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Horizontal Positional accuracy Evaluation of Orthophoto in case of Sebeta town, central Ethiopia.

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Abstract
This study used Global Navigation Satellite System (GNSS) static measurements withSOKKIA ATLAS dual frequency GNSS receiver to assess horizontal positional accuracy in coordinates of orthophoto in the case of Sebetatown, central Ethiopia. The Local, Regional and Global GNSS reference stations, and continuously operating reference station of Ethiopia were included in the adjustment. Thus, horizontal coordinates at 20 checkpoints were obtained, which were used to assess the horizontal positional accuracy of the same points in the orthophoto. The GNSS data was processed using the Ashetch solution software packages. Using checkpoints' coordinates, the horizontal positional accuracy was computed in Excel Spread Sheet and ArcGIS Positional Accuracy Assessment Tool. The results generated were 10.9cm, 18.6cm and 21.5cm in terms of $RMSE_x$, $RMSE_y$ *and* $RMSE_r$ *respectively. The values conform with national Legal cadaster standard No 03/2015; stating that horizontal accuracy in RMSE must not exceed two pixels size of Ground Sample Distance (X and Y) which is equivalent to 30cm RMSE error since the GSD of the Aerial photo was 15cm. Finally, it can be concluded that the results obtained on the horizontal positional accuracy assessment fit the requirement of the cadastral standard.*

Key words: *Global Navigation Satellite System, horizontal accuracy, orthophoto and Sebeta town*

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I. Introduction

Positional accuracy is the quantifiable value that represents the positional difference among twogeospatial layersor among a geospatial layer and reality (ESRI,2020). To assess positional accuracy, two layers are required: the layer whose accuracy you want to evaluate and another layer that can be used as a point of reference. There are four major cases when using Positional Accuracy assessment tool (PAAT) tool to evaluate positional accuracyusing two feature classes, a feature class and a raster, two rasters, and a z-enabled point feature class and digital elevation model (DEM) raster or triangulated irregular network (TIN)(ESRI,2020).Subsequent to the developments in satellite and aerial survey technologies, a high resolution Orthophoto data is contemporarily considered as useful data source to carry out to reliable and fair recording and mapping parcel boundaries using orthophoto mapping technology by aerial or satellite imagery. These mapping can serve not only the cadastral system, but also both rural and urban sustainable land-use systems. Before using any spatial data to support decision making, the positional accuracy needs to be verified using sample check points(Boye et al.,2016).

However, the accuracy of horizontal point localization in urban orthophoto mapping is the main issue of the current paper. Urban mapping has more strict accuracy requirements than general orthophoto mapping since it is primarily concerned with urban land use planning, not only the registration of parcel boundaries. The difficulties of accurately mapping urban landscapes are also unique, as demonstrated by Zhou et al. (2004). Given that many newly industrializing nations exhibit rapid, frequently unplanned urbanizationasa global issue Chhatkuli (2002) and Akdeniz, (2004).

In Ethiopia, however, few positional accuracy assessments of orthophoto mapping have been done so far, no such studies have been done for Sebeta town. Using Sebeta, as a practical test case, this work aims to investigate the accuracy possible for terrain points. The study specifically assesses how well orthophoto-based surface point coordinates match with static GPS data. In other words, the comparison of the location of potential control points like water line at bridge abutment intersection of road, retain wall and ditch (culvert) in a feature class versus their location in Orthophoto image (ESRI,2020).

While evaluating positional accuracy the quality levels are based on purpose of use, international and national geospatial data quality standards. In this study, the Legal cadaster standard of Ethiopia: No 03/2015 was referred, the horizontal accuracy of a digitalOrthophoto in RMSE must not exceed two pixels size of theGround Sample Distance (X and Y) and that of vertical accuracy in RMSE must not exceed three pixels size of the Ground Sample Distance in Z.Consequently, OIULISPCO (Oromia Integrated Urban Land Information System Project Coordination Office) and the stockholders (EGIA and INSA) agreed to work jointly on the positional accuracy assessment of Sebetatown digital orthophoto. The Technical scopes of this study is verifying the positional accuracy (x, y) of the Sebetatown digital Orthophoto using DGNSS static mode observation and then show the discrepancies between coordinates from Orthophoto and coordinates from static observation using root-mean-square error (RMSE). Thespecific objective of this study is to verifythe horizontal positional accuracy of Sebetatowndigital Orthophoto.

II. Materials and Method

2.1. Location of Study Area

The study has been conducted in Sebeta town, Central Ethiopia, it shares boundary at South western of Addis Ababa, Capital city of Ethiopia. It is found at 20km from the center of capital city. It is very suitable for life and one of the fastest expanding towns in Ethiopia Figure1.

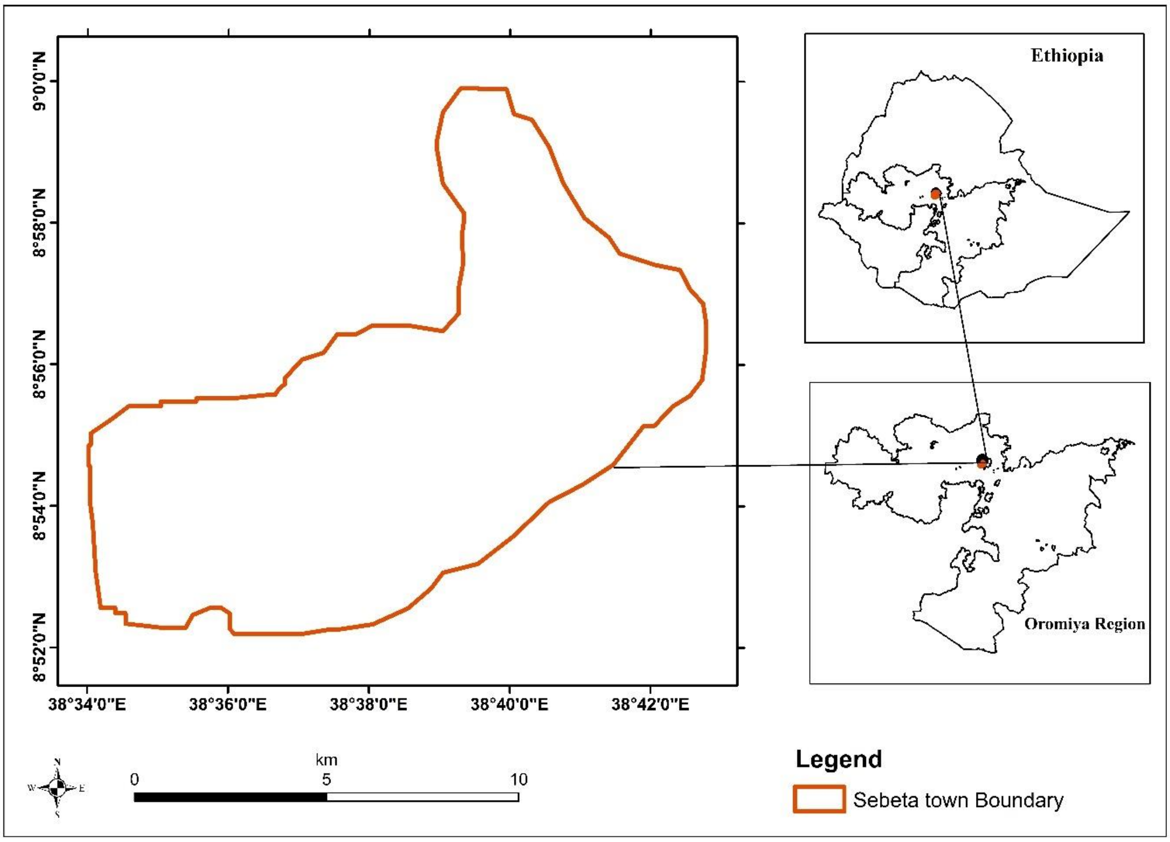

Figure 1: LocationMap of study area

2.2. Data used

To evaluate the horizontal positional accuracy of Sebeta towntwo mainfinal data wereused, Orthophoto fromOIULISPCO (Oromia Integrated Urban Land Information System Project Coordination Office) and GNSS data from field Survey.

2.3. Methods

The major methods employed to accomplish this study wereselecting check points, Traverse observation, field reconnaissance to check points, check points observation, GNSS data Post processing and Adjustment, and positional accuracy Validation.

2.3.1. Check Point Selection

Appropriate sample size and distribution of check points provide a reliable estimate tothe positional accuracy geospatial features.According to NSSDA, any statistical positional accuracy test requires a minimum of 20 sample points (ASPRS, 2015).

In line with this global standard, we have selected 22 sample check points to estimate the positional accuracy of Sebetatown orthophoto. Although it was challenging to have an even distribution of checkpoints to the entire study area which are permanent and distinct features, we have made to have a well distributed number checkpointsover the study areaFigure 2.

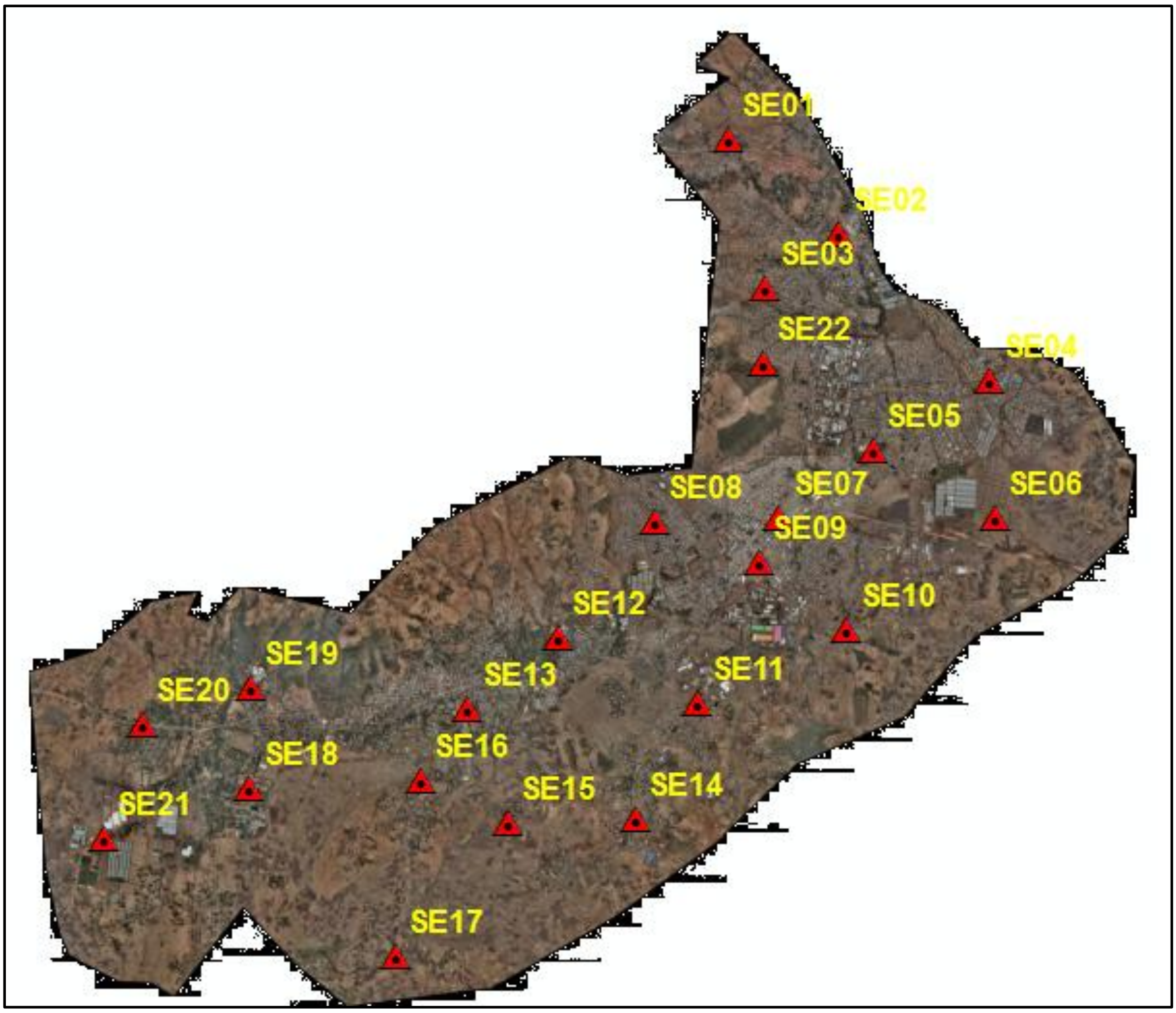

Figure 2: Distribution of selected check points

According to different literatures, the sample check points must consist of well-defined points and should represent a feature in which the horizontal and vertical positions are known accurately. As a result, sharp and well visible points both on the ground and digital orthophoto are considered. These include; Intersection of sidewalks, bridges, culverts, ditches, troughs, pavements, etc. as shown in Figure 2.

2.3.2. Traverse Observation

Before taking observation at check points, reconnaissance and observation of the traverse was conducted. The receiver type used was SOKKIA ATLAS Dual Frequency GNSS. With five instruments of this type, five static GNSS measurement sessions were carried out at duration of 4 hours with a data logging interval of 5 seconds and mask angle of 10 degreesFigure 3.

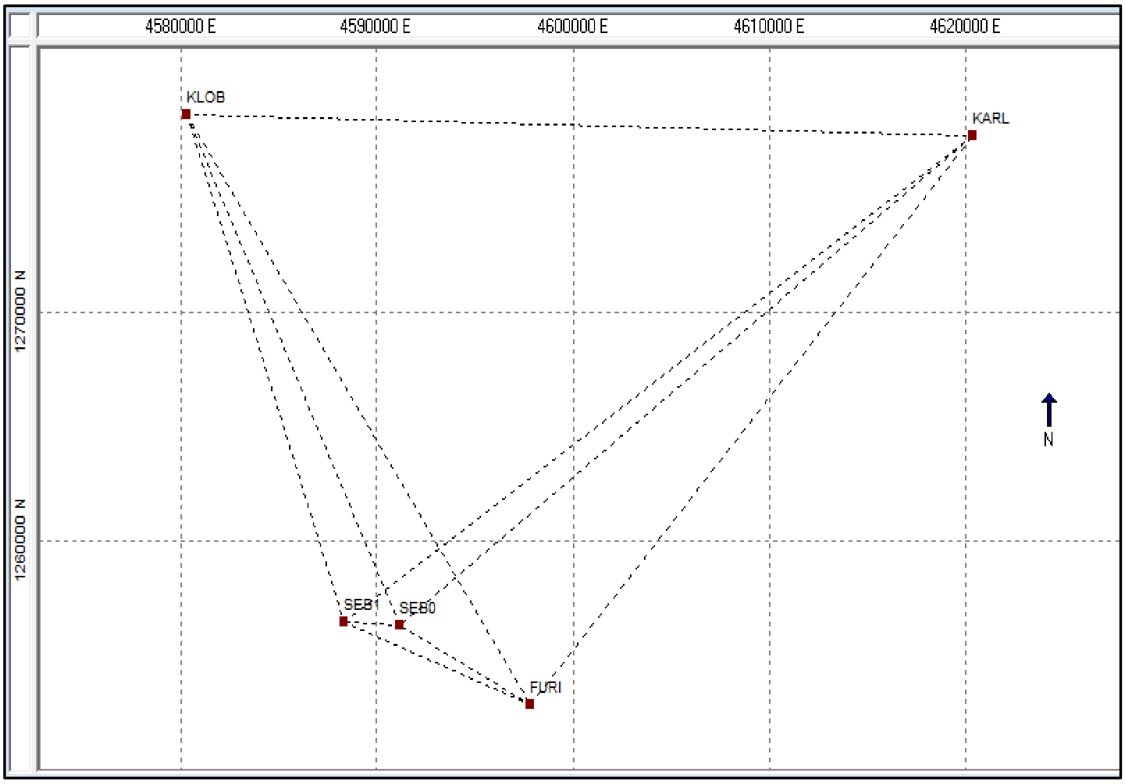

Figure 3:Traverse network scheme

2.3.3. Field Reconnaissance to Check points

Before the actual GNSS observation was conducted, a reconnaissance field survey was conducted to identify and locate the checkpoints selected from orthophoto on the ground and marked as appropriate for the survey to access easily in town. On top of thisassessing point suitability and marking them, selecting and replacement of demolished features are carried out.

2.3.4. Check point observation

Using Sokkia Atlas Dual FrequencyGNSS receiver,static GNSS observation were carried out for 20 checkpoints for duration of 1 hour at a data logging interval of 5 seconds and 10 seconds with mask angle of 10 degree. The 20 checkpoints were enough to check the horizontal positional accuracy of Sebeta town Orthophoto, which covers an area of 98 square kilometerssince (NSSDA ,1998)recommends 20 check points for project having an area of $\leq$ 500 square kilometers.

During data observation, all the necessary information like antenna height, starting time, ending time and reference station were carefully recorded so that it to be used in data post processing. Three first order reference stations namely Kari,Koloo and Furifound in the project area were used as a baseline for check point observations and two second order reference stations namely SEB1 and SEB2 were used during taking observations GNSS.GNSS observationsof checkpoints were carryout in different sessionsform October 20, 2108 to October 24, 2018Figure 4.

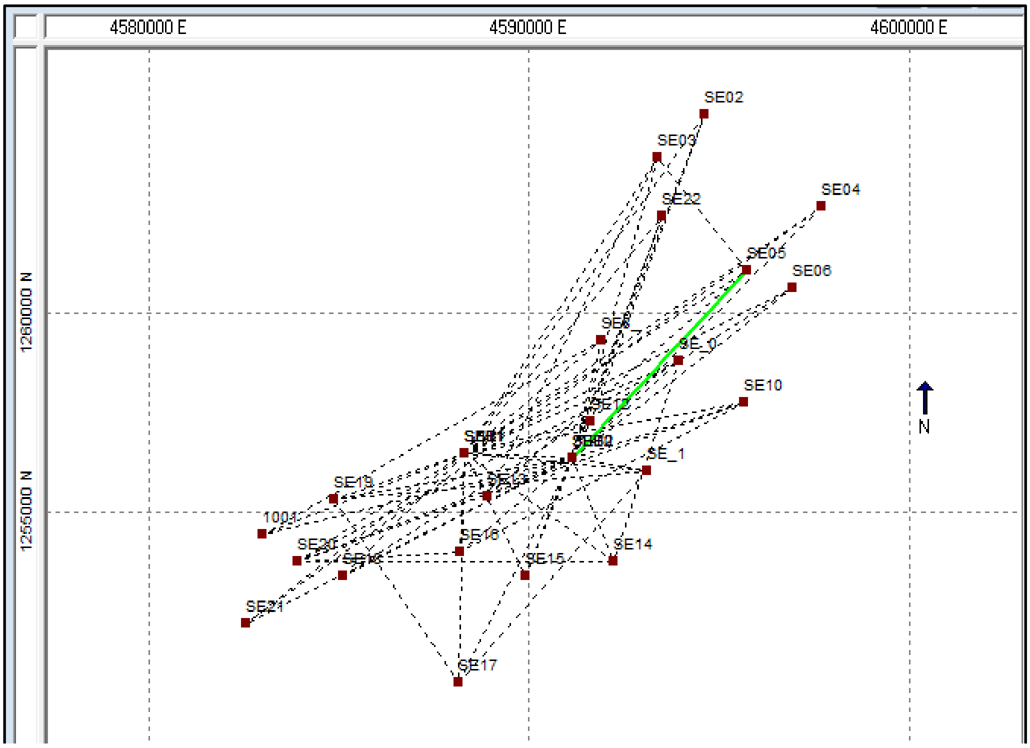

Figure 4: Check points network scheme.

2.3.5. GNSS data Post processing and adjustment

The GNSS data that are collected for the Orthophoto positional accuracy verification were processed using Ashtech solutionsoftware. The datum configuration during data processing in the software was Adindanwith reference ellipsoid Clarke 1880.To transform the data from Adindanto WGS84 a transformation parameter of -162, -12 and 206 is used for X, Y, Z respectively.

Table 1: Check point coordinates computed from Ashtech solution software

PID	X	Y
SE01	462442.107	992907.803
SE02	464061.564	991536.98
SE03	462990.054	990785.918
SE04	466260.562	989409.382
SE05	464557.323	988380.836
SE06	465468.175	987906.524
SE08	461376.113	987372.31
SE09	462925.209	986757.733
SE11	462012.924	984704.24
SE12	460981.233	985810.104
SE13	458666.104	984620.667
SE14	461106.223	983027.105
SE15	459246.105	982965.898
SE16	457980.396	983595.127
SE17	457614.93	981056.323
SE18	455502.072	983410.279
SE19	455511.411	984937.103
SE20	453937.52	984395.845
SE21	453375.239	982735.109
SE22	462954.157	989649.844

2.3.6. Positional Accuracy Validation

Positional Accuracy Assessment is assessing a data layer's accuracy in relation to a known reference layer. Horizontal accuracy is assessed using Root-Mean-Square-Error (RMSE) statistics in the horizontal plane(FGDC, S. C. (1998), i.e., RMSEx, RMSEy and RMSEr.RMSE is the square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points.*RMSEr* is the horizontal linear RMSE in the radial direction that includes both x- and y-coordinate errors. The RMSE statistics of X and Y component is calculated using the following equation:

$$RMSE_x = \frac{\sqrt{\sum(X_{gps - Xdataset})^2}}{n}$$

$$RMSE_y = \frac{\sqrt{\sum(Y_{gps - Ydataset})^2}}{n}$$

The horizontal accuracy at a point in radial direction is computed as:

$$RMSE_r = \sqrt{(X_{gps} - X_{dataset})^2} + \sqrt{(Y_{gps} - Y_{dataset})^2}$$

Based on 20 checkpoints identified to verify theOrthophotohorizontal positional accuracy of Sebetatown,it was calculated using the X, Y coordinates of 20 checkpoints Table2.

Table 2: Coordinates extracted from SebetaTown Orthophoto

PID	X	Y
SE01	462441.840	992907.581
SE02	464061.456	991536.811
SE03	462990.200	990786.050
SE04	466260.311	989409.117
SE05	464557.323	988380.836
SE06	465468.148	987906.410
SE08	461376.073	987372.098
SE09	462925.302	986757.865
SE11	462012.953	984704.208
SE12	460981.167	985810.130
SE13	458666.112	984620.746
SE14	461106.369	983027.211
SE15	459246.198	982966.136
SE16	457980.356	983594.624
SE17	457615.049	981056.297
SE18	455502.138	983410.279
SE19	455511.437	984937.295
SE20	453937.520	984395.656
SE21	453375.214	982735.100
SE22	462954.111	989649.626

The horizontal positional accuracy computation of Sebeta Orthophotowascomputed using “Excel Spread Sheet” and ArcGIS Positional Accuracy Assessment Tool (ArcGIS PAAT)table3.

Table 3:Horizontal Positional Accuracy of Sebeta Orthophoto as computed using Excel spread sheet

Check Point Coordinates			**Ortho Coordinates**			**Delta**		**Delta Squares**	
PID	**X**	**Y**	**PID**	**X**	**Y**	**DX**	**DY**	**DX^2**	**DY^2**
SE01	462442.107	992907.803	SE01	462441.840	992907.581	0.267	0.222	0.071	0.049
SE02	464061.564	991536.98	SE02	464061.456	991536.811	0.108	0.169	0.012	0.029
SE03	462990.054	990785.918	SE03	462990.200	990786.050	-0.146	-0.132	0.021	0.018
SE04	466260.562	989409.382	SE04	466260.311	989409.117	0.251	0.265	0.063	0.070
SE05	464557.323	988380.836	SE05	464557.323	988380.836	0.000	0.000	0.000	0.000
SE06	465468.175	987906.524	SE06	465468.148	987906.410	0.027	0.114	0.001	0.013
SE08	461376.113	987372.31	SE08	461376.073	987372.098	0.040	0.212	0.002	0.045
SE09	462925.209	986757.733	SE09	462925.302	986757.865	-0.093	-0.132	0.009	0.018
SE11	462012.924	984704.24	SE11	462012.953	984704.208	-0.029	0.032	0.001	0.001
SE12	460981.233	985810.104	SE12	460981.167	985810.130	0.066	-0.026	0.004	0.001
SE13	458666.104	984620.667	SE13	458666.112	984620.746	-0.008	-0.079	0.000	0.006
SE14	461106.223	983027.105	SE14	461106.369	983027.211	-0.146	-0.106	0.021	0.011
SE15	459246.105	982965.898	SE15	459246.198	982966.136	-0.093	-0.238	0.009	0.057
SE16	457980.396	983595.127	SE16	457980.356	983594.624	0.040	0.503	0.002	0.253
SE17	457614.93	981056.323	SE17	457615.049	981056.297	-0.119	0.026	0.014	0.001
SE18	455502.072	983410.279	SE18	455502.138	983410.279	-0.066	0.000	0.004	0.000
SE19	455511.411	984937.103	SE19	455511.437	984937.295	-0.026	-0.192	0.001	0.037

SE20	453937.52	984395.845	SE20	453937.520	984395.656	0.000	0.189	0.000	0.036
SE21	453375.239	982735.109	SE21	453375.214	982735.100	0.025	0.009	0.001	0.000
SE22	462954.157	989649.844	SE22	462954.111	989649.626	0.046	0.218	0.002	0.048
							Average	0.012	0.035
							RMSE	0.109	0.186
							RMSEr	**0.215**	

III. Result and Discussion

The results of the computation b/n the tow measurements GNSS (Check point coordinates computed from Ashtech solution software) and Coordinates extracted from Sebeta town orthophoto image were summarized in Table 3. The horizontal positional accuracy of SebetaOrthophoto in terms of $RMSE_{x,}$ $RMSE_y$ and $RMSE_r$are 10.9cm, 18.6cm and 21.5cm respectively.

The result obtained meets the Legal national cadaster standard No 03/2015 ofan Orthophoto horizontal accuracy requirement, stating that horizontal accuracy in RMSE must not exceed two pixels size of Ground Sample Distance (X and Y) which is equivalent to 30cm RMSE error since the GSD of the Aerial photo was 15cm.In other words, $RMSE_x$ which is 10.9cm is less than 2*15cm(30cm) and $RMSE_y$ which is18.6cm is also less than 30cmwhereas$RMSE_r$is less than 30cm.

As the results evaluated to (ASPRS,2015) positional accuracy standards for digital orthoimage data, both $RMSE_x$ and $RMSE_y$meet the conformance with the standards. While$RMSE_r$ which is equal to 21.5cm is alsoless than 1.414*30cm(42.42cm). Therefore, the results generated for the Sebata town orthophoto meet both the national and (ASPRS,2015) standards.

In view of the technical experts, the following problems would be identified as some of the causes for the higher RMSE errorof the orthophoto:-The observation using single frequency GPS receiver,if there is problem of updating the features selected for check points, very few numberof reference stations,if features selected for check points are not sharp and well defined horizontally, and the place of check point coordinates where GPS observation was taken and the Orthophoto coordinates extracted are shifting.

IV. Conclusion and Recommendation

4.1. Conclusion

In order to verify the horizontal positional accuracy of Sebetatown Orthophoto, well distributed 20checkpoints were usedand observed. The GNSS observation was carried out using SOKKIA ATLAS dual frequency GNSSreceiver for 4 hours and 1hour for the traverse and checkpoints respectively, and Ashtech solution softwareis used to process the GNSS.Using the selected checkpoints' coordinates, the horizontal positional accuracy assessment of SebetaOrthophoto wascomputedin Excel Spread Sheetand ArcGIS Positional Accuracy Assessment Tool.

The results obtainedare 10.9cm, 18.6cm and 21.5cm in terms of $RMSE_x$, $RMSE_y$ and $RMSE_r$ respectively.It meets the conformance of national Legal cadaster standard No 03/2015; stating thathorizontal accuracy in RMSE must not exceed two pixels size of Ground Sample Distance (X and Y) whichis equivalent to 30cm RMSEerror since the GSD of the Aerial photo was 15cm. Finally, it is concluded thattheresultsobtained on the horizontal positional accuracy assessment fit the requirement of the cadastral standard.

4.2. Recommendation

- To carry out the positional accuracy assessment of orthophoto, it is better to use a dual frequency GNSS receiver type and consider both horizontal and vertical accuracy values.
- Checkpoints' features selected from Orthophoto must be sharp, stable, and free from obstruction, well distributed and defined.
- According to NSSDA, any statistical positional accuracy test requires a minimum of recommended 20 checkpoints for projects having an area of ≤ 500 square kilometers (ASPRS, 2015). We used 20 checkpoints in the case of Sebeta town, which has an area of 98 square kilometers. It is better to have national-level detail positional accuracy assessment standards for the country Ethiopia.
- It is recommended to conduct the positional accuracy assessment as soon as the orthophoto preparation process is finalized to get sharp and well-defined checkpoint features and to give a fast response if a positional accuracy problem exists on the project.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper

Reference

[1]. Akdeniz, H. (2004). The opportunities that digital orthophotos can supply in urban planning. In XXth ISPRS Congress, Technical Commission VII, July 12–23, 2004, Istanbul, Turkey.

[2]. American Society for Photogrammetry and Remote Sensing (ASPRS),2015. ASPRS Positional Accuracy Standards for Digital Geospatial Data. Photogrammetric Engineering & Remote Sensing, 81(3), 1–26. doi:10.14358/pers.81.3.a1-a26 .

[3]. Boye, C. B; Appeaning Addo, K. and Williams, E. A. (2016, June). Positional accuracyassessment for effective shoreline change.*Ghana Mining Journal, 16*, 1.

[4]. Chhatkuli, R. (2002). Orthophoto mapping: a fundamental data layer for urban GIS in NGII in Nepal. In ACRS 2002: Proceedings of the 23th Asian conference on remote sensing, 25–29 November 2002, Kathmandu. http://a-a-r-s.org/aars/proceeding/ACRS2002/ Papers/URM02-8.pdf.

[5]. Enemark, S., Bell, K. C., Lemmen, C., and McLaren, R. (2014). Fit-for-purpose land administration. Technical report, The World Bank and the International Federation of Surveyors (FIG). https://www.fig.net/resources/publications/ figpub/pub60/Figpub60.pdf.

[6]. ESRI(2020).Retrievedfromhttps://desktop.arcgis.com/en/arcmap/latest/extensions/main/about-arcgis-for-desktop-extensions.htm.

[7]. FGDC, S. C. (1998). Geospatial positioning accuracy standards, part 3: National standard for spatial data accuracy. Technical report. https://www.fgdc.gov/standards/projects/ accuracy/part3/chapter3.

[8]. Greenwalt, C. R. and Shultz, M. E. (1992). Principles of error theory and cartographic applications. Technical Report 96, U.S. Air Force Aeronautical Chart and Information Center. http://earth-info.nga.mil/GandG/publications/tr96.pdf.

[9]. Hailu, Z. and Harris, D. (2014). Rural land registration in Ethiopia increased transparency for 26,000,000 land holders. In Annual World Bank Conference on Land and Poverty, Washington DC. https://www.oicrf.org/-/rural-land-registration-in-ethiopia-increasedtransparency-for-26-000-000-land-holde-1.

[10]. JUHTA (2014). Drafting a Local Zoning Map (in Finnish). Web page, Advisory Board for Information Management in Public Administration. http://www.jhs-suositukset.fi/suomi/ jhs185, read May 25, 2016. Nordic Journal of Surveying and Real Estate Research Volume 13, Number 1, 2018 https://doi.org/10.30672/njsr.65724 17

[11]. Kapnias, D., Milenov, P., and Kay, S. (2008). Guidelines for best practice and quality checking of ortho imagery, issue 3.0. JRC Scientific and Technical Report, European Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen.

[12]. Ministry of Urban Development, Housing and Construction (2015). Urban Legal Cadaster Standard No. 03/2015. Technical report, Addis Ababa, Ethiopia

[13]. Technical report, Addis Ababa, Ethiopia. Palà, V. and Arbiol, R. (2002). True orthoimage generation in urban areas. In Proceedings of the 3rd International Symposium on Remote Sensing of Urban Areas, Istanbul, 11–13 June, pages 309–314.

[14]. Zhou, G. and Chen, W. (2002). Urban Image True Orthorectification in The National Map Program. In Proceedings of the ISPRS Commission VII Symposium 'Remote Sensing: From Pixels to Processes' May 8–11, 2006, Enschede, The Netherlands. Editor(s): Norman Kerle, Andrew Skidmore.

[15]. Zhou, G., Schickler, W., Thorpe, A., Song, P., Chen, W., and Song, C. (2004). True orthoimage generation in urban areas with very tall buildings. International Journal of Remote Sensing, 25(22):5163–5180.