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EXPLORING GEOINFORMATION TECHNOLOGY POTENTIAL FOR AUTOMATING THE DEVELOPMENT AND MAINTENANCE OF DIGITAL TOPOGRAPHIC MAPS

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ABSTRACT
Purpose: The study aimed to determine the possibilities of geoinformation technologies in automating the creation and updating of digital topographic maps.
Design/Methodology/Approach: Induction and deduction were used to determine the structure of Geographic Information Systems (GIS). The deductive component begins with established theories and principles of digital cartography and automation. This comprises an analysis of existing cartographic principles and standards, a review of current automation technologies in GIS, and an examination of topographic map specifications and requirements. At the same time, the inductive component builds a new understanding of observed patterns and practical implementations.
Research Limitation: The study's limitations relate to the restriction of access to national geoportals related to the state of war in the country.
Findings: Based on the analysis of the structure of geoinformation systems, the possibilities of automated digitisation of topographic maps were identified, namely, obtaining a high-resolution image, creating a single digital cartographic database in which it is possible to quickly adjust objects and changes in the relief, ensuring high-quality, accurate planning on based on spatial analysis with error minimisation.
Practical Implication: GIS capabilities allow for the rapid acquisition of high-quality data regarding surface objects. The proposed structure of geographic information systems can be practical as an action algorithm for cartographer specialists.
Social Implication: It will improve the population's access to high-quality topographic and geodetic maps for planning, construction, and economic management.
Originality/Value: The research has demonstrated the possibilities of automated creation and updating digital maps.
Keywords: *Aerial photometry. cartography. digitisation. geodetic. topographic map*

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INTRODUCTION

With the development of the digital era, modern cartography and topographic planning have taken on a new form, as the application of geoinformation technologies has significantly expanded their creation and functioning capabilities. Geographic Information Systems (GIS), as a computer tool for processing and presenting data linked to locations on the Earth's surface, have wholly replaced outdated manual map-making technologies (Wang & Yang, 2021; Otoo-Kwofie, 2015). The software can analyse, modify, and store large volumes of data in an automated mode with minimal risks of errors and inaccuracies in a short period. The advantages of GIS are apparent; therefore, geographic information systems have found widespread application in resource and municipal management, regional planning, military purposes, logistics, navigation, tourism, Earth surface-related sciences, and even in everyday personal life through identifying locations of various objects. This versatile and broad use of GIS has led to an increase in the number and differentiation of software, a variety of equipment, and data collection methodologies, posing a challenge in selecting the necessary technological tools, qualified personnel, and programmes for analysing, updating, and changing data (Ali, 2020).

Over 70% of topographic maps in Ukraine have not been updated since their creation under Soviet Union principles. Of the updated data since 1991, less than 10% have been updated in the last five years, despite a legislative requirement to review cartographic materials every five years (Stadnikov et al., 2023; Lazorenko-Hevel et al., 2021). The demand for topographic planning is growing, but outdated maps do not meet market needs, and the updating and creation of new maps are sporadic and selective. Therefore, it is necessary to identify the reasons for the low level of map updates by international cartographic standards and propose ways to improve the rate of cartographic material updates.

LITERATURE REVIEW

Nowadays, imagining an industry that could function without the modern capabilities of topographic maps created using GIS is difficult. Bansal (2020) describes the importance of using GIS at the construction planning stage to predict construction suitability based on spatial and non-spatial analysis of location and modelling constraints. Hamza and Chmit (2022) demonstrate the importance of urban planning in ensuring the electrical grid's planning and maintenance. Tsilimantou et al. (2020) evaluate a multidisciplinary approach using GIS to determine the characteristics of historic buildings and consider restoration history when planning their renovation. Moisa et al. (2021) investigated the possibilities of GIS for analysing and predicting soil erosion from the perspective of pastureland use for agricultural purposes and forest clearing. Wang and Yang (2021) emphasise the significance of GIS for tourism, which contributes to improving service quality and rural landscape tourism management.

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This varied use of geographic information systems indicates the topic's relevance and highlights the problems associated with the lack of a unified standard among users and qualified personnel. The literature contains studies addressing problems primarily related to the data collection methodology for creating or updating maps, as data collection through aerial photometry and orthophotometry is the most time-consuming and expensive process.

For example, Cilek et al. (2020), in their search for alternatives to traditional topographic survey methods, such as satellite or piloted remote sensing, analyse the potential of using uncrewed aerial vehicles to obtain high-resolution 3D images of landscapes through photogrammetry as an alternative that can save time and costs. Lopes Bento et al. (2022) evaluated the reliability of surface geometry features obtained from UAVs compared to satellite imagery from the Global Navigation Satellite System – Real-Time Kinematic and found that applying a transverse overlap of 70% x 50% maintains accuracy with acceptable errors, which is comparable to results with higher overlaps of 90% x 90% and 80% x 80%, while allowing for faster image capture and data processing, thus reducing the cost of aerial photography.

The quality of the obtained images is influenced by flight characteristics, such as height, trajectory, camera tilt angle, and forward and lateral overlap (Roth et al., 2018). Another problematic aspect is the possibility of aerial photography of complex surfaces, including sloped surfaces, which requires changing the shooting angle with a collection of oblique and vertical images and merging them (Cheng & Matsuoka, 2021). Therefore, Giordan et al. (2020) recommend detailed flight planning for photographing complex terrain.

Orthophotometry is one of the methodological problems at the stage of creating and digitising topographic maps, which considers the relief of the area by determining and representing the concavity and convexity of the landscape. The traditional method of curvature loses accuracy when the scale changes and in quantitative curvature determination when creating a digital model. Instead, Hu et al. (2021) recommend applying the vector method by determining the angles between two aspect vectors to assess the magnitude of curve bending for a specific cell. Ruzickova et al. (2021) described such a problem as visibility assessment considering vegetation permeability. They argued that the proposed method of accounting for the partial permeability of trees and shrubs can significantly improve terrain analysis results and can be included in GIS software.

In Ukraine, geoinformation resources are created by government agencies on a departmental basis without a single coordinated methodology, which leads to heterogeneity in the obtained data. Thus, different institutions use different programmes and classification systems, increasing the cost of collecting topographic-geodetic and cartographic data, which is often duplicated, thereby raising costs and reducing data quality (Karpinskyi & Lazorenko-Hevel, 2020).

The study aimed to determine the possibilities of geoinformation technologies in automating the creation and updating of digital topographic maps based on the definition of the GIS structure and the

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analysis of modern requirements for conducting cartographic activities using the example of Ukrainian cartography.

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MATERIALS AND METHODS

This methodology combines deductive and inductive approaches to comprehensively explore the potential of GeoInformation Technology in automating topographic map development and maintenance. The deductive component begins with established theories and principles of digital cartography and automation. This comprises an analysis of existing cartographic principles and standards, a review of current automation technologies in GIS, and an examination of topographic map specifications and requirements. At the same time, the inductive component builds a new understanding of observed patterns and practical implementations.

RESULTS

We analysed the GIS structure and main factors to raise awareness of GIS capabilities for automated creation and updating of topographic plans (Figure 1).

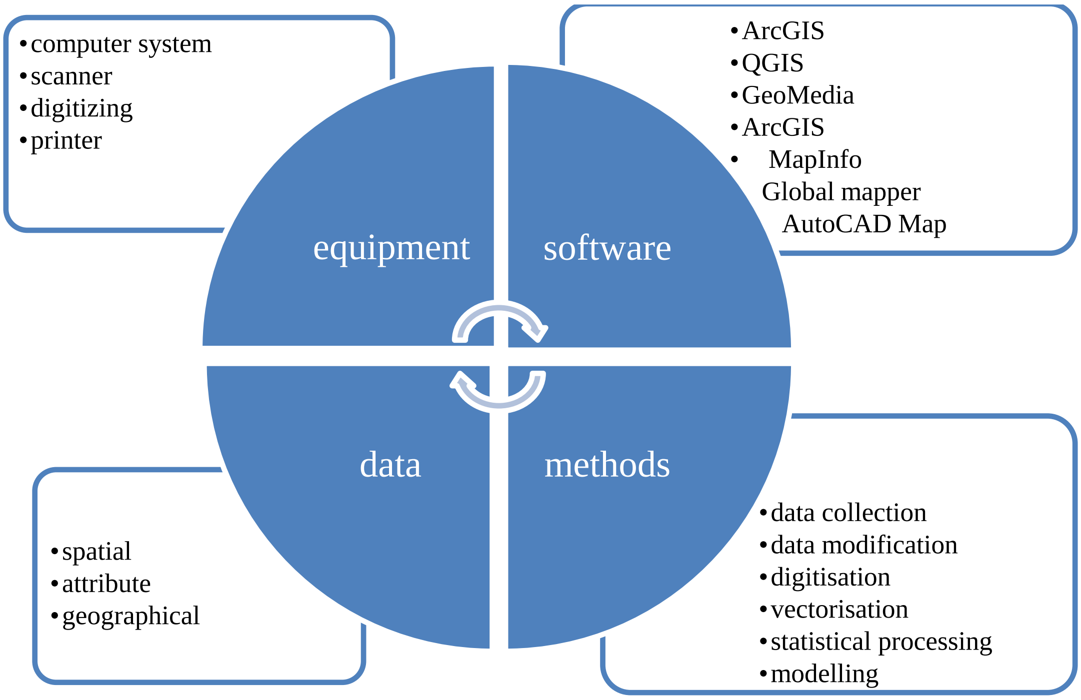

Figure 1: Structure of Geographic Information Systems
Source: compiled by the author based on Ali (2020)

Thus, each structural factor corresponds to the quality of the obtained topographic plan. Equipment requires modern computer systems with the ability to connect to web portals. They are digitised via

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a scanner to update existing maps, obtaining a digital raster image. The digitisation fee is necessary for the vectorisation of objects. The creation of maps is accompanied by the overlaying of aerial photography or aerospace imagery, comparing data obtained from fieldwork using a tachometer method. Modern equipment allows for high-resolution images to be obtained and enables quick corrections of objects and terrain changes.

Software also plays an important role, as the programme choice must be determined by the functionality required. For example, Global Mapper and Mapinfo are suitable for simple tasks that are easy to use and support the main GIS functions. ArcGIS is used to perform more complex tasks involving modelling and report generation. Focusing on workers' qualifications is no less important, as knowledge of working with the software ensures the success of the results. However, low employee qualifications should not be a reason to use outdated, functionally limited software. Instead, it should be a stimulus for planning professional training on modern software, which, in the end, will reduce the time and costs for project implementation while improving the final result quality.

Data and their collection methodology include both spatial and non-spatial forms. Spatial data includes the relationship of objects to a coordinate system in a two-dimensional or three-dimensional format, which can be presented in the form of diagrams, aerial photographs, satellite images, overview maps, and global positioning systems (GPS). Satellite images are mainly used for general outlines, while aerial photography is used to detail objects. Non-spatial data contains information about the attributive characteristics of objects and is presented in the form of symbols and numbers. Data is used as vectors or rasters, presented either by categories, providing information about the type of object, or by continuous maps, for example, a relief model where each cell corresponds to a height.

Methods include GIS functionality parameters such as data collection, updating, modification, mathematical modelling, and statistical processing, depending on the requirements stated for the topographic plan. Applying different methods and programmes allows for a unified database for further processing, including the stated parameters. Thus, GIS enables the automated creation and updating of topographic maps and, with the qualified use of methods and software, allows for error minimisation and ensures high-quality planning based on spatial analysis.

Ukraine's topographic-geodetic and cartographic activities inherited topographic maps created according to Soviet standards, which were primarily military-oriented but characterised by high coordinate accuracy. Ukraine has gradually transitioned to digital technology to create topographic plans by updating outdated maps. At the legislative level, the following steps have been implemented: in 1998, the Law of Ukraine "On Topographic-Geodetic and Cartographic Activities" was adopted; in 2020, the Law of Ukraine "On the National Geospatial Data Infrastructure"; and since 2007, mapping has been carried out in the UCS-2000 geodetic coordinate system (Sossa, 2021). Legislative documents strictly regulate cartographic activities, with the main requirements listed in Table 1.

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Table 1: Basic Requirements for Conducting Topographic, Geodetic and Cartographic Activities

Object of activity	The territory of Ukraine with its existing facilities, including water, industrial, infrastructure
State accounting of cartographic and topographic works	Required for all types of work, except for work performed by the Ministry of Defence
Requirements for specialists	University degree in geodesy or land management
State bodies regulating the activity	State Geocadastre
Tools and equipment	Licensed software, computers, high-precision tacheometers, theodolites, levels, gravimeters, satellite receivers, aerial cameras, aerial cameras, high-resolution scanners
Access to the State Cartographic and Geodetic Fund	Owned by individuals and legal entities

Source: created by the author based on regulatory documents related to topographic-geodetic and cartographic activities

As seen from the table, topographic and cartographic activities are strictly regulated. Before and after the completion of topographic-geodetic and cartographic work, it is necessary to notify the StateGeoCadastre for mandatory registration of planned and completed work. Due to the imposition of martial law, before carrying out geodetic work and using geodetic equipment, including aerial surveys, it is necessary to obtain permission from the Security Service of Ukraine, which is regulated by the Law of Ukraine "On Amendments to Certain Legislative Acts of Ukraine Regarding the Peculiarities of Land Relations Regulation under Martial Law" from 12.05.2022. Access to the geoportals of the National Geospatial Data Infrastructure is also restricted for users, who must complete registration and verification through the Diia application.

In Ukraine, there is a problem with the number of updated topographic maps; however, during the period 2018-2021, a project was implemented in cooperation with the Norwegian Cartographic Service to update the main topographic map of Ukraine at a scale of 1:50000. The difference between Soviet-era topographic maps and modern ones is significant. Figure 2 compares topographic maps of the Kyiv region at a scale of 1:10000, which differ in quality and purpose. While the outdated map (a) is aimed at military object descriptions, the modern map (b) is intended to evaluate construction planning and land resource use, considering terrain features. Another advantage of modern maps is their interactivity, which allows for zooming in on images, identifying neighbouring objects, making changes, and conducting almost real-time analysis.

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a) Soviet-style topographical map

b) Modern topographic map, elevation, relief

Figure 2: Comparing Modern Topographic Maps with Soviet-era Maps
Source: Topographic map of Petropavlivska Borshchahivka; Sofiyivska Borshchahivka

State funding is provided for updating topographic maps ranging from 1:10000 to 1:1000000. This funding includes aerial photography and the compilation of maps using larger-scale maps, which is significant nationwide. Updates of maps with scales from 1:500 to 1:5000 are funded by local budgets and are intended explicitly for territorial planning. Topographic surveys are used and compiled with original larger-scale maps to update this map type.

Among the problems identified from the analysis of the GIS structure and cartographic activities in Ukraine, the lack of funding was noted, as funds have been reallocated for the needs of the army and social aid due to the war. There is also a low level of employee qualification in data collection and working with software, restrictions on access to geoportals, and requirements for carrying out cartographic activities, including aerial photometry, under permission from the Security Service of Ukraine. Based on the literature analysis, the problem of the lack of a unified system for collecting cartographic data was identified, which leads to repeated data collection by different departmental structures, the use of various classifications, and a decrease in the quality of the obtained materials.

The solutions to the problems of optimising the updating of topographic plans are seen in the creation of a unified data collection system and an algorithm for implementing existing data according to accepted unified standards, as well as ensuring the improvement of employee qualifications, especially those directly involved in making changes, integrating, analysing data, and maintaining equipment and software. Since training specialists in the basics of working with software will increase automation in working with data, it will also promote the speed and efficiency of topographic planning. Unfortunately, security measures that restrict access to geoportals and the execution of

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geodetic-topographic and cartographic work after obtaining permission from the Security Service of Ukraine cannot be cancelled due to the complex security situation. However, in our opinion, even solving the problems of personnel training and developing unified standards for creating topographic maps can significantly impact the number and quality of their updates.

DISCUSSION

GIS technologies are widely used for the automated updating of topographic data, as the use of updated maps allows for optimising the process of construction planning or land resource management, as well as preventing landslides, earthquakes, and other natural disasters (Assefa, 2024; Tomaszewski, 2020). GIS technologies play an essential role in construction and urban infrastructure planning and can potentially create the smart cities of the future (Xia et al., 2022). For GIS to function effectively, qualified personnel, equipment, and software development are essential (Sossa, 2021).

The identified problems in domestic topographic-geodetic activities are related to the lack of a unified data collection system, as data collection is a labour-intensive and costly process for updating topographic maps, which requires high accuracy. Modern researchers pay great attention to aerial photometry using uncrewed aerial vehicles, as this method is accurate, fast, and financially accessible (Quamar et al., 2023; Qubaa et al., 2021). The advantages of using drones are that they allow for real-time data updates and increase the efficiency of topographic plans. However, using uncrewed aerial vehicles requires strict control to avoid errors. Syetiawan et al. (2020) recommend linking images from uncrewed aerial objects to ground GPS points, improving and aligning aerial photography results.

Meanwhile, Stott et al. (2020) argue that the linkage to ground GPS points can partially be replaced by a Real-Time Kinematic Global Navigation Satellite System (RTK-GNSS), as deploying ground GPS points is a time-consuming process. However, they do not recommend thoroughly abandoning ground control points due to the risk of vertical systematic errors. Despite the restrictions on using drones for civilian purposes during the war, it is essential to study the experience of international partners in aerial photography achievements for their implementation in domestic cartographic activities.

Our research identified several problems in updating and creating topographic plans in Ukraine. A similar situation was observed with cartography in Uzbekistan, where outdated Soviet-style maps did not meet the state's needs. As a result, the country updated its maps using GIS, considering terrain features and their impact on soil degradation for planning agricultural activities and for the optimal use of forest, water, and agricultural resources (Kadirova et al., 2021). The proposed solutions for updating cartographic materials align with foreign experience in the unification of symbols and classifications, as well as in improving the level of process automation for creating and updating topographic data through training specialists to work with modern GIS software (Bartonek & Andova, 2022; Li et al., 2020).

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CONCLUSION

Based on the analysis of the structure of geoinformation systems, the possibilities of automated digitisation of topographic maps were identified, namely, obtaining a high-resolution image, creating a single digital cartographic database in which it is possible to quickly adjust objects and changes in the relief, ensuring high-quality, accurate planning on based on spatial analysis with error minimisation, provided qualified data collection, use of quality equipment, software and application of effective methodology for working with geoinformation systems.

The study of the requirements for conducting topographical, geodetic and cartographic activities in Ukraine demonstrated strict regulation of cartographic activities and restrictions related to the introduction of martial law. Ukraine's topographical, geodetic, and cartographic weaknesses were identified as insufficient industry financing and low qualification of software and data collection specialists.

It is advisable to create a unified data collection and analysis system and an algorithm for implementing existing data to a unified standard. Personnel should be trained in working with modern software to increase the volume of automated processes using geoinformation technologies for updating and creating topographic maps. The proposed structure of geographic information systems can be practical as an action algorithm for cartographer specialists. It will improve the population's access to high-quality topographic and geodetic maps for planning, construction, and economic management.

REFERENCES

Ali, E. (2020). Geographic information system (GIS): definition, development, applications & components. Department of Geography, Ananda Chandra College. India. https://www.academia.edu/download/62486569/Geographic_Information_System_GIS_Definition__Development__Applications___Components20200326-79633-1dj9rvd.pdf

Assefa, B. (2024). Preparing Topographic Map of Wallaga University Around College of Natural Science by Using GIS Software, West Wallaga, Oromia, Ethiopia. *American Journal of Civil Engineering*, 12(1), 17–26. https://doi.org/10.11648/j.ajce.20241201.13

Bansal, V. K. (2020). Use of GIS to consider spatial aspects in construction planning process. *International Journal of Construction Management*, 20(3), 207–222. https://doi.org/10.1080/15623599.2018.1484845

Bartonek, D., & Andova, P. (2022). Method for cartographic symbols creation in connection with map series digitisation. *ISPRS International Journal of Geo-Information*, 11(2), 105. https://doi.org/10.3390/ijgi11020105

Cheng, M. L., & Matsuoka, M. (2021). Extracting three-dimensional (3D) spatial information from sequential oblique unmanned aerial system (UAS) imagery for digital surface modeling. *International Journal of Remote Sensing*, 42(5), 1643–1663. https://doi.org/10.1080/01431161.2020.1842538

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https://doi.org/10.26437/ajar.v11i1.
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Revised: December 12, 2024
Published: January 2025

Cilek, A., Berberoglu, S., Donmez, C., & Unal, M. (2020). Generation of high-resolution 3-D maps for landscape planning and design using UAV technologies. *Journal of Digital Landscape Architecture,* 5(1). https://gispoint.de/fileadmin/user_upload/paper_gis_open/DLA_2020/537690029.pdf

Giordan, D., Adams, M. S., Aicardi, I., Alicandro, M., Allasia, P., Baldo, M., ... & Troilo, F. (2020). The use of unmanned aerial vehicles (UAVs) for engineering geology applications. *Bulletin of Engineering Geology and the Environment,* 79, 3437–3481. https://doi.org/10.1007/s10064-020-01766-2

Hamza, M. H., & Chmit, M. (2022). GIS-based planning and web/3D web GIS applications for the analysis and management of MV/LV electrical networks (a case study in Tunisia). *Applied Sciences,* 12(5), 2554. https://doi.org/10.3390/app12052554

Hu, G., Dai, W., Li, S., Xiong, L., Tang, G., & Strobl, J. (2021). Quantification of terrain plan concavity and convexity using aspect vectors from digital elevation models. *Geomorphology,* 375, 107553. https://doi.org/10.1016/j.geomorph.2020.107553

Kadirova, D., Usmanova, M., Saidova, M., Djalilova, G., & Namozov, N. (2021). Creating a digital model of regional relief using GIS technologies to evaluate degradation processes. In *E3S web of conferences,* 258, 03025. EDP Sciences. https://doi.org/10.1051/e3sconf/202125803025

Karpinskyi, Y., & Lazorenko-Hevel, N. (2020). Topographic mapping in the National Spatial Data Infrastructure in Ukraine. In *E3S Web of Conferences,* 171, 02004. EDP Sciences. https://doi.org/10.1051/e3sconf/202017102004

Lazorenko-Hevel, N., Karpinskyi, Yu., & Kin, D. (2021). Features of creating (updating) digital topographic maps for the formation of the main state topographic map. *Modern achievements of geodetic science and production,* 1(41), 113–122. http://zgt.com.ua/wp-content/uploads/2021/05/16.pdf

Li, D., Li, Y., Nguyen, Q. C., & Siebeneck, L. K. (2020). A Study on the GIS Professional (GISP) Certification Program in the US. *ISPRS International Journal of Geo-Information,* 9(9), 523. https://doi.org/10.3390/ijgi9090523

Lopes Bento, N., Araújo E Silva Ferraz, G., Alexandre Pena Barata, R., Santos Santana, L., Diennevan Souza Barbosa, B., Conti, L., ... & Rossi, G. (2022). Overlap influence in images obtained by an unmanned aerial vehicle on a digital terrain model of altimetric precision. *European Journal of Remote Sensing,* 55(1), 263–276. https://doi.org/10.1080/22797254.2022.2054028

Moisa, M. B., Negash, D. A., Merga, B. B., & Gemeda, D. O. (2021). Impact of land-use and land-cover change on soil erosion using the RUSLE model and the geographic information system: a case of Temeji watershed, Western Ethiopia. *Journal of Water and Climate Change,* 12(7), 3404–3420. https://doi.org/10.2166/wcc.2021.131

Otoo-Kwofie, C. (2015). Assessing The Reliability Of Dual Frequency Differential GNSS Observations For Orthometric Height Determination In Parts Of Accra, Ghana. *African Journal of Applied Research*, 1(1), 30-42.

Quamar, M. M., Al-Ramadan, B., Khan, K., Shafiullah, M., & El Ferik, S. (2023). Advancements and applications of drone-integrated geographic information system technology – A review. *Remote Sensing,* 15(20), 5039. https://doi.org/10.3390/rs15205039

African Journal of Applied Research
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https://doi.org/10.26437/ajar.v11i1.
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Peer reviewed: October 23, 2024
Revised: December 12, 2024
Published: January 2025

Qubaa, A. R., Hamdon, A. N., & Al Jawwadi, T. A. (2021). Morphology detection in archaeological ancient sites by using UAVs/drones data and GIS techniques. *Iraqi Journal of Science,* 62(11), 4557–4570. https://doi.org/10.24996/ijs.2021.62.11(SI).35

Roth, L., Hund, A., & Aasen, H. (2018). PhenoFly Planning Tool: flight planning for high-resolution optical remote sensing with unmanned areal systems. *Plant methods,* 14, 1–21. https://doi.org/10.1186/s13007-018-0376-6

Ruzickova, K., Ruzicka, J., & Bitta, J. (2021). A new GIS-compatible methodology for visibility analysis in digital surface models of earth sites. *Geoscience Frontiers*, 12(4), 101109. https://doi.org/10.1016/j.gsf.2020.11.006

Sofiyivska Borshchahivka - detailed paper map for printing, free download, road maps, topographic map jpg. https://maps.dokladno.com/map.php?obl=12&raj=183&np=672&s=r

Sossa, R. (2021). Contemporary status of topographic mapping in Ukraine. *Polish Cartographical Review,* 53(1), 1–12. https://doi.org/10.2478/pcr-2021-0001

Stadnikov, V., Likhva, N., Konstantinova, O., & Kolosiuk, A. (2023). Experience in the application of GIS technologies in the creation (updating) of digital topographic maps at a scale of 1: 25000. *Technical Sciences and Technologies,* 4(34), 255–264. https://doi.org/10.25140/2411-5363-2023-4(34)-255-264

Stott, E., Williams, R. D., & Hoey, T. B. (2020). Ground control point distribution for accurate kilometre-scale topographic mapping using an RTK-GNSS unmanned aerial vehicle and SfM photogrammetry. *Drones,* 4(3), 55. https://doi.org/10.3390/drones4030055

Syetiawan, A., Gularso, H., Kusnadi, G. I., & Pramudita, G. N. (2020). Precise topographic mapping using direct georeferencing in UAV. In *IOP Conference Series: Earth and Environmental Science*, 500(1), 012029. IOP Publishing. https://doi.org/10.1088/1755-1315/500/1/012029

Tomaszewski, B. (2020). Geographic information systems (GIS) for disaster management. Routledge. https://doi.org/10.4324/9781351034869

Topographic map of Petropavlivska Borshchahivka. https://uk-ua.topographic-map.com/map-xjbf5k/Петропавлівська-Борщагівка/?popup=50.48832%2C30.31042

Tsilimantou, E., Delegou, E. T., Nikitakos, I. A., Ioannidis, C., & Moropoulou, A. (2020). GIS and BIM as integrated digital environments for modeling and monitoring of historic buildings. *Applied Sciences,* 10(3), 1078. https://doi.org/10.3390/app10031078

Wang, H., & Yang, X. (2021). Planning and design of modern rural landscape tourism based on geographic information system. In *2021 4th International Conference on Information Systems and Computer Aided Education*. (pp. 31–35). https://doi.org/10.1145/3482632.3482639

Xia, H., Liu, Z., Efremochkina, M., Liu, X., & Lin, C. (2022). Study on city digital twin technologies for sustainable smart city design: A review and bibliometric analysis of geographic information system and building information modelling integration. *Sustainable Cities and Society,* 84, 104009. https://doi.org/10.1016/j.scs.2022.104009

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