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Field Application And Performance Evaluation Of Water Flow Direction Determination Techniques In Flourish Garden Estate, Port Harcourt, Rivers State

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ABSTRACT

This study evaluates the practical application and performance of three techniques for determining water flow direction in the flooded urban environment of Flourish Garden Estate, Eneka in Obio Akpor Local Government Area, Rivers State. Through field experimentation and analysis, we assessed the effectiveness of these methods namely Conventional Survey Method, Differential Global Positioning System and Remote Sensing Method, in accurately identifying the direction of water movement amidst the estate's inundated areas. The implementation process involved the deployment of each technique, including any encountered challenges and adjustments made to ensure data reliability. Results indicate varying degrees of performance across the methods, with DGPS having 7.07% and Remote Sensing Method having 22.07% deviation from the actual expected outcome clearly demonstrating higher accuracy and efficiency than others in delineating water flow pathways. Furthermore, we discuss the implications of these findings for flood management and resilience planning in urban settings. Insights gained from this study offer valuable guidance for improving flood risk assessment, early warning systems, and infrastructure planning in Flourish Garden Estate and similar communities facing similar challenges. By enhancing our understanding of water flow dynamics in flooded urban areas, this research contributes to the development of more effective strategies for mitigating the impact of flooding events and building resilient communities.

Keywords. Water Flow, Conventional Survey Method, Differential Global Positioning System

1. INTRODUCTION

Urban flooding poses significant challenges to communities worldwide, often resulting in property damage, economic losses, and threats to public safety (Agonafir et al.,2023). Flourish Garden Estate, a suburban enclave nestled amidst bustling urban development, has been particularly susceptible to flooding events in recent years. In response to recurrent inundation, there is an urgent need for effective strategies to understand and mitigate the impacts of water flow within the estate.

This journal article presents a comprehensive examination of three distinct methods, which is the use of Remote Sensing Techniques, Conventional Surveying Method and the use of Differential Global Positioning System technique, employed to determine water flow direction in the flooded terrain of

Flourish Garden Estate. The research endeavors to address the critical knowledge gap surrounding the practical application and performance of these techniques in a real-world flood management scenario.

The methods under scrutiny encompass a range of approaches, from traditional surveying techniques to modern remote sensing technologies. Through rigorous field experimentation and data analysis, our study evaluates the accuracy, reliability, and feasibility of each method in delineating water flow pathways amidst the complex urban landscape.

The significance of this research extends beyond the confines of academic inquiry. By elucidating the strengths and limitations of different water flow determination techniques, our findings offer valuable insights for urban planners, disaster management authorities, and community stakeholders tasked with devising resilient flood management strategies.

Moreover, this study contributes to the broader discourse on urban flood resilience by illuminating the intricate dynamics of water movement in densely populated urban environments. By fostering a deeper understanding of these dynamics, we aspire to inform evidence-based decision-making processes aimed at enhancing the resilience of Flourish Garden Estate and similar communities facing analogous challenges.

2 STUDY AREA

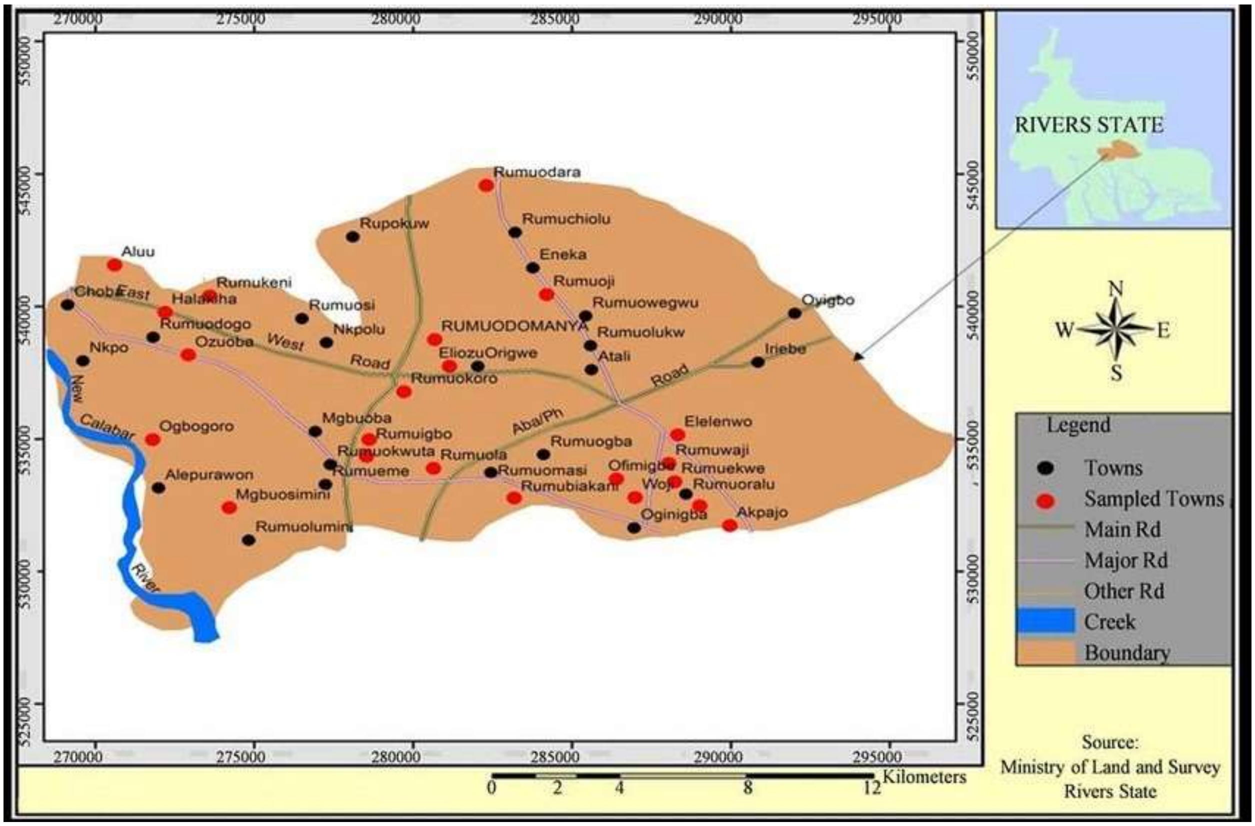

Figure 1: The study area (Obio/Akpor LGA)

The FLOURISH GARDEN ESTATE is having boundary coordinates of Latitude 4° 53′ 22.4″ N longitude 7° 0′ 51.2″ E , Latitude 4° 53′ 16.6″ N longitude 7° 0′ 50.3″ E , Latitude 4° 53′ 21.9″ N longitude 7° 1′ 6.7″E and Latitude 4° 53′ 17.7″ N longitude 7° 1′ 0.8″ E and is nestled on the periphery of a bustling urban center at Eneka in Obio/Akpor Local Government Area, emerges as a pivotal focal point in our endeavor to unravel the complex dynamics of water flow amidst urban flooding. Occupying an expanse of approximately 6.41 hectares, this residential enclave embodies a mosaic of land uses, comprising a harmonious blend of residential dwellings, commercial establishments, and recreational amenities. The estate's spatial configuration is characterized by an intricate network of roads, walkways, and green spaces, interwoven to create a vibrant urban fabric.

The topography of Flourish Garden Estate exhibits a gentle undulating terrain, punctuated by localized depressions and low-lying areas vulnerable to inundation during periods of intense precipitation or storm events. These low-lying zones, often characterized by inadequate drainage infrastructure, are particularly susceptible to the adverse impacts of urban flooding, posing significant challenges to the estate's residents and built environment.

In addition to its built environment, Flourish Garden Estate is also influenced by its surrounding natural features. Adjacent streams, creeks, and wetlands contribute to the estate's hydrological dynamics, shaping the pathways of surface water flow during flood events. The interplay between anthropogenic and natural elements within the study area underscores the multifaceted nature of urban flood risk.

Flourish Garden Estate's susceptibility to flooding is exacerbated by rapid urbanization and limited flood mitigation measures. The estate's burgeoning population and expanding infrastructure further amplify the vulnerabilities to flood hazards, necessitating urgent interventions to enhance resilience and mitigate risks.

Against this backdrop, our study delves into the intricacies of water flow dynamics within the urban landscape of Flourish Garden Estate. By comprehensively analyzing the performance of various techniques for determining water flow direction, we aim to provide valuable insights into flood management strategies tailored to the unique challenges of this dynamic urban environment. The findings of this research hold implications not only for Flourish Garden Estate but also for similar urban communities grappling with the escalating threat of urban flooding worldwide.

3 METHODOLOGY

In this study, we adopted a comprehensive methodology, leveraging three distinct approaches to determine water flow direction within the confines of Flourish Garden Estate: Conventional Surveying, Remote Sensing, and Differential GPS (DGPS).

Our methodology commenced with the initial phase of data collection on the first day, where handheld GPS devices were employed to capture coordinates at random positions scattered throughout the estate. These coordinates served as pivotal reference points for subsequent analysis, facilitating the generation of high-resolution imagery in Google Earth. This imagery formed the cornerstone for the remote sensing method, providing valuable insights into the spatial distribution of land features and potential water flow pathways.

Moving forward to the second day, our focus shifted towards conventional surveying techniques, where meticulous attention was devoted to establishing local control points within the estate. This involved the utilization of the Kolida Total Station to conduct a traverse survey, meticulously detailing the untarred road network within the estate. Following the traverse, a comprehensive leveling exercise ensued, aimed at capturing elevation data at strategic points along the road shoulders. A local Temporary Bench Mark was established at +25m elevation to ensure accuracy and consistency throughout the levelling exercise. This data collection process, spanning approximately three hours for the traverse survey and an additional two and a half hours for the leveling exercise, laid the groundwork for subsequent analysis using the conventional surveying method.

On the third day, we employed state-of-the-art DGPS technology to further enhance our dataset. The Sino DGPS system, comprising both base and rover equipment, was calibrated and connected to CORS stations to ensure optimal precision and accuracy. Traversing and elevation data were meticulously collected within a span of approximately two hours, harnessing the capabilities of DGPS to capture detailed spatial information with unparalleled accuracy.

Subsequently, all collected data were meticulously imported into the AutoCAD 2022 environment for comprehensive plotting, analysis, and inference. Additionally, the robust statistical capabilities of SPSS software were harnessed to derive meaningful insights and conclusions from the gathered dataset.

By meticulously integrating these diverse methodologies, our study aimed to provide a comprehensive assessment of water flow dynamics within Flourish Garden Estate. This comprehensive understanding serves as a cornerstone for informing evidence-based flood management strategies and resilience planning initiatives, aimed at enhancing the estate's ability to withstand and mitigate the impacts of urban flooding events.

4 DATA PRESENTATION

Table 4.1 Field Data (Source: Field Survey 2024)

CONVENTIONAL METHOD ELEVATIONS(METERS)				DGPS METHOD ELEVATIONS(METERS)		
chainage	**Left corridor**	**center**	**Right Corridor**	**Left Corridor**	**center**	**Right Corridor**
0+000	23.63	23.63	23.63	23.78	23.78	23.94
0+010	24.57	24.55	24.56	24.78	24.74	24.72
0+020	24.63	24.63	24.62	24.73	24.76	24.75
0+030	24.66	24.66	24.62	24.68	24.79	24.69
0+040	24.68	24.68	24.64	24.79	24.81	24.73
0+050	24.66	24.64	24.64	24.78	24.80	24.60
0+060	24.64	24.64	24.70	24.82	24.80	24.47
0+070	24.23	24.18	24.36	24.33	24.40	24.48
0+080	24.13	24.13	24.38	24.29	24.35	24.35
0+090	24.14	24.32	24.51	24.25	24.30	24.42
0+100	24.51	24.34	24.33	24.55	24.35	24.42
0+110	24.40	24.40	24.35	24.84	24.40	24.43
0+120	24.44	24.47	24.47	24.67	24.48	24.50
0+130	24.48	24.54	24.59	24.50	24.56	24.56
0+140	24.48	24.65	24.65	24.50	24.56	24.50
0+150	24.45	24.54	24.55	24.59	24.27	24.42
0+160	24.41	24.43	24.45	24.29	24.24	24.28
0+170	24.37	24.32	24.35	24.67	24.67	24.80
0+180	24.34	24.12	24.25	24.21	24.65	24.27
0+190	24.31	24.11	24.21	24.31	24.63	24.39
0+200	24.28	24.10	24.17	24.41	24.62	24.50
0+210	24.25	24.10	24.13	24.51	24.61	24.61
0+220	24.21	24.09	24.09	24.61	24.61	24.72
0+230	24.75	24.56	24.46	24.75	24.75	24.83
0+240	24.84	24.69	24.69	24.89	24.89	24.94
0+250	24.93	24.82	24.92	25.03	25.03	25.05
0+260	25.19	25.10	25.15	25.18	25.18	25.20

Figure 2: Remote Sensing Imagery

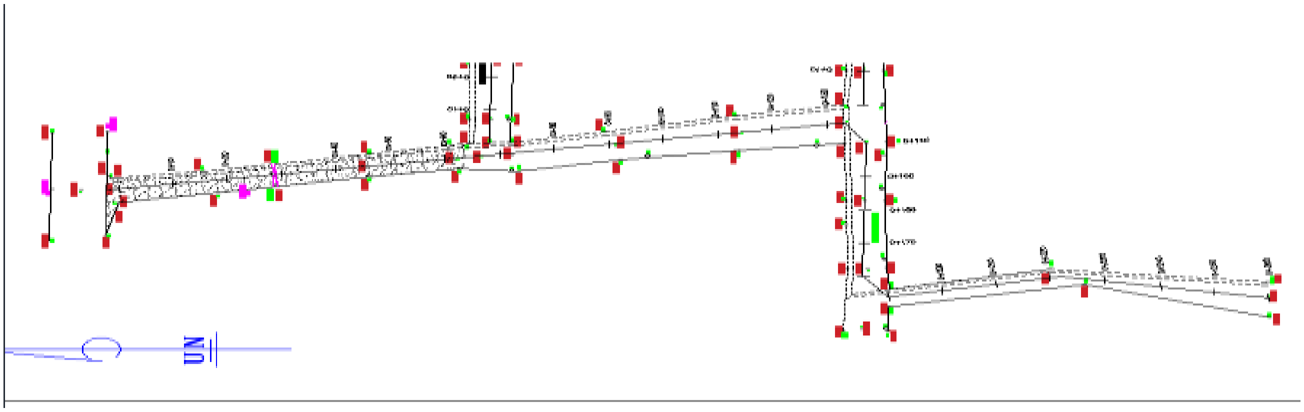

Figure 3: Conventional Method Output from AutoCad 2022

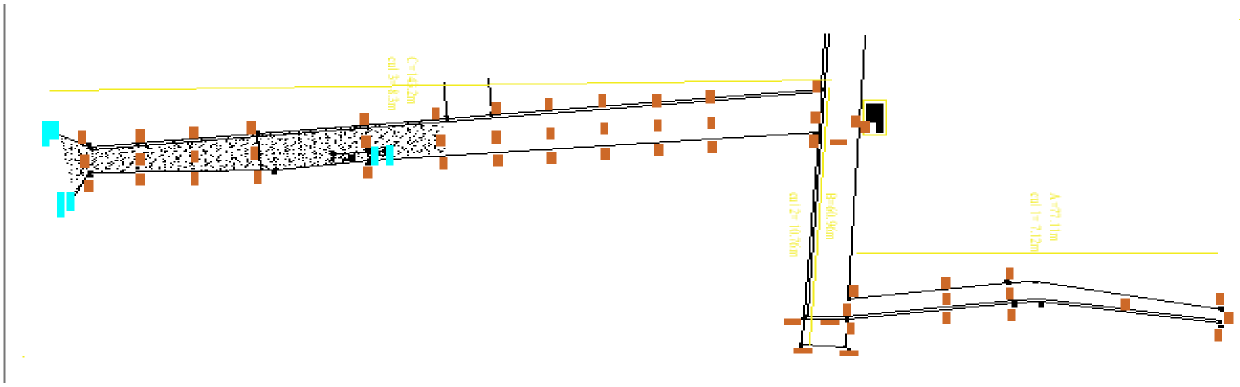

Figure 4: DGPS Method Output from AutoCad 2022

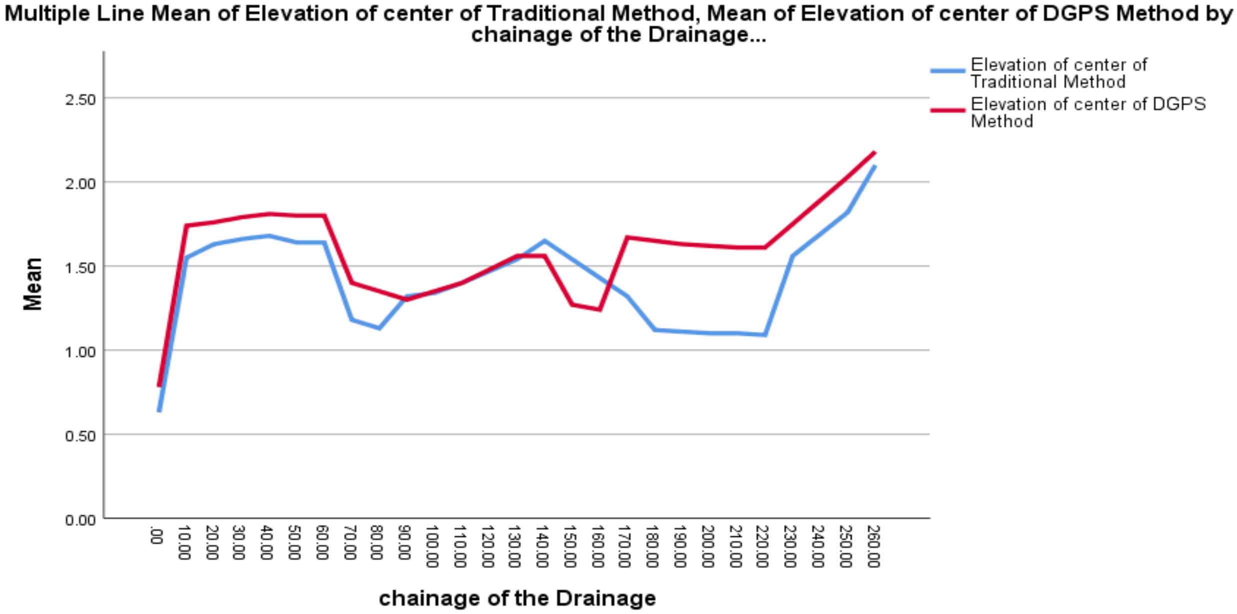

Figure 5: PROFILE showing water flow analysis and comparison between both methods

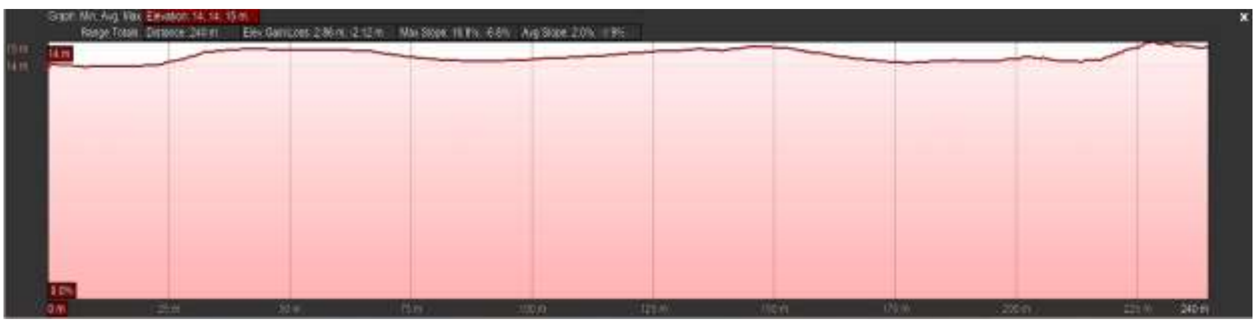

Figure 6: Profile showing water flow analysis using Remote Sensing Technique

DISCUSSION OF RESULT

All profiles show obvious water flow into the estate away from the drainage outlet but also shows clear disparity in the profile output. Below is the summary of the comparison from the three methods adopted.

Table 4.2: Analysis of the Methods Adopted

Methods Adopted	**Time For job execution**	**Area/ Perimeter**	Water Flow Direction	% Disparity
Conventional Survey technique	5hours 30mins	2243.51sqm/ 581.31m	Chainage 60-140 170-220	0
DGPS method	2 hours	2084.87sqm/ 590.95m	Chainage 60-140 140-180	7.07
Remote Sensing method	1hour 30mins	1748.37sqm/ 487.20m	Chainage 60-140 150-220	22.07

Based on the table provided, the remote sensing technique offers the advantage of obtaining field data in less time, allowing for a quick overview of the situation and enabling relatively accurate inferences to be drawn. However, despite its efficiency, the analysis reveals a significant deviation of 22.07% from the actual situation. Therefore, while remote sensing can provide a rapid assessment of the problem and facilitate prompt responses, its accuracy may be compromised.

Conversely, the use of DGPS requires less time in the field and yields results that closely approximate the actual situation, akin to those obtained through conventional survey techniques. However, the primary drawback of DGPS lies in its time-consuming nature, which constitutes a major limitation. Despite this drawback, DGPS offers a viable alternative to traditional survey methods, providing a balance between accuracy and efficiency in data collection and analysis.

5 RECOMMENDATIONS

- Integrated Approach for Comprehensive Flood Risk Assessment: Given the diverse nature of urban flooding challenges faced by Flourish Garden Estate, we recommend adopting an integrated approach that combines the strengths of traditional surveying, remote sensing, and DGPS techniques. Integrating these methodologies allows for a more comprehensive understanding of water flow dynamics, enabling stakeholders to assess flood risk with greater accuracy and effectiveness.
- Investment in Advanced Technological Solutions: To enhance the efficiency and accuracy of water flow determination in urban environments, we advocate for investment in advanced technological solutions, such as high-resolution satellite imagery, LiDAR scanning, and real-time monitoring systems. These technologies offer invaluable insights into flood dynamics, enabling proactive decision-making and timely intervention measures.
- Community Engagement and Capacity Building: Effective flood management strategies rely not only on technical expertise but also on community engagement and capacity building initiatives. We recommend fostering collaboration between residents, local authorities, and relevant stakeholders to raise awareness about flood risk, promote resilience-building measures, and facilitate community-led initiatives for flood preparedness and response.
- In light of Flourish Garden Estate's vulnerability to flooding, there is a pressing need to prioritize sustainable infrastructure development that incorporates resilient design principles. Investments in green infrastructure, such as rain gardens, permeable pavements, and natural floodplain restoration, can help mitigate flood risk while enhancing the aesthetic and ecological value of the estate.

- We emphasize the importance of long-term planning and adaptation strategies that anticipate future flood scenarios and prioritize proactive measures to build resilience against changing environmental conditions.
- Effective flood management requires coordinated efforts across multiple sectors, including urban planning, water management, disaster risk reduction, and climate adaptation. We recommend fostering cross-sectoral collaboration and policy integration to ensure a holistic approach to flood resilience that addresses underlying vulnerabilities and promotes sustainable development goals.

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