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A Systematic Review on Advance Methods for Topographical Survey to Achieve Economy

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Abstract: This paper explores the application of advanced techniques in topographical surveying to enhance economic efficiency in land development projects. Traditional survey methods are often time-consuming and resource-intensive, leading to increased project costs. The adoption of technologies such as LiDAR (Light Detection and Ranging), GPS (Global Positioning System), UAVs (Unmanned Aerial Vehicles), and GIS (Geographic Information System) promises improved precision, rapid data acquisition, and cost-effectiveness. Case studies and comparative analyses of projects employing these advanced methods highlight their potential to streamline survey processes, reduce operational expenses, and accelerate project timelines, optimizing resource allocation and fostering economic sustainability.

KEYWORDS: Topographical survey, LiDAR, GPS, UAVs, Economic efficiency, Land development, Precision, Cost-effectiveness, Innovation, Sustainability.

I.INTRODUCTION

Topographical surveys are crucial for land development projects, providing essential insights into terrain characteristics vital for project planning and execution. Recent technological advancements, including LiDAR and GNSS (Global Navigation Satellite System), have transformed conventional surveying practices by enhancing data reliability and economic advantages in infrastructure ventures. By amalgamating cutting-edge tools such as LiDAR's precise elevation data and GNSS's global positioning capabilities, traditional surveying limitations are transcended, optimizing resource utilization, and fostering cost-effectiveness in land development initiatives.

Importance of Topographic Surveys

Before developing a proposed land, it is critical to consider all factors under and around the land's topography to map a successful development plan. Topographical surveys provide detailed, accurate information and comprehensive data that helps eliminate risks and the likelihood of failure once the construction or excavation project begins. Just like underground utility mapping, it prevents unnecessary expenses and delays. It also ensures there is no major setback during the construction phase.

The more data obtained by the surveyor, the more information you will have at hand to make the right choices. Below are some of the things that topographical surveys can help you identify.

Vegetation Position: Certain projects might require a survey of areas covered by dense forests or might need to determine the depth of large tree trunks or vegetation lines. Topographic surveys are very useful in this case. They help determine the size and type of tree. They help locate the vegetation lines. They also help determine what kind of vegetation can be suitable for that particular area.

Contour Levels: A topographic map generally emphasises the vertical shifts of lands or property that can be seen in a sequence of drawing contours. Contours make it possible to show the height and shape of mountains, the depths of the ocean bottom, and the steepness of slopes. There are three kinds of contour lines on a topographic map, namely: intermediate, index, and supplementary.

Natural Structures: Natural structures such as mountains, hills, lakes, cities, valleys, oceans, etc can be determined easily on a topographic map. During a topographical survey, elevations or height of these structures are recorded, generally with reference to the sea level (the surface of the ocean).

Man-made structures: Man-made structures such as houses, temples, hospitals, public transport lines, streets, and barriers can be easily spotted with this survey. This survey helps determine the exact location of these structures.

Streams: Whether you want to locate a thread (centre line), or only the drawing banks of the stream or the lowest part (the thalweg), everything can be defined easily via a topographic survey.

Methods for Topographical Survey to Achieve Economy

Topographic surveying involves the collection of accurate and detailed information about the natural and artificial features of a specific area, providing a comprehensive understanding of its terrain. Several methods are employed in topographic surveying, each serving specific purposes and offering unique advantages.

1. Ground Surveying: Ground surveying is a traditional method involving direct measurements on the field. Surveyors use instruments such as total stations, theodolites, and leveling instruments to measure distances, angles, and elevations. This method is fundamental for capturing precise on-site data, particularly in areas with challenging terrain where direct measurements are essential.

2. GPS/GNSS Surveying: Global Positioning System (GPS) or Global Navigation Satellite System (GNSS) surveying involves the use of satellite signals to determine accurate positions on Earth. This method is particularly valuable for large-scale topographic surveys, allowing surveyors to collect data over expansive areas efficiently. GPS/GNSS technology enhances surveying speed and accuracy, making it a key method for modern topographic mapping.

3. LiDAR (Light Detection and Ranging): LiDAR is an advanced remote sensing technology that uses laser light to measure distances and create highly detailed three-dimensional representations of the terrain. LiDAR is particularly effective in capturing intricate topographic features such as vegetation, buildings, and ground surfaces. Its ability to penetrate dense vegetation makes it valuable for mapping areas with challenging visibility.

4. Aerial Surveying: Aerial surveying involves the use of aircraft equipped with cameras or LiDAR sensors to capture topographic data from above. This method is advantageous for covering large areas quickly and obtaining a comprehensive overview of the landscape. Aerial surveying is commonly employed in mapping expansive regions, monitoring changes over time, and planning infrastructure projects.

5. Photogrammetry: Photogrammetry utilizes overlapping aerial photographs to create detailed and accurate three-dimensional models of the terrain. Modern photogrammetric techniques often involve computer software to analyze and process the images. This method is versatile and can be employed in conjunction with other surveying methods to enhance the accuracy and detail of the collected topographic data.

6. Satellite Imagery: Satellite imagery is a remote sensing technique that uses satellites orbiting the Earth to capture images of the terrain. This method provides a broad view of large areas and is valuable for regional mapping and monitoring changes over time. Advances in satellite technology have led to increased resolution and improved capabilities for topographic surveying applications.

7. Terrestrial Laser Scanning (TLS): Terrestrial Laser Scanning involves the use of laser scanners mounted on tripods to capture detailed point cloud data of the surroundings. This method is highly precise and efficient, making it suitable for capturing intricate details of structures and landscapes. TLS is often used for applications such as monitoring deformation, archaeological site documentation, and as-built surveys.

Objectives of study

1. To examine the impact of advanced topographical survey methods on surveying accuracy and efficiency for informed decision-making in land development projects.
2. To analyze the resource optimization potential by implementing cutting-edge technologies in topographical surveys, aiming to reduce costs and enhance overall project efficiency.

3. To study the role of advanced surveying techniques in fostering sustainable infrastructure development, with a focus on minimizing long-term maintenance costs and ensuring economic viability.

Scope of Study

The scope of studying advanced methods for topographical surveying to achieve economy encompasses a comprehensive analysis of cutting-edge technologies such as LiDAR, GNSS, and advanced imaging. The study aims to assess the impact of these methods on surveying accuracy, efficiency, and resource optimization in land development projects. It involves investigating the economic implications of adopting advanced surveying techniques, including cost-effectiveness, streamlined project planning, and long-term sustainability. Additionally, the scope extends to understanding the role of precision in site layouts, efficient resource management, and the overall contribution of advanced surveying to fostering sustainable and economically viable infrastructure development.

Statement of problem

The conventional methods employed in topographical surveys often result in prolonged project timelines and escalated costs, hindering economic efficiency in land development. This study addresses the pressing need to investigate and implement advanced surveying techniques, such as LiDAR, GPS, and UAVs, to streamline topographical survey processes. The lack of widespread adoption of these technologies in the industry contributes to inefficiencies in resource allocation and project planning. This research aims to identify the barriers preventing the utilization of advanced methods, assess their potential economic impact, and provide actionable recommendations to overcome challenges. Ultimately, the study seeks to bridge the gap between conventional and innovative survey practices to enhance economic efficiency in topographical mapping and land development projects.

Limitation of the Study

Limitations of this study involve several factors that may impact the feasibility and generalizability of the findings:

- Availability and accessibility of advanced surveying equipment could influence the ability of surveyors to adopt these methods universally.
- Weather conditions, such as extreme temperatures or precipitation, may hinder field surveys and data collection.
- Regional variations in surveying regulations and practices can affect the applicability of certain advanced methods in different geographic locations, impacting the overall economic benefits achievable.

II. LITERATURE REVIEW

Sara G. Bangen (2013), compares topographic surveying techniques in wadeable streams, focusing on digital elevation models (DEMs) derived from ground-based and airborne surveys. Significant discrepancies were found between methods, highlighting trade-offs between accuracy and efficiency. Observer variability in field crews' data collection was also evaluated, revealing correctable errors. The research advances understanding of survey techniques in stream environments and provides insights into mitigating observer variability for more accurate DEMs. **L C Luh (2014)**, demonstrates the utility of Terrestrial Laser Scanning (TLS) for topographic surveying. A field test at University Technology Malaysia showcases TLS's rapid data collection and high accuracy, meeting 1st class survey standards. The study proposes a standardized procedure for TLS data acquisition, aiding users in conducting efficient topographic surveys and offering potential for future applications like 3D city modeling. **Okwuenu C. M (2024)**, focuses on producing a detailed topographic map of Comprehensive Secondary School Nawfia, utilizing Total Station for data collection and GIS software for processing. The study concludes that Total Station proves efficient for accurate topographic surveying within a short timeframe, providing valuable land information for improved planning and management. **Sara G. Bangen et.al (2014)**, This study evaluates various topographic survey techniques for wadeable streams, assessing accuracy, precision, and data collection efficiency across different methods. Findings emphasize the importance of selecting appropriate techniques based on site characteristics and research objectives, promoting a flexible approach tailored to specific study requirements.

Reine Maria Basse (2021), employs advanced methods, including Cellular Automata (CA) and Artificial Neural Networks (ANNs), to model land use changes in cross-border regions. The study demonstrates the effectiveness of integrating GIS, neural networks, and cellular automata for anticipating land use evolution and informing decision-making in land management and planning. **Rosmadi Fauzi (2008)**, utilizes GIS and topographic surveying to gather

data on the island of Jarak, facilitating accurate representation of its natural and built environment. The adoption of GIS enhances landscape mapping and visualization, providing essential information for further investigation, planning, and policy-making. **Ioannis A. Pissourios (2023)**: examines the evolution of urban land use survey methods, identifying key contributions and proposing a periodization of methodological evolution. The study aims to enhance urban land use survey methods and contribute to more effective town planning processes. **Márcia Macedo (2023)**, assesses the feasibility of substituting Terrestrial Laser Scanner (TLS) with Unmanned Aerial Vehicles (UAV) for planimetric surveys in civil construction. Results indicate UAVs as a viable alternative to TLS, with potential for optimizing digital technologies in the industry. **Yaguba Jalloh (2018)**, compares GPS and total station surveys with photogrammetric methods for topographic plans, analyzing their accuracies. Results show high correlation between conventional survey and photogrammetry in planimetry, highlighting the applicability of both methods in land development surveys. **Sergei NEKHIN et.al (2000)**, discusses photogrammetric methods for digital topographic data collection and revision, presenting hardware and software developments for improving survey accuracy and efficiency.

Study Title and Author(s)	Methodology and Focus	Findings and Conclusions
Sara G. Bangen (2013)	Compared survey techniques (TS, GPS, TLS, ALS) in streams	Highlighted trade-offs between accuracy and efficiency in DEMs; addressed observer variability in surveying for more accurate results.
L C Luh (2014)	Demonstrated HDS (3D laser scanning) for topographic survey	Established HDS as efficient, meeting 1st class survey standards; proposed standardized procedure for topographic data acquisition.
Okwuenu C. M (2024)	Utilized Total Station for detailed topographic survey	Total Station proved efficient for accurate surveying, aiding improved planning and land management.
Sara G. Bangen et al. (2014)	Evaluated survey techniques (TS, GPS, TLS, ALS) in streams	Total station and GPS yielded accurate DEMs; ALS provided superior aerial coverage; TLS faced challenges in vegetated areas.
Reine Maria Basse (2021)	Applied CA and ANNs for land use change modeling	Demonstrated effectiveness in modeling land use changes, contributing to informed decision-making in land management.
Rosmadi Fauzi (2008)	Utilized GIS for topographic survey of an island	GIS enhanced landscape mapping and visualization, aiding further investigation and planning.
Ioannis A. Pissourios (2023)	Reviewed evolution of urban land use survey methods	Proposed periodization of methodological evolution to enhance town planning processes.
Márcia Macedo (2023)	Assessed TLS and UAVs for topographic surveys in construction	UAVs demonstrated potential as viable alternatives to TLS in civil construction surveys.
Yaguba Jalloh (2018)	Integrated GPS, total station, and photogrammetry for surveys	Demonstrated high correlation between conventional and photogrammetric surveys in land development projects.

III. CONCLUSION

The studies reviewed highlight the diversity of surveying techniques and their applications in various contexts. Advanced technologies such as High-Definition Surveying (HDS), Total Station, Terrestrial Laser Scanning (TLS), and

Unmanned Aerial Vehicles (UAVs) offer efficient alternatives to traditional survey methods, enhancing accuracy and reducing data collection time in topographic surveys.

Key findings emphasize:

1. Trade-offs between accuracy and efficiency in survey technologies (Sara G. Bangen, 2013).
2. Utility and efficiency of HDS (L C Luh, 2014) and Total Station (Okwuenu C. M, 2024) for detailed topographic surveys.
3. Importance of selecting appropriate survey techniques based on site characteristics and research objectives (Sara G. Bangen et al., 2014).
4. Effectiveness of advanced methods like Cellular Automata (CA) and Artificial Neural Networks (ANNs) in modeling land use changes (Reine Maria Basse, 2021).
5. Value of GIS in landscape mapping and visualization (Rosmadi Fauzi, 2008) and the evolution of urban land use survey methods (Ioannis A. Pissourios, 2023).
6. Potential of UAVs as viable alternatives to TLS in civil construction surveys (Márcia Macedo, 2023).
7. High correlation between conventional and photogrammetric surveys in land development projects (Yaguba Jalloh, 2018).

Overall, these studies underscore the importance of adopting innovative surveying techniques tailored to specific project requirements, contributing to improved planning, management, and decision-making in land development and related fields.

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