AN ENHANCED FRAMEWORK FOR INTEGRATED CENTRALIZED BUILDING PERMITTING SYSTEMS

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Abstract: Building Permit Systems (BPS) play a crucial role in delivering urban planning and land-use regulation. Land management, fragmented workflows, and poor data integration challenge effectiveness in rapidly developing countries like Saudi Arabia. To overcome traditional municipal BPS into a centralized, data-driven framework. Jeddah Municipality as a case study based on prior technology experience and research, following a hybrid method to meet study objectives. Interviews with municipal officials and surveys sent to 190 Authorized Engineering Offices (AEOs), a computation of the Relative Importance Index (RII) of 12 identified key factors, categorized into four dimensions of Process, Organization, Technology, and Information. The Framework of Building Permitting Systems (FBPS) demonstrates effective integration among municipalities by leveraging GIS and land-use regulations to enhance local governance, support overarching national objectives, and advance applications.

Keywords: building permit, integration, land use, municipality.

1. INTRODUCTION

Operationalizing land planning is a critical decision that shapes the metropolis's economy, development, sustainability, and live ability. Effectively managing land use and governance remains a persistent challenge for many countries, as decision-making processes must ensure efficiency and coherence in the government [1]. Land management is beginning to challenge the incorporation of modern technology into municipal Building Permit Systems (BPS), as such systems facilitate informed decisions to implement land use, enforce regulations, and manage infrastructure development, ensuring effective land management. The role of the Ministry of Municipalities and Housing (MoMaH) is to oversee the urban planning framework and align planning and land-use regulations by developing central platforms to address national and local issues, such as urban sprawl, regulatory misalignment, and population growth, through effective data-driven decision-making. Adopting a centralized permit system is considered crucial for enhancing municipal governance and aligning local regulations with national

strategic goals by incorporating spatial regulations and digital technologies to ensure regulatory compliance and urban development efficiency [2]. However, municipal departments are poorly connected with the BPS, hindering effective decision-making, as studies indicated the urgency of identifying technology integration requirements based on the BPS's geospatial data roles [3]. Connecting Geographic Information Systems (GIS) and BPS is an exciting opportunity for municipalities to refine permit processes, optimize land-use policies, and streamline urban planning operations, connecting silo regulations using technology [4]. The study investigates bridging gaps under key dimensions and factors. Specifically, it aims to (1) examine land use geospatial data reflection within municipal BPS; (2) assess the challenges and opportunities in aligning land use regulations with BPS; and (3) identify the fundamental requirements for a centralized building permit system that enhances geospatial data integration. The applied hybrid method enables researchers to create a data-driven framework for urban management, ultimately enhancing cities' liveability, spatial efficiency, and regulatory effectiveness.

2. LITERATURE REVIEW

2.1. Municipal Function of Lands

Decentralized management enables local entities to use regional resources more effectively, whereas central governments typically oversee zoning and land use, which, in turn, impact city planning. Municipal services rely on strategic plans that consider timing, location, and the status of ongoing changes. Land-use geospatial data integration with permit systems is crucial for effective urban governance, aligning spatial strategy with financial factors to manage growth and prevent sprawl [5, 6]. Planners shall oversee local changes to meet national goals, using data to implement zoning, infrastructure, and building permit bylaws. BPS and GIS data have a retrospective influence on spatial strategy [7, 8]. Centralized systems improve bylaws for planning and land use, involving multiple stakeholders. Municipalities oversee local planning and implementation, with detailed land management influencing agglomeration, division, and transfer of ownership activities.

Municipalities' operationalizing cities includes formulating legislation, bylaws, and land-use controls, and overseeing their implementation in the local context. Therefore, effective municipal governance, delegation of responsibilities, and facilitation of decentralization are part of municipal internal models. Municipal leaders, including mayors, play a pivotal role in enabling and supporting technical departments that execute directives. At the national level, formulating city strategic planning and delegating responsibilities to mayors for service provision and infrastructure development [9]. Major cities aim to improve liveability and investment [10]. Initiatives like unified BPS support national vision goals [11] and emphasize smart urban growth. The private sector supports national land legislation as investors and municipalities lead permit processes. Change drivers, such as legislators' spatial strategy, affect permitting factors, as shown in Figure 1. Technology enables government improvements to be clear drivers, comprehensive planning, and permitting processes; each system and element is eligible

to be positively influenced by GIS applications to enhance transparency, decision-making efficiency, and regulatory disclosure [12].

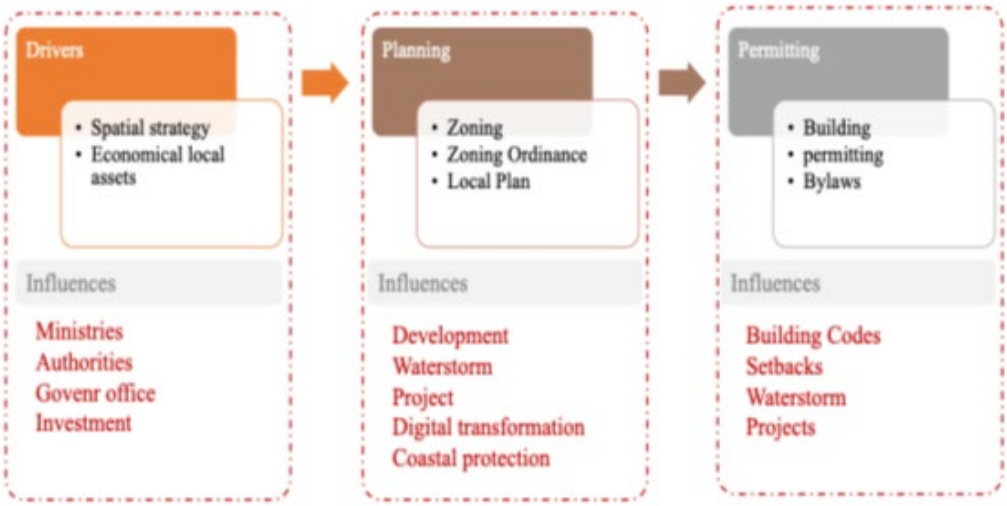

Figure 1. High-level authorities influence the flow to the building permit level

2.2. Land use and Centralized GIS

Municipal departments benefit from technology, with planning departments generating vast, crucial spatial data for strategic planning. Moreover, aligning spatial and planning aspects requires identifying gaps and opportunities to optimize the overall process. There is a lack of integration between GIS and BPS, especially in compliance checks. Advancements include 3D GIS visualization [13] and extend into social studies, with evolving frameworks expected to incorporate new dimensions [8]. However, Online platforms improve information dissemination and service delivery to residents [14]. GIS enhances municipal services by improving data storage and accessibility. The lack of integration with GIS stems from a lack of guidelines, especially in planning and GIS departments. The Spatial Data Infrastructure (SDI) provides a foundation for GIS to effectively embed technology within government processes, supporting applications and local government functions [15]. Municipalities manage GIS operations through specific departments, using software, hardware, data, and methodologies. GIS applications support land management and monitoring urban change [16].

2.3. Building Permits System (BPS)

The integration of innovative solutions with BPS enables efficiency and facilitates continuous improvements across multiple domains, including land use and construction supervision. Technology adoption in Dubai has led to the adoption of structured methods and digital-first approaches, including BIM applications and GIS-integrated platforms. On the national and technology centralization level, the United States faces bureaucratic challenges, primarily due to zoning regulations [17]. The technologies of land Turkey moved to control ownership by the digital transformation of cadastral accuracy with

harmonized data challenges [18]. In Europe, Germany's system faces challenges due to the involvement of multiple agencies [17], Greece struggles with fragmented processes [19], and Italy's system has a strong structure but faces delays [20]. Each case requires the development of BPS to incorporate advanced digital systems and define challenges arising from fragmentation and inefficiencies. Technology is a possible bottleneck due to harmonization issues, requiring a focus on areas of digital transformation and data sharing. The international comparisons show that the governance capacity reflection on the success of BPS modernization depends on a clear legal mandate, interdepartmental coordination, and the adoption of interoperable data protocols led by leadership, regulatory coherence, and citizen accessibility to enable operating within a unified digital ecosystem, as in principles directly relevant to the Saudi context.

Many countries adopted centralized BPS within municipalities; operational and maintenance expenditures accounted for 66%, with the remaining funds allocated to projects and salaries [7]. Thus, human factors influence permit compliance with subdivision regulations, and digital permitting has altered issuance trends relative to global practices. International standards, such as ISO 9001:2008, are considered significant for data quality management and bridge digital spatial practice. Allowing connections to the private sector is beneficial, as in Dubai engineering offices contribute to the centralized system through standardized practices. The e-submission portal enables permit requests and delegates inspection functions to the permits system [21]. Municipality officials approve construction practices. Implementing and supervising permits are critical areas. Centralization resulted in poor performance due to vague stakeholder roles [22].

2.4. Framework Components

Studies have determined the uses of tool checks and data capture. A module was developed showing categories to measure readiness levels to improve systems [23] Spatial levels fall under SDI, and a study mapped practices for municipality levels, creating a concept for Municipal Spatial Data Infrastructure (MSDI) [24]. MSDI comprises a centralized database, data standards, a collaborative environment, and a cadastral foundation. The connection of planning frameworks to the MSDI main items needed to enable effective use of geospatial data, as defined by user needs, the implementation plan, and capacity building. Synthesis and thematic insights from global practices indicate that effective building permitting hinges on robust governance and decentralization, with well-defined authorities.

Municipalities should foster cross-departmental engagement and collaboration, emulating Dubai's one-stop model, which relies on streamlined processes to minimize administrative overlap and expedite decision-making. A comprehensive integration framework requires an SDI to enable permits based on defined GIS and permit processes for the successful utilization of data. Main items were coupled with user engagement, highlighting the need for citizen-centric portals to provide applicants with real-time tracking, interactive mapping tools, and direct feedback channels, thereby enhancing transparency and public trust. Sustained capacity building and legal clarity require organizational professional certification for staff and alignment with bylaw reviews, to ensure consistent enforcement of land use regulations.

3. METHODOLOGY

The research design defined the study area, then applied a hypered-methods data collection (interviews and surveys), conducted a reliability analysis using Cronbach's alpha, and finally applied correlation and RII.

3.1. Data Collection

The research employed hybrid methods to examine Jeddah Municipality's BPS data, the alignment of global practices, and MoMaH's mandates. A pilot survey was designed and tested in collaboration with an official from Jeddah Municipality and an owner associated with one AEO to assess the maturity of the permitting process for GIS integration across the main dimensions and sub-domains through an online meeting. The dimensions to collected data was fixed between the JME and AEO under four dimensions defined as Processes (processes and methods, regulations, procedures), Organization (readiness for change, organizational structure of units, social aspect), Technology (technology for data management, technology for data analysis, interoperability and open format), and Information (data standardization and quality, data and information, codes and regulations).

Jeddah Municipality and AEO were selected as study areas based on their prior experience with the in-house CAD engine, the Jeddah Permitting System (JPS), which features a comprehensive process and organizational maturity. Such process and technology expertise input from both the public and private sectors serves as a significant benchmark for evaluating JPS and Balady systems. A semi-structured interview with Jeddah Municipality Engineers (JME) provided insight into the current workflows for implementing regulatory levels. Simultaneously, an online survey was defined through the official municipality website as 180 AEO offices, yielding 40 responses. Of these, the relevant and complete responses came from 32 offices, which are considered authorized and have experience with both JPS and Balady. However, the semi-structured interview with JME was conducted with 12 officials, each with varying experience and inconsistent responses. Tables 1 show the values are presented as n (%) for categorical variables and mean years for continuous variables; percentages sum to 100 % within each characteristic.

3.2. Systems Analysis

A comprehensive literature review identified a significant gap in the application of centralized systems and land management practice. The defined challenges are organized into four dimensions in the pilot survey questions and analysis, thereby redefining the semi-structured survey. The analysis addresses gaps in local capacity and in compliance-checking methods relative to the centralized system. As highlighted in the interview with JME and the online survey with AEO, the aim is to consider end-user needs. The requirements for an effective national system, as identified in both analyses, shall be ranked. Therefore, an initial reliability test yielded a Cronbach's alpha of 0.731, indicating acceptable internal consistency, as assessed using IBM SPSS for both descriptive and inferential statistical analyses. Frequency analysis summarized demographic attributes, including academic major, degree, role, experience, and system

usage, presented through percentages. Pearson's correlation assessed linear relationships between questionnaire variables (Q2.1–Q5.3), using:

$$r = [n\Sigma xy - (\Sigma x)(\Sigma y)] / \sqrt{\{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}$$

The Relative Importance Index (RII) for a survey item is computed as:

$$RII = A \times N \, \Sigma \, W$$

A RII analysis applied a ranking method to identify significant requirements, distinguishing between centralized system users and JPS users to prioritize items and shape a practical framework for undertaking BPS governance.

Table 1. JME (N = 10) and AEO respondents (N=32)

Area	*JME*		*N (%)*
Assigned engineers to platform	*Balady*		*70*
	JPS		*20*
	JPS & Balady		*10*
Assigned Roles	*Supervision*		*11.1*
	Coordinator		*11.1*
	Reviewer		*77.8*
Major	*Architecture*		*70*
	Civil Engineering		*10*
	Building Engineering		*10*
	Urban Planning		*10*
Level of Education	*Bachelor*		*90*
	Master		*10*
Average years if experience in budling permitting Dept.			*5.6*
Ratio of experts in land Planning			*50*
Ratio of supervisors			*30*
Ratio of using JPS			*100*
Ratio of using Balady			*80*
Ratio of using GIS			*60*
Applications experience		*AutoCAD*	*70*
		Revit	*50*
		GeoMedia	*20*

Areas	AEO	N (%)
Experience on platforms use	Balady	78.1
	JPS	21.9
Office size	Very small (<10 staff)	28.1
	Small (10–49)	37.5
	Medium (50–249)	31.3
	Large (≥250)	3.1
Major	Architecture	62.5
	Urban Planning	6.2
	Electrical Engineering	6.3
	Civil Engineering	18.8
	Mechanical Engineering	3.1
	Interior design	3.1
Level of Education	Bachelor	68.8
	Master	21.9
	Diploma	6.2
	Doctoral	3.1
Years of experience with BPS	0-3	31.3
	04-06	21.9
	07-10	15.6
	11-15	15.6
	More than 16	15.6
Applications experience	AutoCAD	18.8
	Revit	71.9
	GIS applications	9.3

4. RESULTS

Many geospatial frameworks discuss the dependencies of permitting activities and their relation to technology. By prioritizing automation, standardization, and cross-departmental alignment, BPS enables effective permit approvals through automated checks, reduces client delays through transparent compliance regulation, and ensures

consistent enforcement of regulations through live GIS/legal data synchronization. Coherent identified requirements addressed the root causes of the suspended BPS based on the poor GIS integration and reliance on manual processes. The current challenges in the system stem from fragmented workflows, which lead to client confusion. The four dimensions from the JPS and the Centralized system allowed us to define a set of requirements that ensure BPS evolves into a scalable, user-centric system that supports the management of change in urban development. The authors mapped interview and survey data using predefined semi-structured questions to relate both systems to processes, organization, technology, and information.

4.1. Processes

To address challenges from JPS and improve Balady, clear, actionable requirement statements were proposed and categorized by domain. Under the process domain, statements included creating a centralized workflow enforcement to ensure that all permit applications, reviews, and approvals are conducted exclusively through the BPS platform, eliminating deviations to external systems (e.g., email or internal tools). Automated compliance checks will enable real-time validation during the permit application phase, using updated GIS layers, land-use regulations, and zoning bylaws to flag violations before submission. End-to-end digital processes replace paper-based and CAD reviews by digitizing document submissions, approvals, and feedback loops and non-readable formats (e.g., scanned plans), allowing the machine-readable and GIS/CAD-compatible.

4.2. Organization

Municipal functions shall align (Cross-Departmental Alignment) by establishing a governance framework to ensure municipal departments, such as the planning department, GIS centre, and sub-municipalities, align workflows with BPS objectives and shared key performance indicators and accountability mechanisms. Moreover, mandatory training programs are developed to offer tracked, role-specific training for municipal staff and AEOs on BPS functionalities, with regular competency assessments to ensure adoption. Also, client transparency provides a public-facing dashboard for applicants to track permit status, view compliance requirements, and access geospatial data such as red zones and parking counts.

4.3. Technology

Connecting systems rely on the levels of maturity in the organization to ensure information continuity, as Real-Time GIS synchronization is significant to integrate BPS with live municipal GIS databases to ensure geospatial data benefiting (e.g., land use and zoning) is dynamically updated and accessible for compliance checks. Enhancing platform features also enables drawing review and facilitates BIM model adoption with automated validation against regulations, document filtering by permit type, and bulk processing for large-scale projects. Unified data standards provide structured data capture, e.g., CAD layers and geospatial metadata across municipality departments, to ensure compatibility with BPS and reduce manual reconciliation.

4.4. Information

The database data and information are considered significant as housed in a centralized regulatory repository to maintain a single, version-controlled digital resource of all building codes, bylaws, and land-use regulations tagged to GIS layers for automated validation. Standardized CAD/GIS protocols shall define and enforce CAD/GIS standards, e.g., layer naming, scale, and coordinate systems, to ensure system readability and reduce manual corrections. Creating automated feedback tools enables machine learning training to tailor a feedback system that flags discrepancies between submitted plans and regulations, with clear resolutions for the system's developer to maintain.

4.5. Framework of Building Permit System

The statistical analysis highlighted strong positive correlations between organizational readiness, including cross-departmental alignment and targeted training, and information quality, indicating that well-structured governance facilitates the production of accurate and accessible regulatory data. Similarly, a positive relationship emerged between technological integration, such as the real-time GIS synchronization and compliance tools, and process efficiency, as such findings confirm the interdependence of the four framework dimensions

The four dimensions identified significant opportunities to establish a robust framework across four key areas of the FBPS, as shown in Table 2.

Table 2. Ranking of the requirements of the FBPS

Dimensions	ID	Requirements	RII	Category
Organization	OR2	Implement role-specific training with tracked outcomes	1	Very High
Processes	PR3	Digitize end-to-end workflows (submission, review, approval)	0.769	High
Organization	OR1	Align cross-departmental workflows with BPS objectives	0.761	High
Processes	PR1	Connect the procedure with automated rules	0.44	Moderate
Processes	PR2	Automate compliance checks during application submission	0.19	Very Low
Technology	TR3	Standardize data formats across municipalities	0.179	Very Low
Information	NR1	Geospatial data synchronization is significant for enhancing processes, client understanding, and technological tool effectiveness	0.179	Very Low
Information	NR2	Enforce standardized CAD/GIS protocols	0.179	Very Low
Information	NR3	Implement AI-driven feedback for discrepancy resolution.	0.179	Very Low
Technology	TR1	Integrate live GIS synchronization with municipal databases	0.175	Very Low
Technology	TR2	Support CAD/3D uploads with automated regulation checks	0.169	Very Low
Organization	OR3	Provide a public-facing permit status dashboard	0.161	Very Low

The development of a scalable, user-centric system that minimizes delays, enhances transparency, and ensures consistent enforcement of regulations. Moreover, the computed RII values enabled prioritization of twelve key factors across the four framework dimensions, with high value for organizational and process-related factors obtained a very high rank to implement role-specific training (RII = 1), and digitizing end-to-end workflows (RII = 0.769) followed by Aligning cross-departmental workflows (RII = 5.48) considered high. A moderate rank was assigned to the cross-departmental dimension, followed by the technology and information dimensions, which scored lower, reflecting persistent deficiencies in real-time GIS synchronization and in standardized data.

The high rank for the organizational and process factors. Such emphasis on the enablers of effective permit is based on workflow clarity, interdepartmental coordination, and role-specific training. In contrast, the low-rank factors under technology and information reflect deficiencies in real-time GIS synchronization, data standardization, and interoperable platforms.

4. CONCLUSION

The study examined the integration of geospatial governance into municipal BPS to address fragmentation, inconsistent data practices, and limited automation. Using Jeddah Municipality as a pilot case, the mixed-method approach revealed that organizational and process factors -particularly interdepartmental alignment, clarified responsibilities, and role-specific training- are the strongest enablers of centralization. High RII scores for these factors confirm that institutional readiness precedes digital transformation and supports the production of standardized, accessible geospatial data. Strong correlations between governance maturity and information quality further validate the Framework for Building Permit Systems (FBPS) as an empirically grounded model for improving regulatory performance.

The FBPS outlined requirements for a centralized building permit system that improve geospatial data integration across four dimensions and 12 factors, align organizational goals, streamline processes, and provide data-driven urban planning strategies to enhance city liveability and tackle spatial and regulatory challenges [21]. The framework overcomes challenges by integrating systems, such as Greece's legal complexity [19], and Saudi Arabia faces administrative fragmentation that hampers process efficiency. Nevertheless, Dubai's one-stop BPS portal demonstrates that clear governance hierarchies are vital enablers of digital integration. Turkey's experience in linking cadastral and planning data [18] parallels Saudi ambitions for GIS-enabled regulatory enforcement.

Embedding Spatial Data Infrastructure (SDI) principles into permitting workflows, the FBPS integrates land-use regulation, geospatial databases, and automated compliance functions into a unified framework. This integration enhances transparency, reduces manual review, and supports consistency across municipal departments. Key requirements include cross-departmental governance boards, capacity-building programs, unified geospatial repositories, and citizen-facing dashboards that increase accountability and improve service delivery. The model is adaptable across Saudi

municipalities that share similar challenges of system fragmentation and regulatory ambiguity.

The study's examination is limited to a single city and a small AEO response sample, and the framework validation is based on perceptions rather than performance. Future research shall explore multi-city comparisons, longitudinal evaluations, and the integration of emerging technologies, such as BIM–GIS fusion, 3D automated rule-checking, and AI-enabled predictive tools to strengthen predictive urban management. Overall, the FBPS provides a practical, scalable model that improves permitting efficiency, advances GIS integration, and strengthens governance capacity. The implementation enables streamlined operations, enhances transparency, and supports sustainable urban management in line with national spatial planning objectives, providing a foundation for benchmarking and broader municipal adoption.

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