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# Illegal Building Detection System

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**ABSTRACT:** Rapid urbanization has led to a surge in unauthorized constructions that violate zoning regulations, building codes, and approved development plans. Manual monitoring of illegal buildings using field inspections is time-consuming, labour-intensive, and vulnerable to human error and corruption. This paper presents an automated illegal building detection framework that combines multi-temporal satellite imagery, image processing, clustering, and machine learning techniques. The system first performs preprocessing and change detection using K-means clustering to identify potential construction changes across time. A refined building extraction module then isolates candidate structures within changed regions. These detected building footprints are evaluated against existing cadastral and permit databases to identify unapproved or deviated constructions. Quantitative performance metrics such as accuracy, precision, recall, and F1-score are used to assess the effectiveness of the approach. The proposed system aims to support urban local bodies by providing objective, scalable, and semi-automated decision support for detecting and prioritizing potentially illegal constructions for further field verification and enforcement.

**KEYWORDS:** Illegal building detection, change detection, K-means clustering, satellite imagery, image processing, cadastral maps, urban monitoring.

## I. INTRODUCTION

Illegal constructions have become a major challenge in many rapidly growing cities. As land values increase and urban areas expand, buildings are often constructed or extended without proper approvals, setback adherence, or compliance with zoning regulations. Such unauthorized developments can obstruct planned road networks, reduce open spaces, overload infrastructure, and create safety risks due to non-compliant structural practices. Traditional detection relies mainly on manual inspections by town-planning staff, which are often constrained by limited manpower, large spatial extents, and the possibility of biased or delayed reporting. As a result, many illegal buildings are detected only after completion or after complaints from citizens, by which time rectification becomes difficult and costly. With the availability of high-resolution satellite imagery and advances in image processing and machine learning, it is now possible to design automated or semi-automated frameworks for monitoring urban growth. By analysing multi-temporal images of the same region, newly built structures can be identified and compared with official cadastral boundaries and permit databases. This paper presents an illegal building detection system that leverages K-means-based change detection, building extraction, and GIS-based legality assessment. The proposed approach aims to reduce reliance on manual field surveys, provide timely alerts of suspicious constructions, and support urban development authorities in evidence-based decision-making.

## II. LITERATURE SURVEY

A wide range of research has explored building detection, change detection, and integration of remote sensing with urban planning. Ahmad [1] investigated change detection in high-density urban and rural areas using high-resolution satellite imagery, demonstrating that temporal analysis can reveal newly constructed or modified structures. Bayburt et al. [2] applied medium and high-resolution space images for monitoring changes in the Istanbul area, highlighting the potential of satellite data for tracking urban expansion over time.

Several works have focused on automatic building detection from optical or LiDAR data. Benedek et al. [3] proposed a building detection method in a single remotely-sensed image using a point-process of rectangles to model building

footprints. Chen et al. [4] used shadow-based techniques to detect and segment buildings in high-resolution remote sensing images, exploiting the relationship between building height, sun angle, and cast shadows. Hermosilla et al. [5] evaluated multiple automatic building detection approaches by combining high-resolution imagery with LiDAR data, showing that fusing elevation and spectral information improves building delineation. More recent studies have examined advanced techniques and new acquisition platforms. Karantzalos et al. [6] used low-cost optical sensors onboard unmanned aerial vehicles (UAVs) for model-based building detection. Kovacs and Sziranyi

### III. METHODOLOGY

The Illegal Building Detection System follows a structured multi-stage workflow that uses satellite imagery and automated change detection to identify unauthorized constructions. The process begins with the collection of two satellite images from different time periods, which undergo preprocessing such as alignment correction, noise removal, and contrast enhancement. This ensures accurate comparison between past and present land conditions. The system then performs spectral and structural analysis to detect changes, isolating regions that may contain new or modified buildings while filtering out noise such as shadows, vegetation, or temporary objects.

After refining the detected regions, the system moves into legality verification by comparing construction footprints with official cadastral maps and approved building layouts. This allows authorities to determine whether a structure complies with sanctioned boundaries or constitutes an unauthorized development. The final output includes a detailed violation report with deviation measurements and a visual map marking illegal constructions. To ensure secure access to sensitive municipal records, the system integrates JWT-based authentication and bcrypt hashing for protected user login.

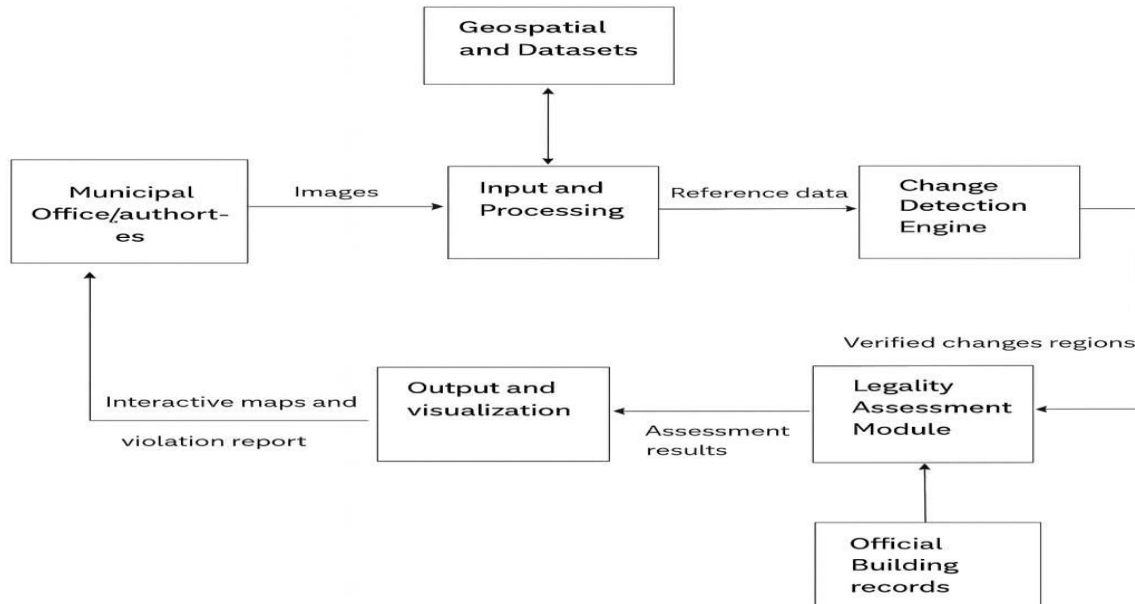


Fig. 2. Data Flow Diagram (DFD)

The flow diagram shows how the Illegal Building Detection System operates from input to final violation report generation. The process starts when the municipal officer uploads or selects the required satellite images through the Input Module. These images are sent to the Core Processing Engine, which performs preprocessing and then communicates with external geospatial datasets such as cadastral maps and approved building layouts. Once both image and reference data are collected, they move into the Change Detection Engine, where spectral comparison and structural pattern analysis identify possible new constructions. The verified change regions are then passed to the Legality Assessment Module, which compares detected buildings with official records to determine whether they lie within approved boundaries. The final results are forwarded to the Visualisation Module, where the system generates



an interactive map highlighting legal structures and unauthorized deviations. The Output Module then delivers a complete, easy-to-understand violation report, helping authorities make accurate and timely decisions for urban regulation.

Algorithm used: The Illegal Building Detection System uses a hybrid AI-based change detection workflow to automatically identify unauthorized constructions from satellite images. The multi-stage approach ensures faster processing, higher accuracy, and reliable verification for municipal authorities.

1. input Acquisition and preprocessing :Two satellite images from different time periods are collected and preprocessed to align resolution, remove noise, and correct visual distortions. This ensures meaningful comparison between past and present land conditions.

Image Alignment Formula:

$$I_{\text{aligned}}(x, y) = T(I(x, y))$$

Noise Reduction:

$$I_{\text{smooth}}(x, y) = \sum_{(i, j) \in K_{N_1}} I(x + i, y + j)$$

2. Multi-temporal Change Extraction :The system compares both images to highlight zones where noticeable structural changes have occurred. Spectral differences and built-up indicators help isolate regions with potential new or modified constructions.

Change Magnitude Formula

$$(x, y) = | I_2(x, y) - I_1(x, y) |$$

Built-up Indicator (NDBI):

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR}$$

3. Intelligent Region Identification and Verification :Detected change regions are refined by evaluating shape, texture, and land-use consistency. This filters out noise (like trees or shadows) and identifies true candidate construction areas for detailed analysis.

Intelligent Region Identification & Verification:

$$\sigma(x, y) = \sqrt{\frac{1}{N_1} \sum (I(x, y) - \mu)^2}$$

Shape Consistency Check:

$$R = \frac{Width \times Height}{Area}$$

4. structured output Generation and Legality Assessment : The system compares detected structures with municipal cadastral and permit records to determine if they are legal or unauthorized. A final report visualizes flagged zones along with deviation details for enforcement action.

Deviation Measurement:

$$Deviation = Area_{\text{detected}} - Area_{\text{approved}}$$

Intersection-over-Union :

$$IoU = \frac{Area(A \cap B)}{Area(A \cup B)}$$

5. Secure User Authentication and Data Protection :JWT-based authentication ensures only authorized officials access reports, while bcrypt hashing protects user credentials. This enhances system security and maintains confidentiality of sensitive municipal data.

A JWT is signed using:

$$\text{Signature} = \text{HMAC}_{\text{SHA256}}(\text{Header} + \text{Payload}, \text{Key})$$

bcrypt Password Hashing:

$$\text{Hash} = \text{bcrypt}(\text{password}, \text{salt}, \text{cost})$$

Testing :

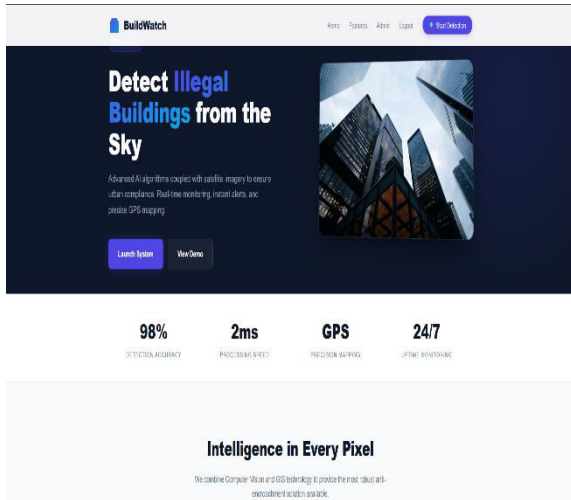
The system is tested using functional and performance testing to ensure accurate detection of unauthorized buildings. Functional testing verifies that each module—image preprocessing, change detection, legality assessment, and report generation—works as expected. Performance testing ensures that the system processes satellite images efficiently and responds quickly during real-world usage.

1. Unit Testing: modules such as image registration, K-Means clustering, connected component analysis, mask generation, coordinate reprojection.
2. Integration Testing: K-Means → RPN pipeline, RPN → Geo-Legality assessment chain, database interactions (WFS queries).
3. System Testing: full pipeline from image upload to DRI generation, including error handling, large-area batch processing.
4. Acceptance Testing: verifying system outputs with ground truth (field inspection labels), running sample cases where building permits are known.

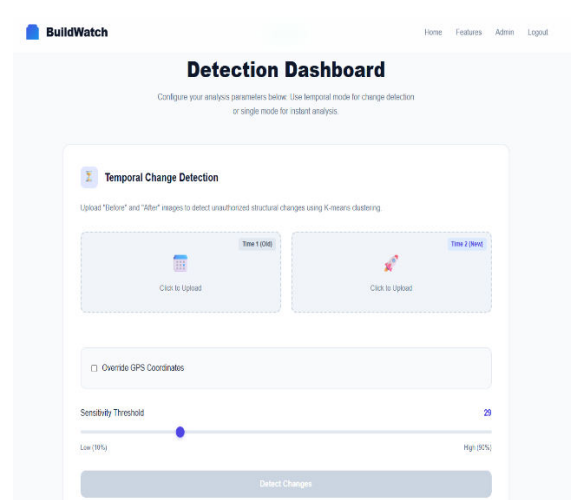
TC ID	Module	Input	Expected Output	Result
TC01	Preprocessing	Pair (I1,I2) perfectly registered	D computed, no major misalignment	Pass
TC02	K-Means	I1,I2 with new building added	Mask M contains building region	Pass
TC03	Morphology & CCL	Noisy mask input	Small objects removed, main building kept	Pass
TC04	RPN Extraction	Crop with new building	Polygon footprint B_d returned	Pass
TC05	Geo-Legality	B_d with no permit	Flagged as 'No Permit'	pass
TC06	Geo-Legality	B_d with permit but deviated	Flagged as 'Deviation' with encroachment area	Pass
TC07	Performance	Batch of 100 tiles	Processing finishes within SLA	Pass
TC08	Failure mode	Partially missing EXIF/geo	System handles gracefully	Pass

#### IV. EXPERIMENTAL RESULTS

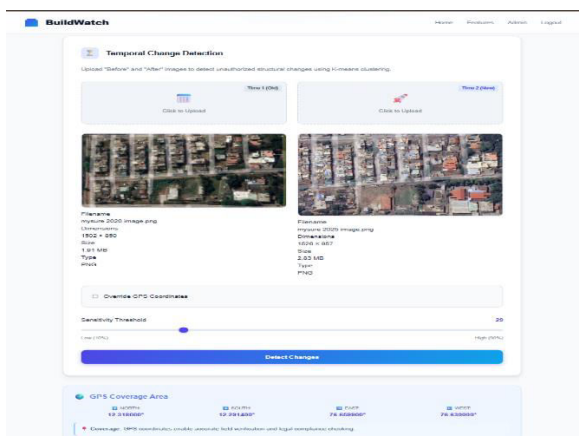
The proposed system was tested on multi-temporal satellite images of selected urban areas where ground truth or approximate reference information about building permits was available. After preprocessing and K-means-based change detection, the building extraction module successfully isolated building-like objects within changed zones.



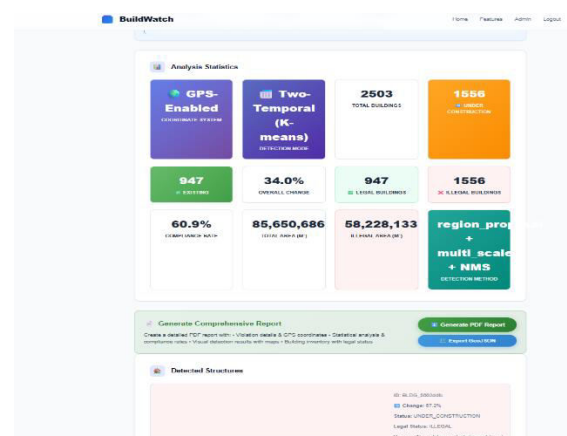
HOME PAGE



DETECTION PAGE



RESULT PAGE



RESULT PAGE

## V. CONCLUSION

The proposed Illegal Building Detection System successfully demonstrates how multi-temporal satellite imagery, automated change detection, and digital cadastral verification can be integrated into a unified pipeline for monitoring unauthorized construction. By combining unsupervised pre-screening with refined region analysis and GIS-based legality assessment, the system ensures faster detection, reduced manual workload, and high reliability in identifying deviations from approved structural layouts.

Beyond its technical accuracy, the system strengthens municipal governance by generating Digital Regulatory Instruments (DRIs) that include spatial evidence, deviation metrics, and property-level violation summaries. This makes the output legally defensible and immediately actionable for enforcement authorities. The integration of secure authentication measures, including JWT-based access control and bcrypt hashing, further ensures that sensitive municipal data is protected while supporting multi-user operations across departments.

Overall, the system demonstrates strong potential for real-world deployment, offering scalability, adaptability, and automation for urban monitoring workflows. Its modular architecture allows seamless expansion to larger cities, different zoning regulations, and varied satellite data sources. Future enhancements may include incorporating 3D height validation using LiDAR or stereo imagery to detect vertical FAR/FSI violations, adopting AI-driven cadastral

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correction to reduce boundary uncertainty, and integrating the system within a real-time municipal single-window approval and enforcement environment. Such improvements will advance the platform toward becoming a comprehensive digital governance solution for urban development regulation.

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