficient options. A well-lit town reduces accidents and enhances the town's charm. Figure 2 shows the internal layout during the night, workshop, residential cum shop of Artian's place at Kumartuli [26].

Figure 2: Internal Layout during the Night, Workshop, Residential Cum Shop of Artisan's Place at Kumartuli

Figure 3: Encroachment of Street with Crowding, and Idols on the Street at Kumartuli (Mujumdar, 2020)

Plight of Kumartuli Street: Firstly, the issue of garbage disposal in Kumartuli, is causing visual and health hazards due to unmanaged waste and excessive straw waste. During peak season, artisans use surplus straw for idol creation, but it rots and ends up on the streets. This not only affects aesthetics but also poses a risk to public health and the environment. Secondly, the transportation of soil from Ganga to Kumartuli artisan workshops is causing logistical challenges, disrupting Kolkata's renowned idol-making process and causing financial stress. Figure 3 indicates encroachment of the street with crowding, and idols on the street at Kumartuli [22], because there is not enough light or ventilation within workshops, the idols are dried on the streets. Similarly, because clay mixing cannot be done inside the workshop, it is frequently done outside. Fourth, the neighborhood's 17th-century workshops lack electric fans and lights, leading to narrow alleys due to their convertible main gates opening onto streets. The awning-covered workplaces that drape over the avenues, expanding the artisan's spaces, give a sense that Kumartuli is a ghetto to visitors who aren't acquainted with it.

However, this is the result of mismanagement and inadequate city planning. Fifth, street network and width are crucial for finished idol distribution and material acquisition. Maintaining appropriate street conditions year-round is essential, as roads can cause irreversible damage, and overhead electrical cables can cause damage. Figure 4 shows a BIM-GIS model of the Kumartuli region.

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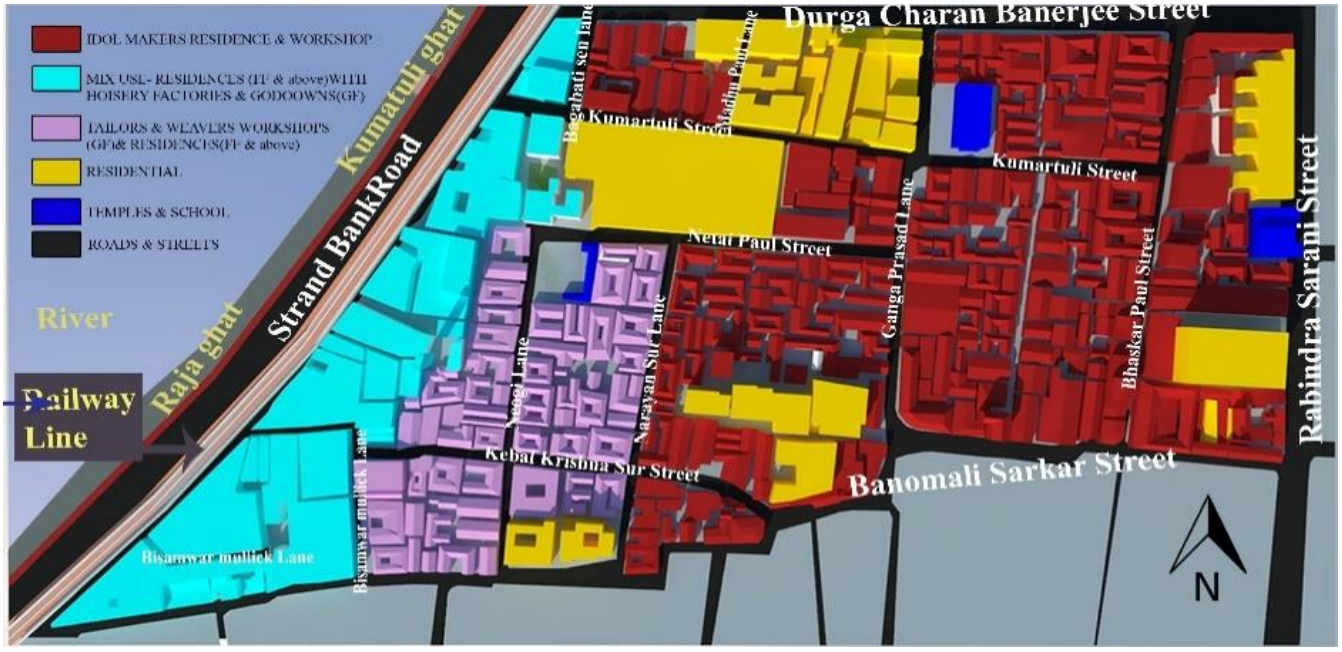

Figure 4: BIM-GIS Model of the Kumartuli Region

This paper discusses a comprehensive and immediate solution using the latest technology of BIM and GIS to restore the heritage vibes of the neighborhood ensuring growth, prosperity, and cleanliness, and offering an exemplary model of effective space management for the artisan neighborhood of Kumartuli.

III. INTEGRATION OF NEW TECHNOLOGIES FOR THE REDEVELOPMENT AND REVITALIZATION OF KUMARTULI REGION OF WEST BENGAL

For many years, idol craftsmen were settled in the Kumartuli neighborhood. It remains a crucial aspect of Bengali heritage and culture today, despite multiple historical revolutions. Regarding religious expression, idols are significant in India since they constitute tangible representations of the divine. In the instance of Kumartuli, residents desire an appropriate amount of space to execute the imaginative and constructive facets of the idol-making tradition. [10]. Therefore, the research comprehending that an in-depth analysis of the spaces and the artisan's narratives is required to correlate the spatial arrangement of existing workplaces and dwelling units with a focus on the enhancement of infrastructure, such as roadways, water distribution, drainage, and sewerage system, illumination, public restrooms, community space, neighborhood parks, daylight, and air circulation of Kumartuli. The study recommends sustainable urban regeneration alternatives for the neighborhood to bring about necessary modifications and possibly balance it with heritage preservation. The transformation of the historical neighborhood of Kumartuli, India's artistic hotspot, can be assessed through literature studies and GIS & BIM-based scenario assessment. This collaborative exploration uses geographical information systems (GIS) to map spatial data and building information modeling (BIM) for detailed architectural installations. By blending the wisdom from literature and advanced analytics, the study identifies key areas of development with an attempt to retain the traditional charm of Kumartuli. Sustainable planning proposals can be strategized based on existing situations. Through such analyses, Kumartuli can undergo a renaissance, promoting community engagement, art appreciation, and urban redevelopment, while staying true to its ancestral roots. The use of GIS and BIM, combined with literary insights, provides a holistic and technology-driven approach to urban transformation and remains an unexplored territory in the field of neighborhood development. These age-old artisans' communities of Kolkata can also integrate bio-climate and Biophilic design principles. The bio-climate design utilizes the local climate and surroundings for building temperature regulation, lessening the reliance on man-made heating and cooling systems. Biophilic design, conversely, is centered on weaving natural elements into the design to boost human health and happiness. Using BIM and GIS synergy can be created between these principles to set a green strategy for this Kolkata neighborhood. The redevelopment strategies that make use of GIS and BIM emphasize essential roadway enhancements that guarantee greater connectivity and travel efficiency. Important services that ensure hygienic living environments, such as access to water, drainage, and an extensive sewerage system, will be planned for major upgrades. Improved street lighting ensures more secure evenings, and the addition of public restrooms improves comfort for every individual. To enhance living conditions, render Kumartuli appealing to visitors, and conserve its distinctive culture, the proposal demands new green spaces, a civic center, and modern housing.

A. Heritage, BIM, and GIS Application

India has an impeccable religious basis and an integrated heritage preservation strategy [31]. Investigated the underlying theories of (i) the antiquated building system, (ii) the significance of emotion in the building process, and (iii) the non-permanence of the material. Maintaining cultural heritage is essential.

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The technique of reviving traditional intangible heritage, and establishing new disciplines will ultimately contribute to the economic sustainability of heritage as an outcome. Digital representations of both natural and architectural objects are made feasible via BIM and GIS. The macro-level depiction of a building's surroundings is provided by GIS, while BIM concentrates on the micro-level representation of the actual structure [32]. The distinct dominating positions of the two technologies are used to categorize three common kinds of BIM-GIS integration: "BIM leads and GIS supports," "GIS follows and BIM endorses," and "BIM and GIS are evenly engaged." Scholars who focus on BIM-GIS integration studies in the sustainable built environment could employ this overview as an outline. Bringing back the essence of physical and intangible features that were dwindling due to the modernist's urge is referred to as revival. After using conservation intervention approaches like restoration, adaptation, preservation, reconstruction, etc. [33], the TREE analysis of Jaipur has been accomplished. They emphasized the importance of preserving and reviving the once-famous Indian city ambiance. [34] Urged the construction of methods that acknowledge the diversity of cultural values and the careful integration of sustainable heritage urban conservation into local urban development strategies. Provided suggestions [35] which can be used by specialists employed by preservation groups, municipal governments, professional practices, non-profit groups, and digital technology businesses to support smart heritage conservation strategies globally. The Goddess Durga, one of the biggest cultural events that reign supreme in the heart of all Bengalis, Kumartuli is the birthplace of idols. A Kumartuli artisan crafting the face of Goddess Durga. Durga Puja is the biggest manifestation of this craft at its peak. Kumartuli's historic streets, till today, echo stories of resilience and reinvention. The painting of Ma Durga's eyes on the auspicious day of Mahalaya, or *Chokhudan*, or giving of the eyes. The craft in itself thus is imbued with a sense of ritualistic holiness, a birthing of the Divine. Earlier researchers on Kumartuli heritage preservation have neglected the use of modern technologies adopted for development and urban planning. Recently, [36] developed a theoretical framework that connects authenticity, cultural heritage values, and urban progress to effectively incorporate heritage into urban development. The study also utilizes a case study approach delving into Ahmedabad, Cairo, and Shiraj as case studies. Very recently, [37] in practice adopted two modern technologies namely BIM and GIS for planning, investment, and construction processes using FME (Feature Manipulation Engine). The built setting of the city views heritage sites as a valuable resource, and the planning of land utilization in the regeneration process is influenced by their significance to the socio-economic structure of the city's urban mechanism. Neighborhoods can connect to their local identity through urban heritage, which is a vital asset. Rapid development and unregulated expansion frequently undermine the authenticity of historic sites by upsetting the cultural fabric and changing their character. An examination of [38]. Unveiled the Relative Positive Impact Index (RPII), a cutting-edge method for evaluating the sociocultural effects of urban renewal. The importance of RPII stems from its capacity to assess the effects on ancient urban areas' cultural identity and fabric statistically, which is crucial for sustainable urban development. Furthermore, they provided insightful advice on how to apply RPII in other urban precincts for comparative analysis and further developed urban practices, which helped to notify choices about urban policy and planning. These suggestions for sustainable urban development and policymaking in historical districts were especially beneficial. The digital built setting idea revolves around two fundamental concepts: building information modeling (BIM) and geographic information systems (GIS). Despite their complementarity and ability to produce digital representations, their goals and areas of attention differ. By describing the advantages, difficulties, and lessons discovered for the integration of BIM and GIS from a technical, process, and managerial standpoint, [39] have advanced knowledge. To examine the integration of BIM and GIS at a global design and consulting firm, this study used numerous case studies as the basis of its research.

B. Reviewing the literature for Integration of BIM and GIS, and Urban Planning

Integration of BIM with GIS and Urban Planning for the development of Kumartuli is studied by referring to recent research articles on BIM, GIS, and urban planning. When combined, BIM and GIS are two essential technologies that potentially revolutionize digital building. However, there remains a point of contention in this integration. Experts are increasingly integrating BIM and GIS, arguing that BIM provides detailed 3D visualization and can organize large volumes of building data, while GIS is highly customizable, ideal for campus or multi-site projects, and is more applicable for data outside buildings, making it a more progressive approach [15]. Digital representations of environmental and architectural entities are made possible via BIM and GIS. GIS provides a macro-level representation of the exterior environments of buildings, while BIM concentrates on micro-level modeling of the actual buildings [32]. By the various dominant positions of the two technologies, three common styles of BIM-GIS integration are categorized: "BIM leads and GIS supports," "GIS leads and BIM supports," and "BIM and GIS are equally involved." Numerous references on the application of BIM and GIS in urban planning and construction are described in the literature. A case study on the use of geospatial data in building information models (BIM) and land information models [40]; benefits of integrating GIS and BIM in 2023 [41]; mapping slums using remote sensing and street view imaginary [42]; an integrated BIM-CIS platform for displaying and representing 3D cadastral data [43]; and combining GIS and BIM for infrastructure design and construction Participant in GIS [44]; BIM-GIS use for post-disaster reconstruction: a critical assessment[45]; integrating GIS and BIM creates smart communities [46]; reviewing the integration of GIS and BIM methods in construction project management [47]; a synopsis of the integrated application of GIS and BIM [48]. As urban development has a direct impact on daily living, it is regarded as one of the most significant research areas at the moment.

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Figure 5 shows the flowchart of different factors of the urban development process. [49] Have reviewed existing models on GIS and BIM developed by different researchers, suggesting that GIS and BIM at the data level can address various issues by transforming coordinates from City GML to IFC. [50] The study explores the integration of BIM & GIS for assessing urban risk and offers benefits for project and asset management, allowing access to large datasets. BIM and GIS have developed rapidly, but their strengths in projects differ. Integrated BIM-GIS is rarely used in the AEC industry, but its integration can bring significant value, according to [51]. As mentioned in [52], the significance of these technologies may be seen in the various ways they are applied in the field of urban planning, including master planning, future planning, land use, site selection, and strategic urban planning. When the GIS is incorporated with BIM, it adds a certain geospatial element to the design which makes the system smarter and safer. It enhances the overall workflow of the process. [53]. He has summarized the nine advantages of integration in construction and heightens the project value by adding security to it and upgrading its facilitation with the building design [41]. [54] highlights the benefits of integrating GIS and BIM in urban planning, emphasizing the need for better designs and data exchange between BIM, CAD, and GIS for sustainability and resilience.

- **The Integration of BIM + GIS can Significantly Benefit AEC Professionals Through Cooperation**

BIM enables the creation of 2D drawings from 3D models that optimize time and precision. BIM enables the creation of prototypes that help analyze patterns in different designs and construction scenarios. Table 2 provides the benefits of the integration of BIM and GIS for AEC professionals through cooperation. BIM allows project stakeholders to interact in the same virtual building model.

Table 2. Benefits of the Integration of BIM and GIS for AEC Professionals Through Cooperation

Sr.no.	Particular Parameter	Application	Significance /impact
1	Infrastructure layout in relevance to the environment	GIS data assists in contextualizing facilities and streamlining the design-build process.	It improves the surrounding context, provides building owners guidance, and offers precise knowledge about construction sites
2	Smart urban planning and management	BIM design is data sharing, which is essential for addressing macroeconomic: problems	Developing robust and sustainable facilities
3	Saving costs and making efficient design decisions	Using GIS and BIM integration will enhance workflow, and prefabrication, reduce data loss,	Improve logistics, and streamline scheduling to enhance design and build efficiency
4	Smart cities & BIM integrated GIS effectiveness	Well-being, growth, social cohesion, safety, and direction are fundamental components of smart city planning.	Applying BIM and GIS to integrate physical information with design methods allows for a unique perspective on a building or infrastructure.

- **Applications and Benefits of GIS and BIM Integration**

For the AEC industry, GIS and BIM collaboration is vital. By incorporating BIM data from several disciplines, the combination of these elements offers a spatial real-world management solution for structures and projects in the AEC industry. Data from Google Earth Pro is extracted and the spatial Model is created in ESRI's ArcGIS software for studying existing contours, built structures, open spaces, and connectivity. Later Revit, BIM software is used for climate analysis, proposing solutions for the infrastructure development. Figure 1 shows the 3D model of the Kumartuli area, which is derived from the existing data and can be used for future proposals for infrastructure development. The application of BIM using GIS is demonstrated in Figure 5 with three illustrations. Figure 5(a) represents urban development and planning flowchart. It includes various stages along with the use of software, equipment, and data extraction, Figure (b) shows the application of BIM and GIS via 10 steps adopted for analysis, whereas, Figure 5(c) displays the design, build, operation, and planning process.

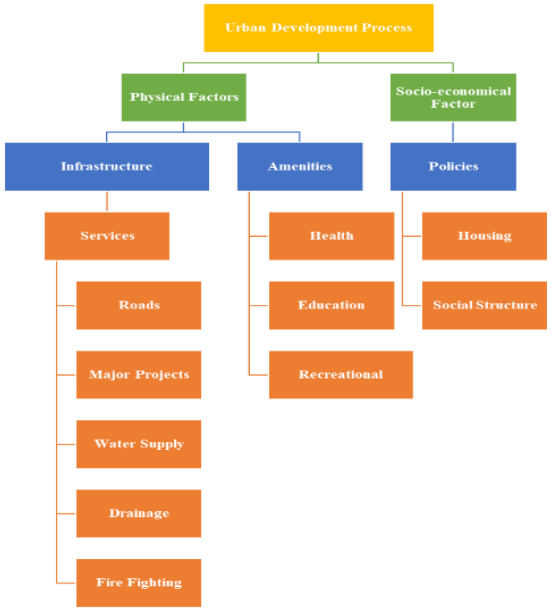

Figure 5(a): Urban Development & Planning Process

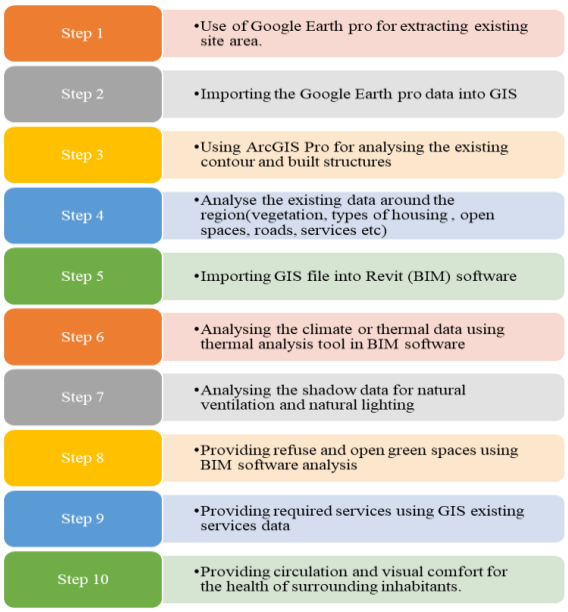

Figure 5(b): Implementation of BIM and GIS via 10 Steps Adopted for Analysis

- **Open BIM and GIS: Integration Advantages between the Two Technologies:**

To improve the design, building, and engineering projects, the IFC model encompasses BIM and Territorial Information Systems allowing for the development and oversight of GIS Digital Twins. A collaborative method for managing data, design, and development is called open BIM. Its foundation is made up of open standards that promote information exchange between various software platforms. All members of the design and execution teams can work together with greater effectiveness and efficacy with open BIM, preventing data exchange errors and raising the standard of projects.

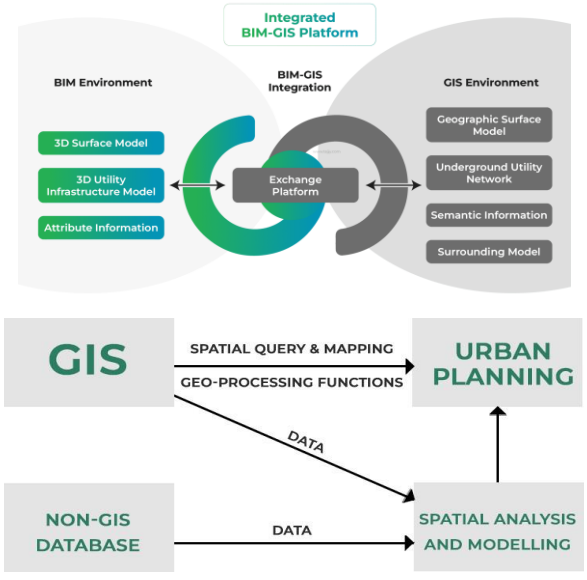

Figure 5(c): The Design, Build, Operate, and Plan Combined with BIM and GIS

- **Application Integration of Open BIM and GIS Software:**

The integration between open BIM and GIS requires project teams to carefully plan and introduce adequate training. The top GIS and open BIM players in the world have teamed up to offer the ArcGIS Digital Twins of us BIM. Geotwin is a solution that allows AEC professionals to construct and manage digital twins of their projects by fusing IFC models and GIS Digital Twin data. It is a dynamic and bidirectional fusing of the two systems rather than a static import of data from one to another system. All relevant GIS functions and activities are managed by ESRI's ArcGIS, and all pertinent BIM functions and activities are managed by ACCA's us BIM ecosystem. The GIS-based service dynamically updates any new or modified data on the IFC open BIM model in the usBIM platform.

- **GIS as a Tool for Urban Planning:**

GIS enables planners, surveyors, and engineers to design and map neighborhoods and cities. It aids in visualization, spatial analysis, and modeling, storing, manipulating, and analyzing social, physical, and economic data. GIS can identify land development differences with the environment. One common use is route planning and analysis, where GIS can be used to identify the most efficient or cost-effective routes for vehicles. GIS can also be used for traffic analysis and management, such as by analyzing traffic patterns and identifying bottlenecks or areas of congestion.

Local management bodies can more easily perceive features like prime agricultural land, surface water, high flood frequency, and highly erodible land by using Geographic Information Systems (GIS), a multi-layered mapping feature. To evaluate a site's viability for development, building a school or hospital, or handling and disposing of waste, GIS can also be utilized for feasibility evaluations. Professional planning and decision-making are made possible by its assistance in identifying changes in geographical features or land behavior over time. [55] Have examined several variables to comprehend the inappropriate urban development and connected them with the modifications in implementation brought about by the use of BIM and GIS software. Cities increase for future development as a result of faster urbanization and population movement.

Building information modeling (BIM), historic BIM (HBIM), and geographic information systems (GIS) have become increasingly important when it comes to managing smart neighborhoods, within the building industry, infrastructure, and cultural heritage preservation and administration [56]. The main features of the web platform—the Planner, the whole Dashboard, and the Viewers for artifacts, GIS, and BIM—are highlighted in this article.[57] To improve urban heritage management, this has been made possible by the creative combination of BIM and GIS. The GIS framework has been utilized for importing BIM data for 3D visualization and analysis of multiple scenarios for the sustainable development of facilities. They provided evidence of the vital importance of society as a whole engagement, the numerous economic and social advantages, and the enhancement of urban historical assets. It is a strategy for managing urban history that is more egalitarian and profitable, which benefits lawmakers, decision-makers, urban planners, and the population at large.

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- **The Application of GIS in Urban Planning:**

When it comes to effective urban planning, GIS is a major and useful technology that has shown to be quite important for many. The inventory of resources, creation of designs and maps for land use, analysis of environmental and socioeconomic data, analysis of site selection and appropriateness for land, measurement of connectivity, impact assessments, evaluation, monitoring, and feedback. When using GIS in urban planning, these factors are considered. Table 3 illustrates a few real-world uses of GIS in urban planning under current modeling conditions.

Table 3 Application of BIM + GIS at Various Construction Stages

Sr. No	BIM Use Case	Softwares	Equipment	Data
1	Project Site Modelling and Infrastructure Modelling (existing ground surface)	Sketch-Up, Revit, Revit MEP, Navisworks, BIM 360, Bentley Context Capture	3D Scanner - LIDAR, Drone Photogrammetry	CAD or GIS drawings, Google Earth photos, and scans
2	Surrounding Site modelling (Includes the Buildings, and infrastructure (roads, railroad, subways, pathways) adjacent to the project site necessary for project analysis)	Sketch-Up, Revit, Revit MEP, Navisworks, BIM 360, Bentley Context Capture, Autodesk Recap	3D Scanner - LIDAR, Drone Photogrammetry	Project Site Model, CAD or GIS drawings
3	Existing conditions – laser scanning (existing facilities and assets.)	Sketch-Up, Revit, Revit MEP, Navisworks, BIM 360, Bentley Context Capture, Autodesk Recap	3D Scanner - LIDAR, Drone Photogrammetry	CAD or GIS drawings, Google Earth photos, and scans
4	Geo-technical modelling (geo-technical analysis report supporting project scope and requirements.)	Revit Architecture, Navisworks	3D Scanner - LIDAR, Drone Photogrammetry	Geo- technical data, CAD and GIS drawings

- **Use case studies for the Application of GIS_BIM Tools Toward the Conservation of Heritage Structures**

Project-specific BIM applications' goals are outlined in BIM use cases. The use case selection and prioritization process partly determine the degree of complexity of the intended BIM deployment. The infrastructural legacy along the Chinese Eastern Railway (CER) Main Line is a prime example of this phenomenon. To aid in the preservation of this historic infrastructure, [57] suggested creating a database that combined HBIM and GIS and examined the viability of this approach. To successfully integrate heritage into city growth, they built an exacting, effective, and cooperative technique for integrating [58]. They constructed a conceptual structure that links authenticity, cultural heritage values, and urban advancement. To understand how [36] have appeared in actual circumstances, the study also applies a case study methodology, using Ahmedabad, Cairo, and Shiraz as case studies. Specifically, the study examined the connection between genuineness and feeling of place. Highly integrated visualization, bi-directional interactive data flow, open standards, specifications, customization, and user-friendly experiences are fundamental aspects addressed [37] in future BIM GIS integration. [59] Underscored the importance of land-use planning and renovation strategies in securing the advantages of including these 26 ancient structures within Foah City's socioeconomic development. After Cairo and Rasheed City, it is in third place among Egypt's most significant historic cities (Table 4). The results [60] offer important insights into the developments, trends, and new technologies in HBIM for ancient renovation and preservation. We have taken these 6 case studies as a guideline for further application of GIS and BIM tools that can be adopted for the revitalization and development of the Kumartuli region of Kolkata. No work appears in the literature as a case study of Kumartuli region for revitalization concerning investment approach either by private companies or government agencies. So, we feel this is a good opportunity for researchers to work out further this aspect scientifically and commercially.

Table 4: Use Case Study for Application of GIS -BIM Tools Towards Conservation of Heritage Structures

Sr. No.	Author /Year, and Ref. No.	Title of the Paper - Case Study	Impact on the Preservation of Heritage
1	Puerto, A. et al. (2024). [60]	Building information modeling and complementary technologies in heritage buildings: A bibliometric analysis	Heritage Building Information Modeling (HBIM) is a technology that has made significant strides in preserving and efficiently managing cultural and architectural structures. (ii) Provided valuable information on the advancements, patterns, and emerging technologies in HBIM for preserving and maintaining historic buildings.
2	Youssef, M.M. (2023). [59]	Land Uses Integration in Revitalization of Heritage Urban Sites: Foah City as a case study	(i) Focus on the priority for value on the socio-economic body of urban city mechanism and the importance of land-use planning in the revitalization process(ii)Ensured the benefits of integrating these 26 historic buildings in the socio-economic process of Foah City

3	Xu ,J. and Scaioni,M. (2023) [58]	A brief feasibility analysis of HBIM/GIS integration in the infrastructure heritage conservation: the case of the Chinese Eastern Railway CER main line	(i)Proposed building of a database that integrates HBIM and GIS to facilitate the preservation of this historic infrastructure and analyzed the feasibility of this method(ii)established an accurate, efficient, and collaborative method for heritage conservation
4	Bonfantia, H. et al. (2023) [56]	Development of an integrated BIM-GIS management tool for the maintenance plan of historical heritage	The case study is the system of the Sacri Monti of northern Italy and Switzerland, groups of chapels and other architectural artifacts (ii) collect information on the characteristics of the heritage for maintenance and conservation purposes
5	Pedó1, B. et al.(2023) [39]	BIM and GIS integration: lessons learned from multiple case studies.	(i)Contributed to knowledge by outlining the benefits, challenges, and lessons learned for the BIM and GIS integration from a management, technical, and process perspective. (ii) adopted multiple case studies as its research strategy to explore the BIM and GIS integration at a multinational design and consultancy company
6	Shah ,A.A.et al.(2023) [36]	Preserving the Past and Shaping the Future: An Articulation of Authenticity of Heritage within Urban Development	(i) Utilizes a case study approach delving into Ahmedabad, Cairo, and Shiraz as case studies to unravel how they have manifested in real situations and specifically explored the relationship between authenticity and sense of place (ii) effectively incorporate heritage into urban development.

In Kumartuli, a traditional neighborhood in Kolkata, religious idols made of straw and clay are carved [10]. The neighborhood is becoming increasingly challenged by the city's plans to revitalize the city. Following the city's Durga Puja festivities were designated as Intangible Cultural Heritage (ICH) by UNESCO, idol builders in Kumartuli, the clay modelers hub in north Kolkata, anticipate an overhaul of the local facilities, municipal services, and operational circumstances.

Numerous Indian cities have tried to deal with historical regions under Delhi's master plan (2021). According to preserve name, location, and year-end completion, a lot of Indian cities are categorized into 1 to 5 categories in this study. The Compendium of Urban Heritage Management Best Practices (2022) published by the Institute of Urban Affairs, New Delhi offers helpful details on cultural heritage. The earthy smell of clay and the rhythmic sounds of chisels fill the narrow alley ways of Kumartuli, a neighborhood in the northern part of Kolkata, offering origin to a singular form of craftsmanship that has stood the test of time: idol-making. The artisans of Kumartuli, with their skilled hands and unwavering dedication, transform humble clay into divine manifestations that grace the grand festivities of India.

A unique celebration that blends custom with fashion, belief with pleasure. Durga puja in Kolkata is additionally referred to as the world's largest public art festival. Durga Puja, which is included in the List of Intangible Cultural Heritage of Humanity, was first conducted in private homes by members of the upper class until the 18th century, at which point the idea of community pujas developed. The fact that Kolkata's Durga Puja has been included in the 2020 UNESCO Intangible Cultural Heritage list is evidence of the festival's importance and the ethnic groups that create its remarkable idols.

- **Limitation of the Present Work:**

We have taken these 6 case studies as a guideline for further application of GIS and BIM tools for the revitalization of the Kumartuli region of Kolkata. No work appears in the literature as a case study of Kumartuli region for revitalization is concerned with investment approaches either by private companies or government agencies. So, this is a good opportunity for researchers to work out this aspect scientifically.

IV. CONCLUSION

Urban history as a social, cultural, and financial resource for city growth. This historic urban landscape approach considers the complete human context, including all of its material and immaterial components, rather than only the preservation of the physical surroundings. Guidelines for managing urban heritage, with an emphasis on historic urban layout planners, compiled. With a variety of legacy routes giving distinctive experiences based on UNESCO-recognized heritage, India is among the countries with the broadest range of cultural legacies. The urban expansion of Kolkata has facilitated creative advancements in the Kumartuli neighborhood, which was inducted into the UNESCO list of intangible cultural heritage in 2021. The community supports Durga puja, which is a religious and artistic performance open to the public. Urban modernization initiatives, which have overlooked housing, amenities, and essential services, pose an imminent risk to Kumartuli's rich cultural fabric. It is imperative to maintain Kolkata's rich cultural legacy despite the hurdles presented by urban growth. Environmental, transportation and hydrological research studies greatly benefit from the use of GIS as a means of decision-support for technical challenges. It allows for storage, updating, manipulation, and retrieval of spatially referred data. The integration of GIS and BIM is vital for the industry, both commercially and evolutionally. This integration could be the next significant step for the global AEC industry. The sacred sculptures of Durga in Kolkata's Kumartuli are sculpted using straw and clay, a historic district that is growing increasingly vulnerable as a result of the city's pursuit of urban redevelopment. Combining GIS with BIM is an ideal way to generate outputs that are more effective and productive for smart communities. However, more than just the cooperation of software vendors would be required to achieve this level of integration; very specific requirements for BIM data would also be needed for later management-related workflows, including the inclusion of GIS attributes as early as possible in every project execution.

For big cities, several standards about different project kinds—such as architecture, utilities, transportation, and others—would need to be developed. Ensuring standardized access to GIS data and its appropriateness at various phases of a BIM project's realization is the responsibility of the Government. With the increasing stress caused by urban growth worldwide, the optimal strategy for managing urban assets is likewise becoming increasingly crucial. A city's legacy is a great social, cultural, and economic resource that, in the current environment, needs to be acknowledged as vital to the city's future growth.

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Authors Contributions	All authors have equal participation in this article.

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