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Analysis of accuracy of traditional and satellite methods of geodetic measurements

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Abstract. The article presented a detailed comparative analysis of the accuracy of traditional and satellite methods of geodetic measurements in relation to the tasks of the agricultural sector. The aim of the work was to identify the conditions under which a particular method or their combination provides the optimal ratio of accuracy, time of performance and stability to external factors in land surveying and land reclamation works, as well as in the process of monitoring of agricultural lands. As part of the study, field experiments were conducted in areas with different geomorphological characteristics of Kyrgyzstan, including flat areas of the Chüy Valley, hilly pasture zones and mountain gardens of Jalal-Abad region. The results showed that levelling retains its leading position in terms of vertical accuracy (up to 2 mm/km), which makes it indispensable in the design of irrigation systems. Tacheometry demonstrated stable values of RMS error in plan (8-12 mm) and elevation (15-25 mm) in conditions of plains and built-up areas. GNSS measurements in RTK mode provided high performance and accuracy (5-10 mm in plan, 10-20 mm in elevation) in open terrain, but in mountainous areas the accuracy decreased to 3-5 cm due to signal interruptions. Static GNSS survey provided the highest accuracy results (3-5 mm), but it was the most time-consuming (20-40 min/point). The practical value of the study lies in the development of recommendations on the selection of the optimal methodology for cadastral works, design of land reclamation systems and implementation of precision farming technologies, where the combined use of traditional and satellite approaches is most effective

Keywords: geodesy; measurement accuracy; RMS error; traditional methods; combined methods; GNSS; GPS

Introduction

Modern development of the agricultural sector is impossible without the use of accurate geodetic measurements, which provide a reliable basis for land management, design of land reclamation systems, monitoring of agricultural land and implementation of precision farming technologies. In recent years, there has been a growing interest in the integration of satellite and traditional methods, as shown in papers such as A. White *et al.* (2022). New studies emphasise the value of global georeferencing systems and the combination of GNSS (Global Navigation Satellite System) with other methods (Huisman & de Ligt, 2023; Haines *et al.*, 2024). In conditions of agricultural intensification, there is an increasing need for efficient methods that allow obtaining spatial data on land objects with high accuracy and in the shortest possible time. Studies aimed at improving the efficiency of land reclamation works are of particular relevance. As shows the study of N. Kutymbek *et al.* (2025), complex ameliorative measures on compacted grey soils can significantly improve soil structure and increase their water permeability, which requires high-precision geodetic support in the design and monitoring of such systems. Geodetic measurements become not only a technical procedure, but also an important element of an integrated rural management system, which gives the study additional relevance. Traditional geodetic methods – levelling, tacheometric surveying, theodolite observations – are

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characterised by high accuracy and time-tested reliability. They are still used in land surveying and agricultural engineering projects, especially where accurate vertical surveying is required or works are carried out in difficult terrain conditions. However, these methods are time-consuming and labour-intensive, which limits their use when surveying large areas of agricultural land.

Against this background, satellite technologies – GNSS, differential correction, RTK (Real-Time Kinematic) and static imagery – offer new opportunities. They allow to significantly increase productivity, automate the process of data acquisition and integrate them into geographic information systems (GIS) used for agricultural resource management. Recent years have seen a rapid development of these technologies, with improved receivers, post-processing algorithms and methods for combining satellite data with unmanned aerial vehicles and laser scanning. The greatest development potential is related to PPP (Precise Point Positioning)-RTK, integration of GNSS with InSAR (Interferometric Synthetic Aperture Radar) and automation of data processing (Cheng *et al.*, 2023; Papco *et al.*, 2024; Reshadati & Shirzaei, 2024). Prospective studies such as N. Chodura *et al.* (2025), also concern the application of AI and big data analysis. UAV (Unmanned Aerial Vehicle) photogrammetry has shown to be highly effective for site monitoring (Maboudi *et al.*, 2025). Modern works such as D. Chai *et al.* (2025), also emphasise the integration of GNSS with INS (Inertial Navigation Systems) and partial ambiguity resolution techniques.

The relevance of this study lies in the need for a comprehensive analysis of the accuracy of traditional and satellite methods of geodetic measurements in relation to the tasks of the agricultural sector. Such analysis allowed to identify optimal approaches for specific conditions of agricultural production, to determine the balance between accuracy, costs and stability to external factors, as well as to justify the feasibility of implementing combined technologies in the practice of land management and agricultural engineering. The aim of the study was to conduct a comparative analysis of the accuracy of traditional and satellite-based methods of geodetic measurements with a focus on their applied use in the agricultural sector. The main objectives of the study were: to characterise traditional methods and their role in the agricultural sector; to analyse satellite methods and identify their advantages and limitations; to perform a comparative analysis of the accuracy and efficiency of the methods on the example of land management, land reclamation and land monitoring; to formulate practical recommendations for the selection of the optimal methodology for the agricultural sector.

Materials and Methods

In order to achieve the set objectives the method of field comparative analysis with subsequent mathematical processing of the results was used. The study used field methods (levelling, total station, GNSS RTK and static survey) in different geomorphological conditions of Kyrgyzstan. Similar approaches are described in current sources on the integration of GNSS with unmanned aerial vehicles and laser scanning (Reinprecht & Kieffer, 2025; Sestras *et al.*, 2025a; Sestras *et al.*, 2025b). The studies were conducted on sites with different geomorphological characteristics in three types of agricultural areas:

- Plain area (Chüy Valley) – irrigated fields and reclamation canals. In this area, 18 control points were measured on a regular grid of 200 × 200 m to evenly cover the territory and to obtain a representative sample of elevations;
- Moderately hilly terrain (neighbourhood of Kara-Balta) – pastures and hayfields. Fourteen control points were selected, located at the bends in the relief (watersheds, hilltops, depressions). This choice allowed to reflect the characteristic features of the relief and to check the stability of the methods in conditions of partial visibility;
- Mountainous area (Kazarman, Jalal-Abad region) – orchards and vineyards. Here 12 control points located on slopes and in gorges were measured taking into account the availability of satellite signal and visual contact for traditional methods.

Various field measurement methods and equipment were used in the study. Class II levelling (Leica NA730) was used to obtain highly accurate elevation difference data for irrigation and drainage canal design; vertical accuracy was up to 2 mm/km. Tacheometric survey (Leica TS06 Plus) was used to construct topographic plans of agricultural land and agro-infrastructure facilities. The root mean square error (RMSE) for plan was 8-12 mm, for elevation – 15-25 mm. GNSS measurements (CHCNAV I50, RTK and static modes) were used to obtain coordinates of control points for cadastral survey of land plots. The methods used for data processing were those described by A. El-Rabbany (2002) and A. Leick *et al.* (2015). The RTK mode provided rapidity (10-20 seconds per point), while statics gave maximum accuracy (3-5 mm) with an observation time of 20-40 minutes per point. Figure 1 shows the GNSS receiver I50 CHCNAV.

Figure 1. GNSS receiver I50 CHCNAV
Source: author's photo

During the field survey, Class II levelling was carried out using a Leica NA730 leveller. The average length of the sighting beam was 60-70 m and the distance between stations was about 500 m. The accuracy of the elevations was in accordance with Class II standards and was within ±2.0 mm per 1 km of double-tracking. The altitude data were compared with the results of levelling, which confirms the relevance of the work comparing RTK-GNSS and classical methods (Naumowicz & Kowalczyk, 2025; Raufu, 2025). A total station survey was also carried out using a Leica TS06 Plus electronic total station. The survey was carried out at 20-25 m spacing in open areas and 10-15 m in areas with pronounced microrelief. RMS error of distance measurements was ± (2 mm + 2 ppm), angular measurements – ±2″. Point coordinates were measured using a CHCNAV i50 GNSS receiver in RTK and static modes. In RTK mode, the initialisation time was 5-10 seconds and the RMS error in plan did not exceed ±1.5 cm and in elevation ±2.5 cm. In static observations, the duration of sessions ranged from 30 minutes to 1 hour, which ensured the accuracy of coordinate determination up to ±5 mm in plan and ±10 mm in height.

The Leica Geo Office and GNSS Solutions software packages were used to process the satellite data. The following algorithms were used during post-processing: double difference method (to eliminate ephemeris and ionosphere errors) (Leick *et al.*, 2015); Kalman filter (in RTK mode for smoothing coordinate solutions); least squares method (for network equalisation in static mode, as well as for total stations and levelling). The quality assessment criteria were: the value of the RMS error, the inconsistencies in stroke closures and the accuracy coefficient of the equated networks. To ensure comparability of the results, the data were initially recorded in the global World Geodetic System (WGS84, n.d.), and then transformed into local coordinate systems used in land surveying projects of the Kyrgyz Republic: Chüy Valley – SK-42 (coordinate system of 1942), zone 13 (Gauss-Kruger); Kara-Balta vicinity – SK-42, zone 14, coordinated with cadastral projects of the region; Jalal-Abad region – SK-95 (coordinate system of 1995), relevant for state land surveying works.

Results and Discussion

Field studies have shown that each of the considered methods has both advantages and limitations. The highest vertical accuracy was demonstrated by levelling, where the error did not exceed 2 mm/km. These results correspond to generally accepted standards of accuracy of geodetic levelling, which confirms its indispensability in the design of irrigation systems, especially in the flat areas of the Chüy Valley. The tacheometric survey showed stable results: the RMS error was 8-12 mm in plan and 15-25 mm in elevation. In the conditions of urban development of Bishkek, the accuracy of tacheometry proved to be higher than that of GNSS RTK. The comparative data are presented in Table 1 and Figure 2, where the advantages of tacheometry over other methods in conditions of limited visibility can be seen.

Table 1. Comparative accuracy of traditional and satellite-based methods of geodetic measurements in three types of agricultural areas in Kyrgyzstan

Method	RMSE by plan (mm)	RMSE in height (mm)	Conditions of application
Levelling (II Class)	–	2.0 mm/km	High-precision survey of height differences
Tacheometry (electronic)	8-12	15-25	Plains, built-up areas
GNSS (RTK)	5-10	10-20	Open terrain, signal required
GNSS (static)	3-5	5-10	Long observations (20-30 min/point)

Note: averaged values calculated on the basis of control points measured as part of the study
Source: compiled by the author on the basis of field studies

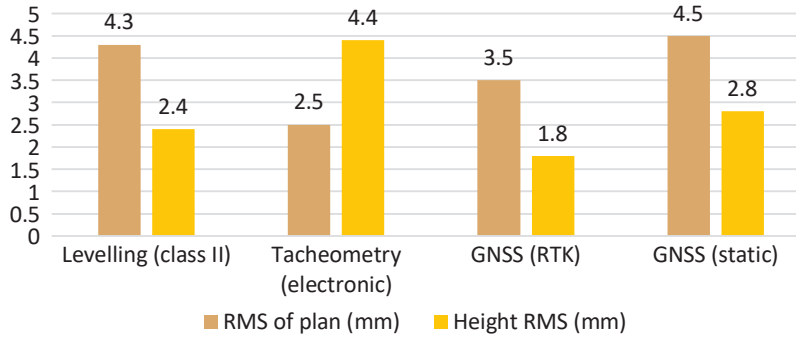

Figure 1. Comparative accuracy of traditional and satellite methods of geodetic measurements
Source: compiled by the author based on field survey data

GNSS measurements in RTK mode provided high speed of operation – about 10-20 seconds per point – and accuracy of about 5-10 mm in plan and 10-20 mm in height in open terrain. However, in mountainous terrain, the accuracy decreased dramatically, to 3-5 cm, which is consistent with the findings of V. Hamza *et al.* (2025) and H. Zhong *et al.* (2025) who noted the sensitivity of GNSS to interference and terrain obstacles. The advantage of this method is its high throughput: Table 2 and the time plot (Fig. 2) show that RTK significantly reduces the survey duration compared to traditional methods. At the same time, as X. Zhang *et al.* (2025) point out, modern technologies such as multi-frequency and multi-system (multi-GNSS) methods, as well as Precise Positioning Services (PPP), allow high real-time accuracy, reducing convergence time to a few minutes and providing an accuracy of up to 2.5 cm. Static GNSS surveying in this study provided the highest accuracy (3-5 mm in plan and 5-10 mm in elevation) but was time consuming (20-40 minutes per point). Similar findings are cited by K. Maciuk (2018), noting that statics remains the most reliable method, but its practical application is limited by the need for long-term observations. The data on time costs are summarised in Table 2, which confirms the limited application of static surveying for mass cadastral and engineering works.

Table 2. Time taken to measure one point by different methods

Method	Time per point	Comments
Levelling	10-15 minutes	Requires moving and setting up of slats
Tacheometry	5-8 minutes	Faster than levelling, but depends on visibility conditions
GNSS (RTK)	10-20 seconds	High speed, if RTK station is available
GNSS (static)	20-40 minutes	Long-term observation, high accuracy

Note: RTK – real time kinematic; static – static mode of GNSS observations
Source: compiled by the author on the basis of field experiments on agricultural land

Comparison of the methods showed that none of them is universal. In urban areas, traditional methods such as levelling and tacheometry are more reliable, while in flat, open terrain satellite technologies are optimal. In mountainous areas, the best results are achieved by a combination of approaches: first RTK surveying is performed to determine the general configuration of points, and then refinement is carried out by statics or total stations. This combined approach is also noted by P. Jansson & L. Lundgren (2018), emphasising that the combination of methods allows minimising errors in cadastral works. The influence of topography and other factors on measurement accuracy is summarised in Table 3.

Table 3. Influence of external factors on the accuracy of geodetic methods

Method	Building	Forest cover	Mountainous terrain	Cloudy weather	Need for line of sight
Levelling	+	+	±	+	Yes
Tacheometry	±	±	±	±	Yes
GNSS (RTK)	–	–	–	±	Yes, to satellites and base
GNSS (static)	±	±	±	±	Desirable, but post-processing is possible

Note: "+" – high stability; "±" – limited applicability; "–" – sharp decrease in accuracy
Source: compiled by the author on the basis of field survey data

The results obtained are in agreement with the findings of R. Wagh & S. Auti (2025) who showed that the integration of satellite technologies with geographic information systems improves the efficiency of land surveying projects. In particular, the combination of GNSS with tacheometry for land surveying is effective in agricultural tasks, as well as the use of levelling to refine elevations in the design of land reclamation systems. Thus, the conducted research confirms that the choice of the optimal technique depends on the terrain conditions and tasks. Satellite methods provide high productivity and sufficient accuracy in flat areas, but need support of traditional approaches when working in mountains and dense buildings. The best performance is achieved when they are used in combination, which is also supported by current research.

Conclusions

The analysis of traditional and satellite methods of geodetic measurements has shown that there is no universal approach, equally effective in all conditions. For flat conditions satellite technologies are optimal,

and for mountainous and built-up areas – traditional or combined. The choice of the optimal methodology is determined by terrain features, technical capabilities and the objectives of the survey. In flat areas satellite technologies are the most productive, providing high productivity and sufficient accuracy, while in mountainous areas and densely built-up areas traditional methods or their combined application should be preferred. Levelling retains its leading position in vertical accuracy and remains indispensable in the design and construction of irrigation systems. Tacheometry demonstrates stable results when surveying limited and built-up areas. GNSS surveying in RTK mode provides high speed and automation of measurements, but its accuracy decreases in difficult terrain and unstable signal, which requires combination with other approaches. Static GNSS remains the most accurate method, although its application is limited by significant time costs. Thus, the most effective strategy in geodetic surveying is the integration of traditional and satellite technologies, which can compensate for their mutual limitations and increase the reliability of the data obtained.

The prospects for further research are related to the development of integrated systems combining data from satellite receivers, total stations, laser scanners and unmanned aerial vehicles within the framework of geoinformation platforms. Particular attention should be paid to the introduction of artificial intelligence and machine learning methods for the automatic processing and analysis of spatial data. Further work should also be directed towards assessing the stability of combined techniques in complex natural and anthropogenic conditions, as well as developing adaptive algorithms to improve the accuracy of real-time measurements.

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Conflict of Interest

None.

References

[1] Chai, D., Wang, X., Ning, Y., & Sang, W. (2025). Partial ambiguity resolution strategy for single-frequency GNSS RTK/INS tightly coupled integration in urban environments. *Electronics*, 14(13), article number 2712. doi: 10.3390/electronics14132712.

[2] Cheng, C., Yang, J., Wang, C., Zheng, Z., Li, X., Dong, D., Chang, M., & Zhuang, Z. (2023). Automatic detection of aerial survey ground control points based on Yolov5-OBB. *arXiv:2303.03041*. doi: 10.48550/arXiv.2303.03041.

[3] Chodura, N., Greeff, M., & Woods, J. (2025). Evaluation of flight parameters in UAV-based 3D reconstruction for rooftop infrastructure assessment. *arXiv:2504.02084*. doi: 10.48550/arXiv.2504.02084.

[4] El-Rabbany, A. (2002). *Introduction to GPS: The global positioning system*. Norwood: Artech House.

[5] Haines, B., *et al.* (2024). A global combination of geodetic techniques at the observation level: New perspectives on the terrestrial reference frame. *Journal of Geophysical Research: Solid Earth*, 129, article number e2024JB029527. doi: 10.1029/2024JB029527.

[6] Hamza, V., Stopar, B., Sterle, O., & Pavlovčič-Prešeren, P. (2025). Recent advances and applications of low-cost GNSS receivers: A review. *GPS Solutions*, 29, article number 56. doi: 10.1007/s10291-025-01815-x.

[7] Huisman, L., & de Ligt, H. (2023). Validation of reference frame consistency of GNSS service products. In J.T. Freymueller & L. Sánchez (Eds.), *Gravity, positioning and reference frames. REFAG 2022. International Association of Geodesy Symposia* (vol. 156, pp. 175-182). Cham: Springer. doi: 10.1007/1345_2023_232.

[8] Jansson, P., & Lundgren, L. (2018). *A comparison of different methods using GNSS RTK to establish control points in cadastral surveying*. Stockholm: KTH.

[9] Kutymbek, N., Yestaev, K., Rustem, E., Musabekov, K., & Tursunbayev, Kh. (2025). Justification of the impact of complex melioration on the fertility of compacted sierozem soils of irrigated lands of the Zhambyl region. *Scientific Horizons*, 28(3), 68-79. doi: 10.48077/scihor3.2025.68.

[10] Leick, A., Rapoport, L., & Tatarnikov, D. (2015). *GPS satellite surveying*. Hoboken: John Wiley & Sons.

[11] Maboudi, M., Backhaus, J., Mai, I., Ghassoun, Y., Khedar, Y., Lowke, D., Riedel, B., Bestmann, U., & Gerke, M. (2025). Very high resolution bridge deformation monitoring using UAV-based photogrammetry. *Journal of Civil Structural Health Monitoring*. doi: 10.1007/s13349-025-01001-0.

[12] Maciuk, K. (2018). Advantages of combined GNSS processing involving a limited number of visible satellites. *Scientific Journal of Silesian University of Technology. Series Transport*, 98, 89-99. doi: 10.20858/sjsutst.2018.98.9.

[13] Naumowicz, B., & Kowalczyk, K. (2025). Integration of leveling and GNSS data to develop relative vertical movements of the earth's crust using hybrid models. *Applied Sciences*, 15(15), article number 8224. doi: 10.3390/app15158224.

[14] Papco, J., Bakon, M., Kubica, L., Belicova, G., Droscak, B., Ferianc, M., Rovnak, M., Ruiz, A.M., & Sousa, J.J. (2024). Satellite-based InSAR geodesy and collocation with GNSS. *Procedia Computer Science*, 239, 2329-2340. doi: 10.1016/j.procs.2024.06.426.

[15] Raufu, I.O. (2025). Exploring the accuracy of height measurements with multi-constellation RTK GNSS. *Nova Geodesia*, 5(2), article number 336. doi: 10.55779/ng52336.
[16] Reinprecht, V., & Kieffer, D.S. (2025). Application of UAV photogrammetry and multispectral image analysis for identifying land use and vegetation cover succession in former mining areas. *Remote Sensing*, 17(3), article number 405. doi: 10.3390/rs17030405.
[17] Reshadati, M., & Shirzaei, M. (2024). A model-based approach for transforming InSAR-derived vertical land motion from a local to a global reference frame. *arXiv:2412.10282*. doi: 10.48550/arXiv.2412.10282.
[18] Sestras, P., Badea, G., Badea, A.C., Salagean, T., Roșca, S., Kader, S., & Remondino, F. (2025a). Land surveying with UAV photogrammetry and LiDAR for optimal building planning. *Automation in Construction*, 173, article number 106092. doi: 10.1016/j.autcon.2025.106092.
[19] Sestras, P., *et al.* (2025b). A novel method for landslide deformation monitoring by fusing UAV photogrammetry and LiDAR data based on each sensor's mapping advantage in regards to terrain feature. *Engineering Geology*, 346, article number 107890. doi: 10.1016/j.enggeo.2024.107890.
[20] Wagh, R.V., & Auti, S.K. (2025). The role of geographic information systems (GIS) in land use planning. *International Journal of Innovations in Science, Engineering and Management*, 4(1), 366-370. doi: 10.69968/ijisem.2025v4i1366-370.
[21] White, A.M., Gardner, W.P., Borsa, A.A., Argus, D.F., & Martens, H.R. (2022). A review of GNSS/GPS in hydrogeodesy: Hydrologic loading applications and their implications for water resource research. *Water Resources Research*, 58, article number e2022WR032078. doi: 10.1029/2022WR032078.
[22] World Geodetic System (WGS84). (n.d.). Retrieved from https://gisgeography.com/wgs84-world-geodetic-system/.
[23] Zhang, X., Yang, Y., Yang, H., Ren, X., Lin, X., Le, X., & Li, X. (2025). Performance of PPP and PPP-RTK with new-generation GNSS constellations and signals. *Satellite Navigation*, 6, article number 17. doi: 10.1186/s43020-025-00169-6.
[24] Zhong, H., Duan, Y., Tao, P., & Zhang, Z. (2025). Influence of ground control point reliability and distribution on UAV photogrammetric 3D mapping accuracy. *Geo-Spatial Information Science*, ahead of print. doi: 10.1080/10095020.2025.2451204.

Салттуу жана спутниктик геодезиялык өлчөө ыкмаларынын тактыгын талдоо

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Аннотация. Бул макалада геодезиялык өлчөөлөрдүн салттуу жана спутниктик ыкмаларынын тактыгынын деталдуу салыштырма талдоосу агрардык тармактагы колдонууга басым жасоо менен берилет. Изилдөөнүн негизги максаты – жерге жайгаштыруу, мелиорация жана айыл чарба жерлерин мониторигдөө иштеринде ар бир ыкма же алардын айкалышы тактык,өлчөө жүргүзүү убактысы жана тышкы факторлорго туруктуулук боюнча оптималдуу натыйжа берген шарттарды аныктоо болуп саналат. Талаа изилдөөлөрү Кыргызстандын ар түрдүү геоморфологиялык шарттарында аныктоо болуп саналат. Талаа изилдөөлөрү Кыргызстандын ар түрдүү геоморфологиялык шарттарында жүргүзүлдү: Чүй өрөөнүнүн түздүктөрүндө, Кара-Балтанын айланасындагы адырлуу жайыттарда жана Жалал-Абад облусунун тоолу бак-даракту аймактарында. Натыйжалар көрсөткөндөй, нивелирлөө вертикалдык тактык боюнча эң жогорку деңгээлди (2мм/км чейин) камсыз кылып, ирригациялык системаларды долбоорлоодо алмашкыз бойдон калууда. Тахеометрия түздүк жана курулуш көп болгон аймактарда орточо квадраттык катанын туруктуу маанилерин (планды 8-12 мм, бийиктиги боюнча 15-25 мм) көрсөттү. GNSS RTK ыкмасы ачык аймактарда жогорку өндүрүмдүүлүк жана тактыкка (пландык 5-10 мм, бийиктиги боюнча 10-20 мм) жетишти, бирок тоолуу райондордо сигнал үзүлүүлөрүнө байланыштуу ката 3-5смге чейин көбөйдү. Эң жогорку тактык (3-5 мм) статикалык GNSS олчөөлөрүндө байкалган, бирок убакыттык чыгым эң көп болгон (20-40 мин/чекит). Изилдөөнүн практикалык мааниси – кадастрдык иштерде, мелиорациялык системаларды долбоорлоодо жана так дыйканчылык технологияларын киргизүүдө оптималдуу ыкмаларды тандоо боюнча сунуштарды иштеп чыгууда,мында салттуу жана спутниктие ыкмаларды айкалыштырып колдонуу эң эффективдүү экендиги далилденди

Негизги сөздөр: геодезия; өлчөө тактыгы; орточо квадраттык ката; салттуу ыкмалар; айкалышкан ыкмалар; GNSS; GPS

Анализ точности традиционных и спутниковых методов геодезических измерений

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Аннотация. В статье представлен детальный сравнительный анализ точности традиционных и спутниковых методов геодезических измерений применительно к задачам аграрного сектора. Целью работы было выявление условий, при которых конкретный метод или их комбинация обеспечивают оптимальное соотношение точности, времени выполнения и устойчивости к внешним факторам при землеустроительных и мелиоративных работах, а также в процессе мониторинга сельскохозяйственных угодий. В рамках исследования проведены полевые эксперименты на участках с различными геоморфологическими характеристиками Кыргызстана, включая равнинные территории Чуйской долины, холмистые пастбищные зоны и горные сады Джалал-Абадской области. Полученные результаты показали, что нивелирование сохраняет лидирующие позиции по вертикальной точности (до 2 мм/км), что делает его незаменимым при проектировании ирригационных систем. Тахеометрия продемонстрировала стабильные значения среднеквадратической ошибки по плану (8-12 мм) и высоте (15-25 мм) в условиях равнин и застроенных территорий. GNSS-измерения в режиме RTK обеспечили высокую производительность и точность (5-10 мм по плану, 10-20 мм по высоте) в открытой местности, однако в горных районах точность снижалась до 3-5 см из-за перебоев сигнала. Наивысшие результаты по точности (3-5 мм) обеспечила статическая ГНСС-съемка, но она оказалась наиболее затратной по времени (20-40 мин/точка). Практическая ценность исследования заключается в разработке рекомендаций по выбору оптимальной методики для кадастровых работ, проектирования мелиоративных систем и внедрения технологий точного земледелия, где наиболее эффективно комбинированное использование традиционных и спутниковых подходов

Ключевые слова: геодезия; точность измерений; среднеквадратическая ошибка; традиционные методы; комбинированные методы; GNSS; GPS