Assessing the Impact of Base Station Proximity on Continuous Operating Reference Stations (CORS) Accuracy and Its Implications for Geospatial Surveying in Sri Lanka

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Abstract

The Continuous Operating Reference Stations (CORS) system has significantly enhanced geospatial data accuracy by utilizing GNSS (Global Navigation Satellite System) technology to provide real-time corrections, essential for various applications such as urban planning, civil engineering, and environmental monitoring. However, the impact of the proximity between CORS base stations and the rover on the accuracy of RTK (Real-Time Kinematic) surveys remains underexplored. This study aims to bridge this knowledge gap by analyzing how distance variation from CORS base stations impacts RTK positioning accuracy in Sri Lanka. Control points were selected from survey departments, spanning distances from 5km to 30km from the CORS stations. Positional data were collected using various GNSS receivers and compared to known coordinates to evaluate accuracy. Additionally, several land parcels were surveyed using both the CORS method and other methods (Radio RTK and Total Station) to assess area measurement accuracy. The results demonstrate that the mean differences in Northing (dN) and Easting (dE) are minimal, with standard deviations of 0.0166 and 0.0190 respectively. Paired t-tests reveal no significant discrepancies, while regression analyses indicate positive spatial relationships with R-squared values of 0.61 for Northing and 0.76 for Easting. Notably, the results fall within the accuracy standards of the Departmental Survey Regulations of Sri Lanka. The findings underscore the high reliability of CORS for precise geospatial data collection, even at extended distances, making a significant contribution to the optimization of CORS setups in developing regions. This research ultimately aims to facilitate the widespread adoption and efficient expansion of CORS, particularly in developing regions where geospatial data accuracy is paramount.

Keywords: GNSS,CORS,RTK ,Boundary,Accuracy

1.0.Introduction

The accurate and reliable geographical and geospatial data are crucial for effectual land and property management, urban planning and infrastructure development. Continuously Operating Reference Stations (CORS) has become as essential component for high-precision positioning, providing indispensable real-time correction data for various kind of geospatial applications (Abidin et al., 2015). Sri Lanka, enhancing and upgrading CORS network is vital for improving the accuracy and efficiency geodetic surveying and mapping methods across the country.

RTK positioning accuracy is affected by several factors, including satellite geometry, atmospheric conditions, and the distance between the CORS base station and the rover. Base station proximity within CORS networks significantly affects the accuracy of the retrieved data. Being closer to the base station usually results in higher accuracy because of the signal degradation and atmospheric interference. Conversely, greater distance from the base station may results in reduced accuracy, affecting the precision of collected geospatial data (Rizos, 2007). Despite their widespread adoption, the impact of physical distance between CORS base stations and the rover on the accuracy of RTK (Real-Time Kinematic) surveys is not well-documented, especially under varying environmental and topographical conditions. This gap hampers the optimization of CORS setups and limits the understanding necessary for expanding these systems efficiently.

This research aims to provide actionable insights into the relationship between base station proximity and RTK survey accuracy, allowing for better design and operation of CORS. These improvements are vital for increasing the utility of CORS networks in areas where geospatial data collecting is important for development but is currently ignored. The outcomes of this study will have practical implications for improving geospatial data collection techniques, which are critical for national development projects, environmental monitoring, disaster management, and resource management. The research could influence policy and operational guidelines related to geospatial data acquisition and management. The primary objective of this research is to quantify how the distance from a CORS base station to a rover influence the accuracy of RTK positioning. The secondary objective is to evaluate the reliability of CORS network data when used to survey established control points, providing a benchmark comparison against traditional survey methods.

Earlier research studies have thoroughly explored the overall accuracy of RTK (Real-Time Kinematic) GNSS for terrestrial cadastral surveying (Gibbings & Zahl, 2014) compared traditional RTK to network RTK survey methods (Erenoglu, 2017). Also (Erenoglu, 2017)proved that CORS network integration greatly enhanced accuracy of the survey. (Bramanto et al., 2019) demonstrated the pros and cons of using that kind of advanced GNSS technologies. While these researches have given useful insights, there is a significant gap regarding understanding the precise influence of base station proximity on CORS network accuracy, particularly considering the geospatial context of the Sri Lanka. The importance of CORS networks and GNSS in improving geodetic survey accuracy has been thoroughly examined. (Rizos, 2007) provide an in-depth review of CORS network and their implementation and functional implications. This highlights the network geometry importance, strategies of data communication and multi-GNSS constellation integration to improve position accuracy and reliability. This highlights the significance of the base station proximity in reducing falls and improving RTK performances. (Dabove, 2019) provided the evaluation of mass-market GNSS receivers performances using RTK and NRTK (Network RTK).

Using the insights from these research papers, this research aims to fill the knowledge gap and produce comprehensive guidelines for improving the CORS network structure to obtain higher accuracy in RTK positioning. And also, through this research, aims to provide more precise and accurate geodetic survey methods, to support the land management and urban planning in Sri Lanka.

2.0. Literature Review

2.1. Global Navigation Satellite System (GNSS)

The Global Navigation Satellite System (GNSS) is a constellation of satellites stationed at the Medium Earth Orbit (MEO) that transmits positioning and timing data to GNSS receivers. These satellites are used in obtaining the position of stationary and moving objects and find great applications in surveying, geology, geography, geophysics, navigation, robotics, and various other purposes. The constellation consists of the United States of America's GPS (Global Positioning System), Russia's GLONASS (Global'naya Navigatsionnaya Sputnikovaya Sistema), China's BeiDou Navigation Satellite System, and the European Union's GALILEO (Segun & Abiodun, 2022).

Even though GNSS has many benefits in terms of usability and accuracy, there are a number of different sources of error that can affect how precise the data is collected. GNSS receiver-dependent errors and GNSS receiver-independent errors are the two primary categories into which these errors fall. By eliminating or reducing different kinds of errors that have an impact on GNSS measurements, differential correction is a technique used to improve the accuracy of GNSS data. In order to achieve the high degree of precision needed for surveying and geospatial applications, this procedure is crucial. Real-Time Kinematic (RTK) which has another two sub category as radio RTK and network RTK , and Post-Processing are the two main differential correction techniques; they are both categorized as Differential Global Navigation Satellite System (DGNSS) techniques(Bernhard Hofmann ; Herbert Lichtenegger, 2007).

2.2. Continuously Operating Reference Stations (CORS)

Continuously Operating Reference Stations (CORS) are a special case under Network RTK. Using a network-based approach called CORS, field-based roving receivers can receive real-time corrections from permanently positioned GNSS base stations. Every CORS station continuously gathers satellite data and sends correction data to a central server, which uses cutting-edge algorithms to process and improve the data. The centimeter-level accuracy is then possible because the server broadcasts these corrections to users in real-time. The network-wide synchronization and improved precision of the corrections are guaranteed by this centralized processing (Erenoglu & Erenoglu, 2016). Applications for CORS in high-precision geospatial tasks are numerous. CORS offers real-time correction data to land surveyors, allowing them to map boundaries and cadastral information with centimeter-level accuracy. It helps with accurate machine guidance, infrastructure monitoring, and construction staking in civil engineering. Precision farming methods like automated tractor guidance and site-specific crop management are made possible by CORS. CORS is used in environmental monitoring to track coastal erosion, seismic activity, and land deformation with high accuracy. CORS allows precise location services for advanced transportation systems and autonomous vehicles, in addition to transportation and navigation(Botsyo, 2020).

The accuracy of Single Base CORS for GNSS applications has been thoroughly examined in the literature, especially in relation to its dependability over longer baseline distances. To enable high-precision positioning, rovers in the field can receive real-time correction data from a fixed reference station via a Single Base CORS system. However, due to spatially dependent errors like atmospheric delays, satellite geometry, and signal multipath effects, the accuracy of Single Base CORS tends to decrease as the distance between the base station and the rover increases. Research shows that baseline distance is a significant factor in GNSS measurement precision. Single Base CORS systems can achieve centimeter-level accuracy for short baselines, usually up to 10-20 km, which makes them appropriate for high-precision applications like cadastral mapping (Bramanto et al., 2019). The Virtual Reference Station (VRS) technique is an additional CORS scenario that tackles the drawbacks of Single Base CORS, especially when it comes to longer distances. In order to establish a virtual reference station close to the location of rover, VRS CORS makes use of a network of CORS stations. The central server gathers information from various base stations, analyzes it, and produces real-time adjustments that are precisely based on the location of the rover.

In his work,(Rizos, 2007) draws attention to the “CORS” and, on the scopes of services and infrastructure associated with the base CORS, suggests exploring specific alternatives to the existing GPS-RTK models. The study looks into the advantages posed by single-base CORS in terms of the ease of installation and relatively low cost in the instance of an area for which it is sparse with base stations. The researchers enabled certain RTK settings that improved the performance of active correction of geographic location explaining the reduction in time latency when making a correction in real time.

(Dabove, 2019) considers the possibility of cadastral surveying with non-metric GNSS receivers, both by RTK and NRTK. The study highlights the fact that single base CORS networks are capable of providing good results when the rover is quite far from the base station. Also, single-base systems correct constantly, which is why they are suitable for applications that provide instantaneous solutions. In their paper, (Gibbings & Zahl, 2014) evaluate the efficient distance measurement via Cadastral distance with RTK GNSS. They further found out that, more favorable results are provided for small areas by the single base CORS networks. In other words, as long as the rover is in the vicinity of the base station, accuracies obtained from single-base systems are not comparatively higher than those derived from sophisticated multi-base adaptation. This makes them convenient for proximal stalking tasks. At the same time, the study emphasized that the farther the user is from the base station, the high accurate the static CORS survey is even without dynamic compromises in terms of providing correction over long distances.

The research of (Erenoglu, 2017) examines the GNSS and CORS infrastructure in detail with particular reference to its application in cadastral surveys. This research also points out that CORS single base networks are effective for relatively small geospatial tasks like cadastral mapping or construction layout where only a small area needs to be covered. Single-base systems also have the advantage of applying real-time corrections, which are crucial in certain applications that demand immediate positioning data. (Bramanto et al., 2019) assess the feasibility of long-range single baseline RTK GNSS positioning for the purpose of land cadastral survey. Their conclusions suggest that a single-base CORS network is cost-effective to some extent especially because it eliminates the need for communication and infrastructure.

In considering the accuracy constraints over long-range baselines, determining the effective baseline range is crucial to obtaining accurate data with CORS. The accuracy of measurements can be harmed by errors caused by atmospheric delays, satellite geometry, and signal multipath effects, all of which increase with the distance between the rover and the base station. Finding the maximum effective range that CORS can maintain high precision in is essential to ensuring accurate and dependable geospatial data. By assessing this baseline range, best practices for the deployment of CORS networks in diverse surveying and mapping applications are informed and the deployment of CORS networks is optimized (Bramanto et al., 2019). This evaluation is essential for striking a balance between coverage and accuracy trade-offs, guaranteeing that CORS systems deliver consistent outcomes over longer distances.

2.3. Paired t-Test and Statistical Methods in Accuracy Assessment

Statistical methods are crucial for assessing the precision and dependability of measurement systems in accuracy assessment for geospatial data. The paired t-test is one of these techniques that is especially useful when comparing two related datasets, like measurements from various survey methods or GNSS systems. In order to assess the consistency and precision of the measurements, this test is used to see if there is a statistically significant difference between the means of the two datasets. By comparing the differences between paired observations, the paired t-test aids in the identification of systematic errors and biases when evaluating accuracy using multiple data sets (Hedberg & Ayers, 2014).

$$t = \frac{\bar{d}}{sd / \sqrt{n}} \tag{1}$$

Where:

$\bar{d}$ = Mean of the differences between paired observations

s_d= Standard deviation of the differences

n = Number of pairs

To evaluate accuracy, in addition to the paired t-test, other statistical techniques such as descriptive statistics, regression analysis, and analysis of variance (ANOVA) are commonly used. A description of the data's central tendency and variability can be found in descriptive statistics, such as mean differences and standard deviations. Understanding the relationship between variables, such as how distance affects positional accuracy, is made easier with the use of regression analysis. When comparing more than two datasets or measurement conditions, ANOVA can be used to see if there are any notable differences between them (Rietveld & Hout, 2017). All things considered, these statistical techniques are necessary for a comprehensive accuracy evaluation, enabling researchers to assess and validate the various scenarios and datasets.

2.4. Computational Tools for Accuracy Assessment

Using cutting-edge computational tools and programming languages can greatly improve data analysis and interpretation when it comes to assessing the accuracy of geospatial data (Wu, 2021). Python was used in this study through Google Colab to perform the accuracy assessment. Datasets were handled and processed efficiently by using rich libraries of Python, which include NumPy for numerical operations, Pandas for data manipulation, SciPy for statistical analysis, and Matplotlib and Seaborn for data visualization. With its cloud-based environment, Google Colab makes collaborative work easier and provides scalable computing resources. The study was able to conduct rigorous statistical analyses, including regression analysis and paired t-tests, to evaluate the accuracy of geospatial measurements by using these Python libraries and Google Colab. This incorporation of contemporary programming tools emphasizes how crucial cutting-edge technical solutions are to getting accurate and trustworthy results in geospatial research (Naik & Naik, 2022).

3.0. Methodology

The study was conducted across several regions in Sri Lanka, utilizing Continuously Operating Reference Stations (CORS) of Global GIS Pvt Ltd to gather GNSS data. The selected CORS stations were strategically distributed across different geographical areas: Hambantota(N6°07'17.64961",E81°01'10.29472"),Pelmadulla(N6°38'01.91766",E80°31'03.46426"),Thanamalwila(N6°25'42.27186",E81°07'20.55128"),Walasmulla(N6°09'21.30309",E80°41'33.96898"),Mirissa(N5°56'17.69413",E80°28'40.26985"),Badulla(N6°59'40.24350", E81°03'37.57907"), and Nugegoda (N6°52'58.85370", E79°53'46.18750"). These stations were chosen to evaluate the impact of baseline distance on GNSS positional accuracy. Four GNSS receivers were employed in the study: TOKNAV T5 LITE, TOKNAV T10 Pro, Esurvey E600, and Esurvey E100 due to their reliability and precision in surveying.

In order to evaluate the effect of base station proximity on CORS accuracy and its implications for geospatial surveying, the study employed two main methodologies (Figure 1). The first method used CORS-based GNSS data collection at various base distances to measure the existing control points of the survey department. These precise control points were employed to assess the positional accuracy of observed points using the use of CORS.

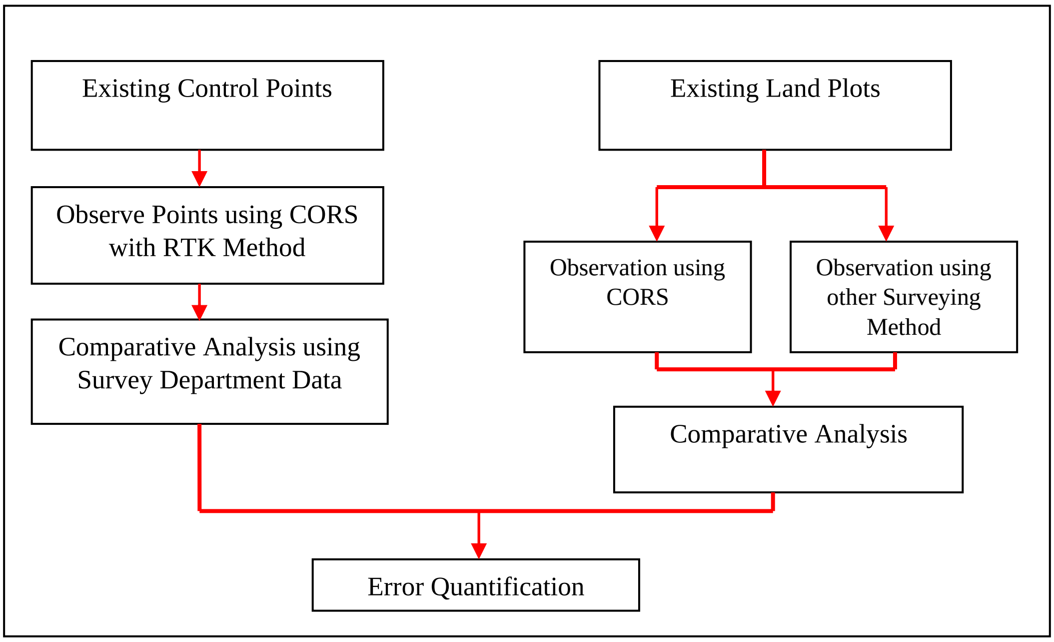

Figure 1 : Flow Chart of the Methodology

The second approach used CORS to survey existing land plots and compare the results to those from other surveying techniques such as Total Station and Radio RTK. Using both techniques, the research offered a thorough examination of how CORS proximity affects the accuracy of positional and area measurements, offering important new understandings into the utility of technology in geospatial surveying.

Control points, known for their precision and stability, were selected from survey departments and strategically located at varying distances from the CORS stations, ranging from 500 meters to 30 kilometers. Two datasets were created: one consisting of eight control points, selected in proximity to the Nugegoda CORS, and another containing eleven control points with twelve observations from the other six CORS stations. These datasets enabled a thorough comparison between the collected data and the known coordinates of the control points, allowing the assessment of the positional accuracy of real time kinematic using CORS.

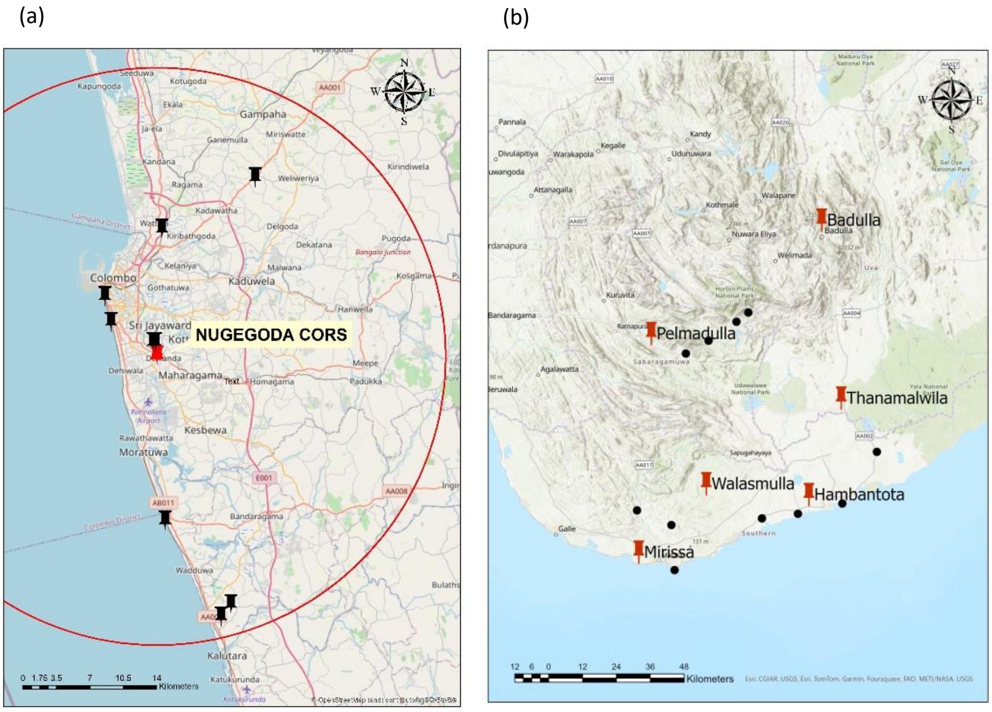

Figure 2: Selected Control Points of Survey Department and Continuously Operating Reference Stations of Global GIS Pvt Ltd

The differences in easting (dE) and northing (dN) were calculated to measure this accuracy. To assess the overall accuracy of the measurements, descriptive statistics were computed, such as the mean and standard deviation of these differences. In addition, a paired t-test was run by using python coding using google collab (Suplymentery A) to ascertain statistically whether there were any significant differences between the known control point coordinates and the observed GNSS data.

Table:1 Control Points near Nugegoda CORS

Control Point ID	Northing (N)	Easting (E)	Distance from Nugegoda CORS
52SL-412-028	486523.453	402763.523	596.109
52SL-412-029	486497.683	402516.591	753.891
52SL-407-010	488607.451	398148.414	5103.742
51C20001	498270.726	403463.073	13140.015
53B20009	467960.835	403723.065	17396.021
51C40154	503597.075	413152.066	21131.5
53C40017	459262.624	410575.36	27191.88
53C40268	457963.461	409544.548	28063.28

Table 2 : Control Points near other CORS Stations

CORS	Control Point ID	Northing (N)	Easting (E)	Distance from CORS (m)
Hambantota	83A024	400454.972	523562.071	8236.700
Hambantota	83A025	404045.86	539183.359	8420.390
Pelmadulla	62B20020	456846.495	484068.408	12654.313
Pelmadulla	62B20032	461336.982	492068.042	20481.297
Pelmadulla	NSG 1	467958.372	501891.446	30397.389
Walasmulla	82B60009	396481.454	478933.879	15761.823
Walasmulla	83A020	398809.239	510851.995	21282.387
Walasmulla	82B60003	401618.924	466858.268	24684.879
Walasmulla	82B60006	380643.767	480085.897	28151.094
Mirissa	82B60003	401618.924	466858.268	16574.000
Thanamalwila	83A028	422251.993	551375.054	19324.176
Badulla	62B20029	471240.77	506047.071	27526.000

The second step of the study involved comparing area measurements. Using CORS-based GNSS methods, ten number of land parcels (Figure 2) at varying distances from the CORS stations were surveyed. The area measurements that were obtained, in square meters, were compared with those obtained using conventional surveying methods like Total Station and Radio RTK. This comparison indicated how baseline distance influences both positional and area measurement accuracy, offering insights into the accuracy and dependability of using CORS for area measurement surveys.

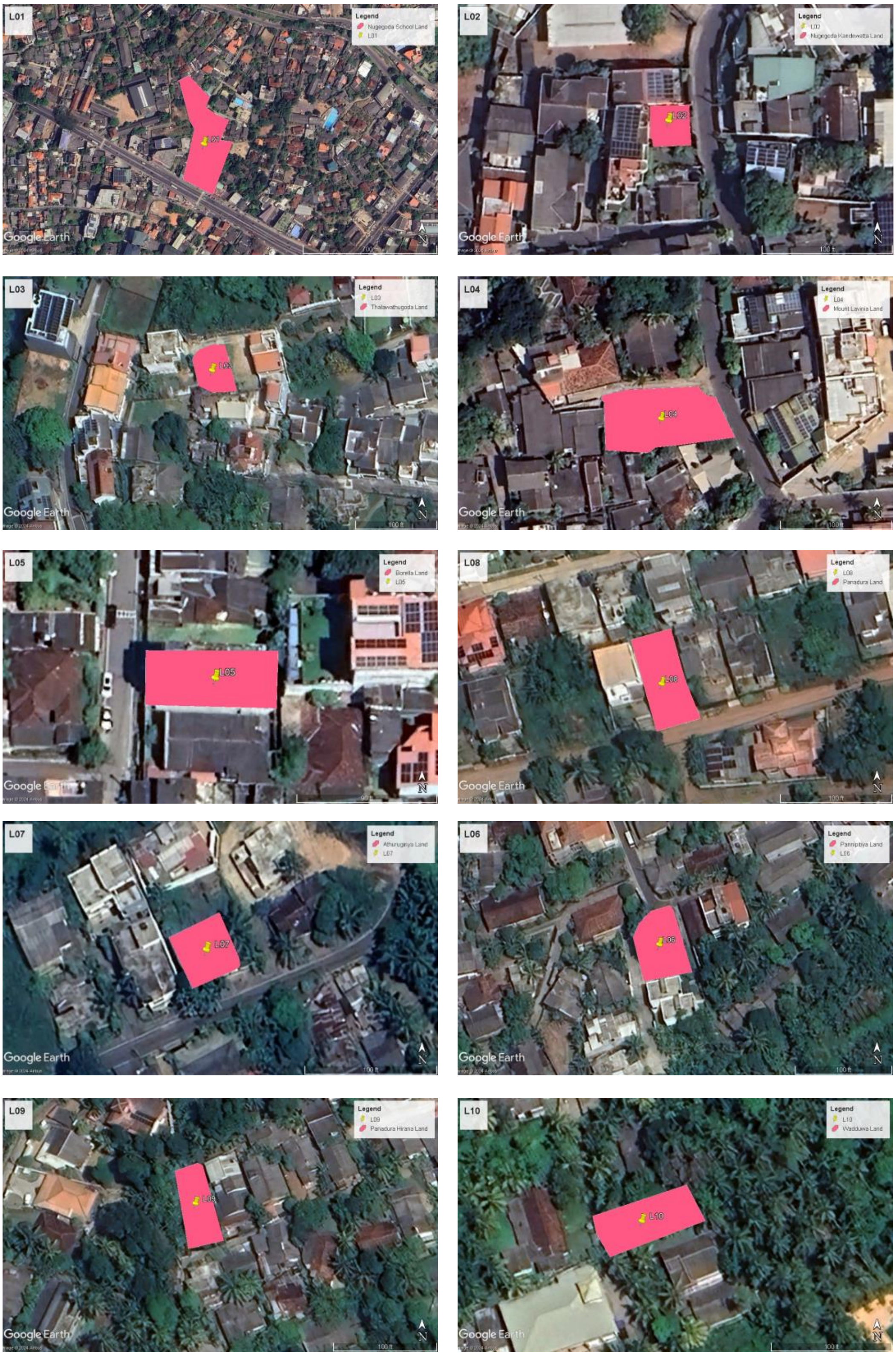

Figure 3: Location of the land parcels surveyed using CORS

4.0. Results and Discussion

4.1. CORS Accuracy Comparison with Control Points

Using the first data set which is Control Points near Nugegoda CORS, the positional differences between the observed and known coordinates were analyzed to assess the accuracy of the Continuously Operating Reference Stations (CORS). Calculating mean differences, standard deviations, paired t-tests, and regression analysis for both Northing (dN) and Easting (dE) were all part of the assessment. Descriptive statistics revealed that the standard deviation was 0.0166 meters and the mean difference in Northing (dN) was 0.0062 meters. In a similar vein, the standard deviation was 0.0190 meters and the mean difference in Easting (dE) was 0.0068 meters. The coordinates obtained from the CORS appear to closely match the known coordinates of the control points, based on these small mean differences. The standard deviations indicate a consistent level of accuracy across the control points, reflecting the reliability of CORS in providing precise positional data.The paired t-tests for Northing and Easting further support the accuracy of the CORS system. For Northing, the t-statistic was 1.1258, with a p-value of 0.2929. For Easting, the t-statistic was 1.0729, with a p-value of 0.3146. Both p-values are greater than 0.05, indicating that the differences between the observed and known coordinates are not statistically significant. This lack of significant discrepancy implies that the CORS-based positional data is comparable to the established control points, confirming the reliability and precision of the CORS system.

Using the second data set, which includes Control Points that was observed using other six CORS Stations, the positional differences between the observed coordinates obtained through CORS and the known coordinates were analyzed to assess the accuracy of the Continuously Operating Reference Stations (CORS). The assessment again involved calculating mean differences, standard deviations, paired t-tests, and regression analysis for both Northing (dN) and Easting (dE). The standard deviation for Northing (dN) was determined to be 0.0190 meters for the second data set, with a mean difference of 0.0080 meters, according to descriptive statistics. The mean difference for Easting (dE) was -0.0028 meters, while the standard deviation was 0.0214 meters. Despite the slightly higher standard deviations than in the first data set, the small mean differences show that the coordinates acquired from the CORS are quite close to the known coordinates of the control points. The accuracy of the CORS system is further supported by the paired t-tests that were carried out for both Northing and Easting. The t-statistic for Northing was 1.4602 and the p-value was 0.1722. The t-statistic for Easting was -0.4459, and the p-value was 0.6643. This non-significant difference suggests that even at longer distances from the base station, the positional data derived from CORS is still similar to the defined control points

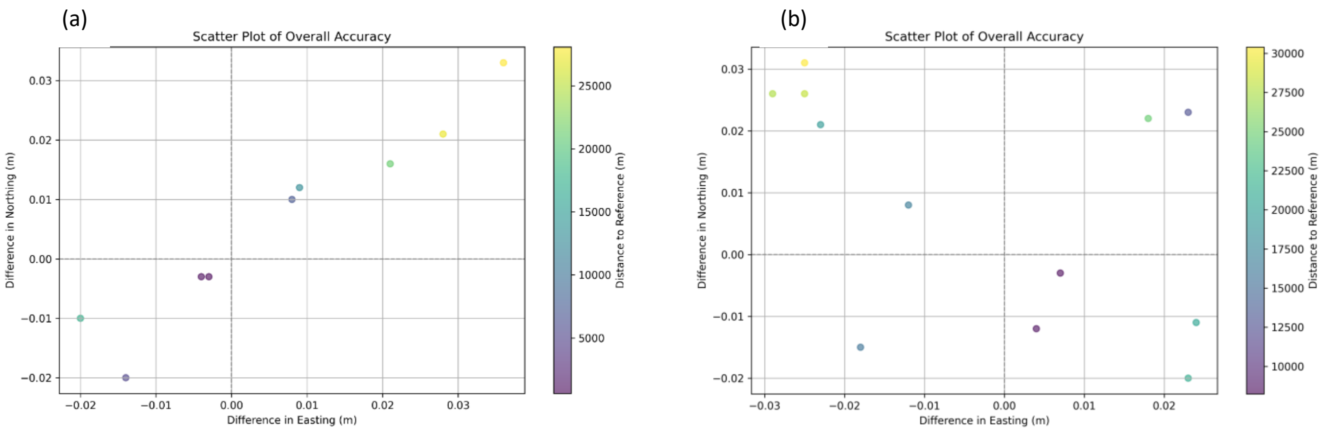

Figure 4 : Scatter Plot of overall accuracy of a) selected points in proximity to the Nugegoda CORS b)selected points in proximity to the other CORS

The regression analysis provided additional insights into the relationship between positional differences and the distance to the reference station. For Northing (dN), the regression analysis of data set 01 revealed an intercept of -0.0089 and a coefficient of 1.1291e-06, with an R-squared value of 0.5306. For Easting (dE), the intercept was -0.0100, with a coefficient of 1.2557e-06 and an R-squared value of 0.5023. These results indicate a positive spatial relationship, with the R-squared values demonstrating a moderate level of correlation. Specifically, the R-squared value of 0.5306 for Northing suggests that approximately 53.06% of the variability in Northing differences can be explained by the distance to the reference station, while the R-squared value of 0.5023 for Easting indicates that about 50.23% of the variability in Easting differences can be attributed to this distance. Regression analysis for the second data set revealed an R-squared value of 0.62 for Easting (dE) and 0.61 for Northing (dN). In comparison to the first data set, these R-squared values show a slightly greater correlation between positional differences and distance. In particular, the distance to the reference station accounts for approximately 61% of the variability in Northing differences, according to the R-squared value of 0.61 for Northing and 62% for Easting, respectively.

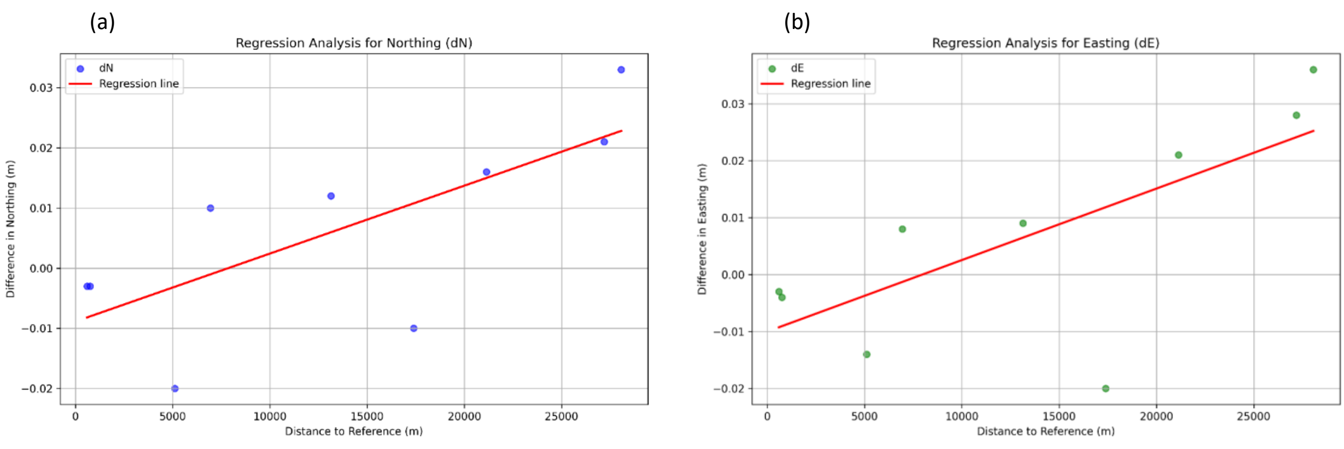

Figure 5 : Regression Analysis of selected points in proximity to the Nugegoda CORS

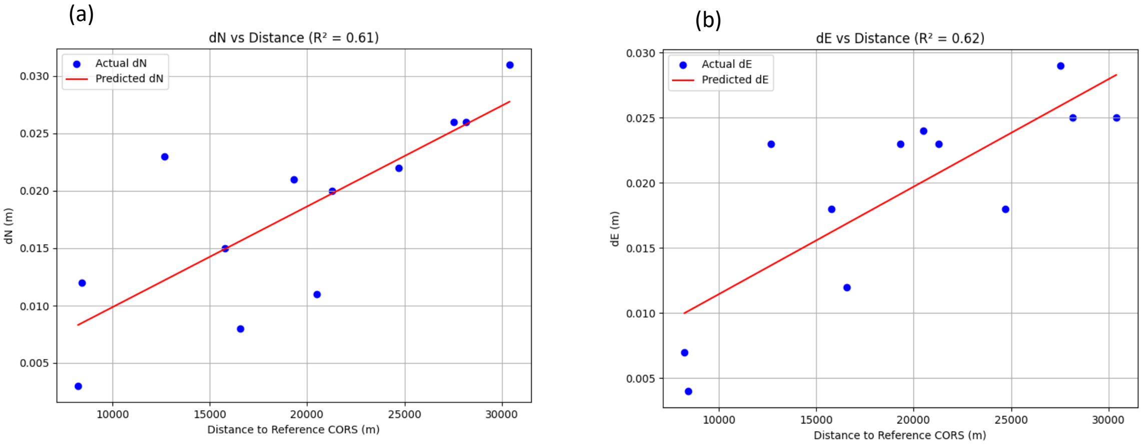

Figure 6 : Regression Analysis of selected points in proximity to the other CORS

Notable knowledge regarding the relationship between positional deviations and distance from the CORS base station was obtained from the combined regression analysis of 21 control points from both data sets. With regard to Northing (dN), the R-squared value of 0.61 denotes a moderate correlation, meaning that the distance can account for 61% of the variability in Northing differences. This aligns with a trend noted in distinct data sets. A stronger correlation is seen for Easting (dE), where distance accounts for 76% of the variability in Easting differences, according to the higher R-squared value of 0.76. This suggests that the locational accuracy is more significantly impacted by the base distance from the CORS.

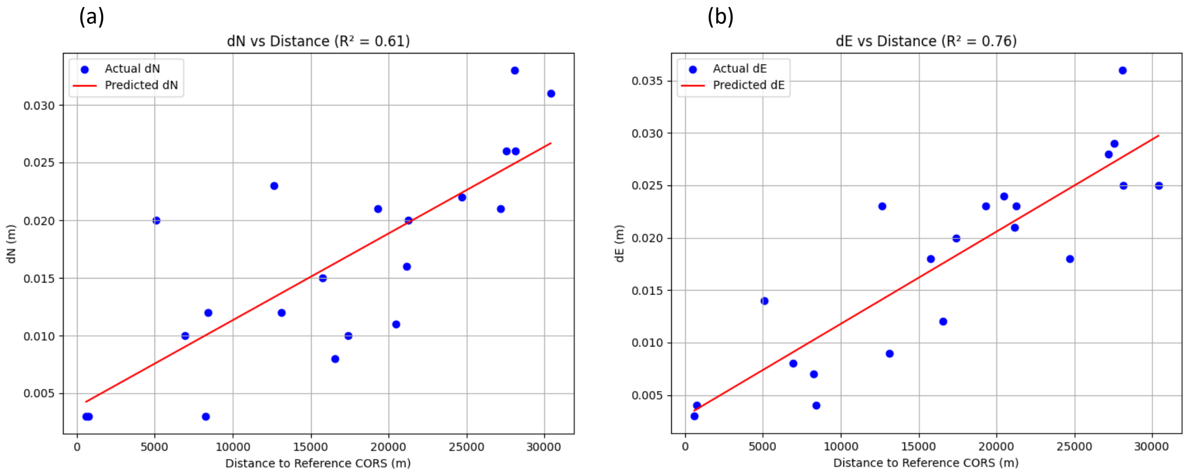

Figure 7 : Regression Analysis of all selected control points

Overall, the findings highlight the high reliability of the CORS system in providing accurate and precise positional data, even at extended distances from the reference station. The minimal mean differences and the non-significant results of the paired t-tests reinforce the accuracy of CORS-derived coordinates. The correlation observed in the regression analysis suggests that while distance does play a role in the accuracy of positional data, the CORS system remains a robust tool for geospatial surveying. These insights are particularly valuable for optimizing CORS setups in developing regions, where accurate geospatial data is crucial for various applications, including urban planning, environmental monitoring, and infrastructure development.

4.2. Results of Area Comparison for Land Boundary Surveys

The analysis of area differences between the CORS method and other methods (Total Station and Radio RTK) across various locations reveals that the differences are consistently minimal. The highest percentage difference observed is less than 0.1%, which is negligible in practical terms for most geospatial and surveying applications.

Table 3: Area differences

Location	Area from other method(m2)		Area from CORS(m2)	Base distance to the reference CORS Station (Nugegoda CORS)	Area Difference	%
	Total station	Radio RTK				
L01	8,550.53		8,550.91	1 202.23	0.38	0.004468251
L02	111.620339		111.589288	1 806.65	0.031051	0.027818407
L03		209.226	209.347	4027	0.121	0.057832201
L04	485.395438		485.558006	5 119.87	0.162568	0.033491868
L05	206.032304		205.982481	5 527.56	0.049823	0.02418213
L06	330.229208		330.429475	6 848.85	0.200267	0.060644848
L07		254.7	254.882	9630	0.182	0.071456616
L08	248.312025		248.117194	16 358.46	0.194831	0.078462169
L09		255.632	255.507	17150	0.125	0.048898416
L10		239.462	239.237	23000	0.225	0.093960628

The mean difference in the area measurement was 0.0782 meters, with a standard deviation of 0.2084 meters. These statistics indicate that the differences between the areas measured using the CORS method and the other methods (Radio RTK and Total Station) are relatively small. The mean difference represents the average discrepancy in area measurements, suggesting that on average, the CORS-based measurements are very close to those obtained by other methods. The standard deviation provides a measure of the variability in these differences, indicating that while there is some variation, it remains within an acceptable range for accurate land boundary surveys.

These results can be attributed to the advanced technological infrastructure supporting the CORS network. CORS networks utilize a number of modern technologies to generate location data that is reliable and highly accurate, which enhances the overall accuracy of system and efficiency. One of the key components is the CORS antenna, where high-precision choke ring antennas are widely used. These antennas are made expressly to mitigate the effects of multipath by reducing off signal interference from nearby buildings and topography. This ensures the integrity of the GNSS signals, leading to more accurate positional data. At CORS stations, sophisticated GNSS receivers are used in conjunction with choke ring antennas (Janssen & Haasdyk, 2011). These receivers improve the ability of the system to provide precise, real-time positioning by tracking signals from various GNSS constellations (GPS, GLONASS, Galileo, etc.). Support for multiple frequencies and constellations guarantees that trustworthy data can be obtained even in difficult situations where satellite visibility may be obscured. Another essential component to guaranteeing continuous CORS operations is the dependability of the power supply. Solar-powered batteries are a common sustainable energy solution used by CORS stations, enabling the stations to continue operating even in remote locations without connection to conventional power grids. Despite external power outages, this self-sufficient power source guarantees continuous data collection. Patch antennas linked to reliable network providers are often used to keep users and CORS stations in constant and real-time communication. For rovers and other field users to receive GNSS correction data in real time, these antennas guarantee a steady internet connection. Interruptions in real-time kinematic (RTK) solutions can be reduced with a dependable network, guaranteeing users receive precise and timely positional corrections. The CORS server, which is central to the CORS architecture, is essential for handling and processing the GNSS information gathered by base stations. The server gathers raw data from several stations, processes it using sophisticated algorithms, and creates corrected data that is delivered to users instantaneously. The server also makes sure that GNSS data is synchronized throughout the network, which enables users to access extremely accurate positioning services. High data integrity and continuous operation are ensured by the CORS server through effective stream management and strong data storage and analysis (Rubinov et al., 2012).

5.0. Conclusion and Recommendation

With a focus on the impact of base station proximity on positional accuracy, this study evaluated the accuracy of RTK (Real-Time Kinematic) positioning in Sri Lanka using Single Base CORS. The findings show that CORS-based GNSS technology is highly reliable for geospatial surveying and land parcel measurement, even at distances up to 30 km, by analyzing control points at various distances (500m to 30 km) from multiple CORS stations. The accuracy of the system is demonstrated by the mean differences in Northing (dN) and Easting (dE) and by the small standard deviations. The accuracy of the CORS system is validated by the statistical analysis, which includes regression analyses and paired t-tests, which further demonstrates that the observed positional differences are not statistically significant. Strategic placement of additional CORS stations is crucial to improve the precision and dependability of CORS-based surveys, particularly in developing regions. By lowering baseline distances and lessening the effect of spatially dependent errors, this strategy will eventually increase positional accuracy over a wider area. The dependable accuracy seen up to 30 km emphasizes the potential for GNSS technology to support land surveying, cadastral mapping, and other geospatial applications in these areas, making the expansion of the CORS network to remote or underserved regions imperative. Furthermore, the deployment of Virtual Reference Station (VRS) technology ought to be taken into consideration in order to mitigate the constraints of Single Base CORS that extend beyond its 30-kilometer range. Large-scale geospatial tasks can be ensured with consistent precision by VRS, which can provide highly accurate real-time corrections over longer distances by utilizing data from multiple CORS stations.

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