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METHODOLOGY FOR OPTIMIZING MASTER PLANS THROUGH GIS AND BIM INTEGRATION IN UZBEKISTAN'S URBAN PLANNING PRACTICE

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Abstract: This article provides an in-depth analysis of the methodology for integrating Geographic Information Systems (GIS) and Building Information Modeling (BIM) technologies in the development of urban planning documentation and master plans for cities in Uzbekistan. Highlighting the limitations of traditional 2D design approaches, this study substantiates how the GeoBIM approach enhances urban zoning, facilitates infrastructure network simulations, and improves spatial data accuracy. Furthermore, digital algorithms for calculating urban development indicators and systematic procedures for aligning workflows with Uzbekistan's national Urban Planning Norms and Rules (SHNQ) are proposed.

Keywords: Urban planning, Master plan, GIS, BIM, GeoBIM, Spatial analysis, Interoperability, SHNQ.

1. INTRODUCTION AND PROBLEM STATEMENT

Modern urbanization processes demand rational resource utilization, environmental sustainability, and the creation of safe, comfortable urban environments. In recent years, extensive reforms have been initiated across the Republic of Uzbekistan to develop and digitize master plans for cities and human settlements. However, most methods currently applied in urban planning practice remain conventional—characterized by fragmented workflows and static data.

In traditional master planning, topographic and geodetic data, land cadastres, demographic dynamics, and utility networks are handled independently on disjointed 2D drawings. This separation leads to severe spatial clashes during project implementation, inaccurate calculations of infrastructure utility loads, and inefficient land use.

The modern resolution to this bottleneck lies in the seamless integration of Geographic Information Systems (GIS) and Building Information Modeling (BIM). While GIS handles macro-level spatial, geographic, and environmental analyses at the regional or municipal scale, BIM delivers micro-level parametric and 3D geometric intelligence for individual buildings and engineering structures. Their synergy—the GeoBIM platform—transforms static urban master plans into dynamic, continuously updated "Digital Twins."

2. METHODOLOGY AND GEODATA INTEGRATION

The methodology for integrating GIS and BIM datasets into a unified master planning framework comprises three principal stages:

2.1. Macro-Level GIS Analytical Layer

This stage establishes the geographic foundation of the urban area. Digital Elevation Models (DEM), cadastral boundaries, transportation networks (road and rail), sanitary protection zones, and hydrological features are consolidated as vector and raster layers. All spatial data are projected into the national geodetic coordinate system (EPSG: 32642 – UTM Zone 42N).

2.2. Micro-Level BIM Data Transfer and Transformation

BIM models of individual facilities and infrastructure assets (in open IFC format) are transferred into the GIS environment using CityGML and Open Geospatial Consortium (OGC) standards, preserving both geometric and semantic properties (materials, capacity, energy consumption). Throughout this process, objects are structured across appropriate Levels of Detail (LoD)—scaling systematically from LoD1 (basic 3D bounding masses) up to LoD3 (detailed exterior envelopes and architectural components).

2.3. Semantic and Attribute Harmonization

A primary challenge in GeoBIM interoperability stems from structural data discrepancies: GIS identifies spatial features via coordinate-linked attribute tables, whereas BIM defines assets using parametric geometry and object classes. To bridge this gap, automated ETL (Extract, Transform, Load) pipelines are deployed to standardize and map semantic attributes across platforms.

Table 1. Comparative analysis of GIS, BIM, and integrated GeoBIM systems

Evaluation Criteria	GIS (Geoinformation Systems)	BIM (Building Information Modeling)	Integrated GeoBIM
Spatial Scale	**REGIONAL / City & regional level (Macro)**	**FACILITY / Building & site level (Micro)**	Comprehensive urban, building, and utility networks
Data Formats	Shapefile, GeoJSON, PostGIS, Raster	IFC, RVT, DWG (Parametric 3D)	CityGML, GeoJSON-LD, Digital Twin (3D)
Role in Master Planning	Zoning, transit networks, and environmental analysis	Facility capacity and mechanical/electrical utilities	Automated, real-time urban simulation
Tolerance / Error Margin	Low precision at micro-scale (±1–5 m)	Lacks global geographic reference	High precision (±0.01 m with precise georeferencing)

3. RESULTS AND DISCUSSION

In accordance with Uzbekistan's urban planning regulations (SHNQ 2.07.01-03: *"Planning and Development of Urban and Rural Settlements"*), implementing the GeoBIM methodology yields substantial practical and economic benefits:

1. **Optimization of Land Use Balances:** GeoBIM tools enable automatic calculation of residential, public, and green space ratios, offering immediate verification against density and land allocation ceilings stipulated by SHNQ.
2. **Infrastructure Load Simulation:** Incorporating BIM models into the macro GIS utility network enables automated flow and capacity analysis for water, electric power, natural gas, and sewage systems. This predictive capability prevents network overload and infrastructure failures.
3. **Insolation and Environmental Microclimate Analysis:** Accurate 3D modeling of building masses and solar shadow projections (insolation), coupled with wind vector analysis, ensures the development of energy-efficient and bioclimatically balanced urban spaces.

Analytical assessments indicate that adopting a GeoBIM framework reduces master plan development and approval cycles by **30–35%**, while reducing technical and spatial design discrepancies by up to **80%**.

4. CONCLUSION AND RECOMMENDATIONS

The integration of GIS and BIM across Uzbekistan's urban planning landscape fundamentally elevates the quality of urban development and management. Master plans transition from static drawings into dynamic digital ecosystems that reflect municipal growth in real time.

To ensure broad and effective adoption, the following measures are recommended:

• Formally introduce the concepts of **GeoBIM** and **Digital Twins**—along with mandates for their phased adoption—into the Urban Planning Code and national SHNQ regulatory frameworks;

• Establish unified national GeoBIM data exchange protocols and modeling standards for design and engineering organizations;

• Modernize professional higher education and training curricula to equip urban planners and architects with interdisciplinary GIS and BIM competencies.

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