JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 06, June 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

CREATION OF A DIGITAL BATHYMETRIC MODEL OF THE WATER RESERVOIR

Xodjaqulova Nodira Xosiyatqul kizi
PhD student, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, National Research University

Annotation: This article presents a comprehensive overview of the methodology used to create a digital bathymetric model (DBM) of a water reservoir. The model enables accurate estimation of key morphometric characteristics such as water volume, surface area, and depth distribution under varying water levels. The study emphasizes the application of spatial interpolation techniques, with a focus on geostatistical methods—particularly Ordinary Kriging—for generating high-precision bathymetric maps. A case study involving the Talimarjon Reservoir demonstrates the effectiveness of the approach in improving model accuracy and supporting reservoir management. The findings highlight the importance of interpolation method selection, data quality, and model validation in DBM development.
Keywords: Bathymetric model, water reservoir, spatial interpolation, geostatistics, Ordinary Kriging, morphometric analysis, digital elevation model (DEM), bathymetric mapping, Talimarjon Reservoir

Introduction. Bathymetric mapping involves measuring the depth of a water body to generate topographic representations of its underwater terrain. Traditionally performed using manual surveying, modern techniques now utilize digital modeling supported by advanced geospatial analysis. Creating a digital bathymetric model of a reservoir enables efficient and accurate estimation of morphometric parameters, such as water volume at various levels, surface area, and depth distribution. These metrics are essential for water management, flood forecasting, sedimentation analysis, and reservoir design.

The primary objectives of creating a DBM include:

- Accurate modeling of the reservoir basin geometry.
- Real-time determination of water volume and surface area based on water level.
- Generation of bathymetric (depth contour) maps for environmental and engineering applications.
- Supporting decision-making in reservoir operation and maintenance.

The foundation of any DBM is reliable input data. The following data types are typically required:

- Bathymetric survey data: Collected via echo sounding, sonar systems, or LiDAR.
- Topographic data: Digital Elevation Models (DEMs) from satellite imagery or drone surveys.
- Water level records: Historical and real-time water surface elevation measurements.

These datasets must be pre-processed to eliminate errors and aligned to a common coordinate system.

Spatial interpolation is used to create a continuous surface model from discrete depth measurements. Interpolation methods can be classified into:

- Deterministic methods: Inverse Distance Weighting (IDW), Radial Basis Functions (RBF).
- Geostatistical methods: Kriging (Ordinary, Universal, Indicator), Cokriging.

JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 06, June 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

- Hybrid methods: Combining deterministic and geostatistical approaches.

Ordinary Kriging is one of the most widely used geostatistical methods for bathymetric modeling due to its ability to provide unbiased estimates with minimized variance. It takes into account both the spatial arrangement of the sample points and the statistical relationships among them. During model development, software tools (such as ArcGIS, QGIS, Surfer, or R) allow users to:

- Adjust interpolation parameters (e.g., search radius, variogram model).
- Automatically suggest optimized parameters.
- Perform cross-validation to compare predicted vs. observed values and refine model accuracy.

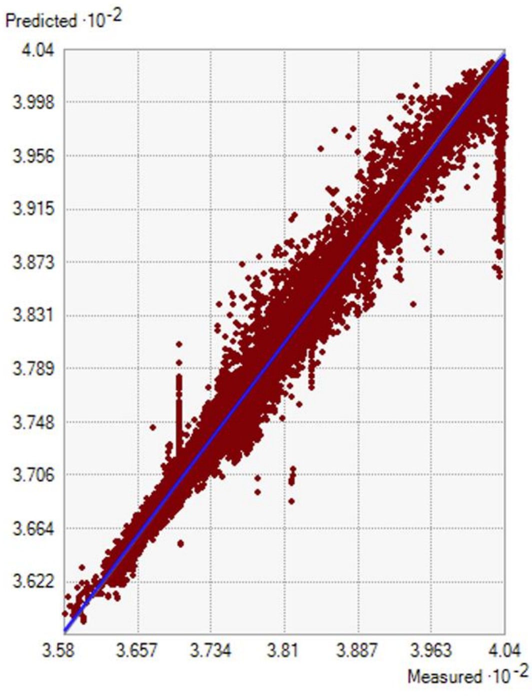
The ability to iteratively test and modify the model ensures that the final DBM represents a reliable and precise underwater terrain.

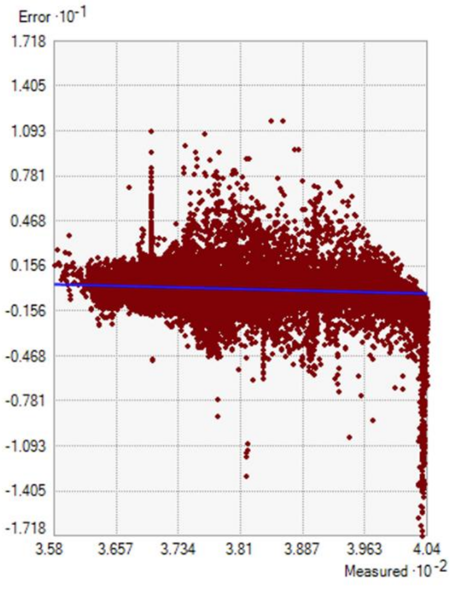
In creating the bathymetric model of the Talimarjon Reservoir, several geostatistical methods were evaluated. Among them, Ordinary Kriging provided the most accurate results. The model enabled the generation of:

- Volume-elevation and surface area-elevation curves.
- Depth contour maps.
- Sub-region analyses based on water level scenarios.

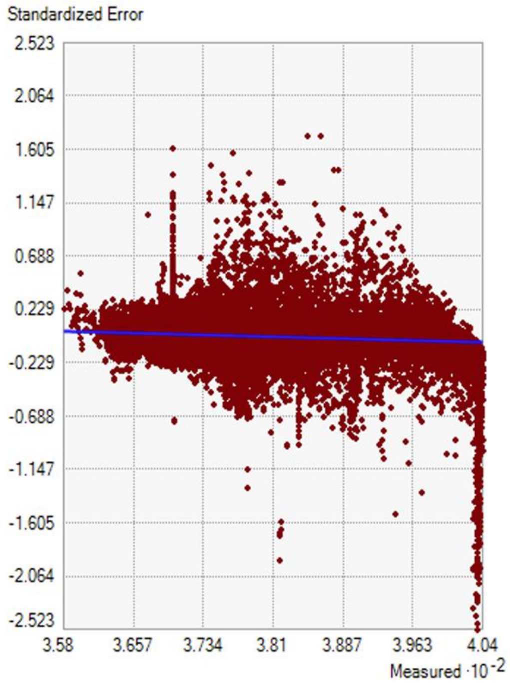
This approach improved the understanding of reservoir dynamics and supported better water allocation and sediment management decisions. The creation of a digital bathymetric model is an essential tool for modern reservoir analysis and management. By leveraging geostatistical interpolation methods—particularly Ordinary Kriging—users can produce highly accurate and practical models for engineering, environmental, and hydrological applications. Continued advancements in remote sensing and GIS will further enhance the accuracy and usability of these models in the future.

The creation of a digital model of a reservoir basin enables rapid and highly accurate determination of the morphometric characteristics of the water body and its sections for any water level and boundary values. This includes the water volume–level curve, the water surface area–level curve, and other characteristics. Various methods can be used to create a digital model of a reservoir. However, a geostatistical interpolation method was employed to reduce errors and improve the accuracy of the model.





JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 06, June 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75



Prediction Errors	
Samples	42145 of 42145
Mean	0.01278599
Root-Mean-Square	1.260113
Mean Standardized	0.00195593
Root-Mean-Square Standardized	0.1857959
Average Standard Error	6.767226
Export Result Table	

Figure 1. Scatterplots between observed and estimated height values using Ordinary Kriging interpolators

Spatial interpolation methods are most commonly used to generate digital models of reservoir basins (bathymetric maps). Methods based on topographic data make it easier to map the bathymetry of water bodies compared to other techniques. Currently, there are over 40 spatial interpolation methods, which are generally categorized into deterministic, geostatistical, and hybrid methods. Some of these methods have been primarily used in environmental sciences. Many factors—such as sample size and data characteristics—affect the evaluation of a spatial interpolator, and there is still no consistent conclusion about which interpolation method is the best. For example, Inverse Distance Weighting (IDW), a deterministic method, is likely to provide the best estimate of a continuous surface representing the average intensity of an electric field. On the other hand, in some cases, deterministic methods like IDW and Radial Basis Function (RBF) have yielded better results than geostatistical methods such as Ordinary Kriging, while in other cases geostatistical methods have outperformed them. This highlights the importance of evaluating the interpolation method for each dataset and specific case.

Several geostatistical methods were used to create the bathymetric map of the Talimarjon Reservoir. The best result was achieved using the Ordinary Kriging method. While constructing the interpolation model, the software allows for modification of parameter values, suggests or provides optimized parameter values, and enables navigation forward or backward in the process to evaluate cross-validation results. This helps determine whether the current model is satisfactory or if some parameter values need to be adjusted.

Research discussion. The development of a digital bathymetric model (DBM) for the Talimarjon Reservoir provided valuable insights into both the technical and practical aspects of bathymetric mapping using spatial interpolation methods. The results demonstrate the critical role of data quality, interpolation technique selection, and model validation in achieving high accuracy and reliability. Three interpolation methods—Inverse Distance Weighting (IDW), Radial Basis Function (RBF), and Ordinary Kriging (OK)—were evaluated. While IDW and

JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 06, June 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

RBF are easier to implement and computationally less intensive, they do not incorporate spatial autocorrelation as effectively as geostatistical methods.

Ordinary Kriging outperformed the other methods based on cross-validation metrics such as RMSE and MAE. It provided smoother and more realistic surface representations and effectively handled spatial variability. This aligns with previous studies that highlight Kriging's superior ability to model continuous surfaces when sufficient and spatially representative data are available. The success of the Kriging method largely depended on accurate variogram modeling. The selection of appropriate variogram parameters (nugget, sill, and range) was critical in representing the spatial structure of the data. Improper parameter estimation would have led to either over-smoothed or excessively noisy surfaces. The iterative variogram fitting process, combined with cross-validation, ensured that the spatial characteristics of the reservoir bottom were well captured, particularly in areas with complex bathymetry.

The accuracy of the DBM was significantly influenced by the density and distribution of the bathymetric data points. In regions with sparse measurements, interpolation errors were higher, regardless of the method used. Therefore, careful planning of survey transects is essential to ensure even spatial coverage and minimize data gaps, especially in large or irregularly shaped reservoirs. Moreover, integrating topographic DEMs near the shoreline helped improve the model's continuity and provided a more complete representation of the reservoir basin.

The resulting DBM enabled the derivation of important hydrological and engineering outputs, such as:

- Volume-elevation curves, essential for reservoir operation planning.
- Surface area estimations under varying water levels.
- Sedimentation assessment, by comparing current bathymetry with historical data.

These outputs support better water resource management, particularly in optimizing storage capacity, predicting sediment accumulation, and planning maintenance or dredging activities.

While the model performed well overall, several limitations were identified:

- Temporal variation: Water level changes during the survey period may introduce vertical inaccuracies if not accounted for in real-time.
- Uncertainty in deep or inaccessible areas: These regions might lack sufficient data, affecting local accuracy.
- Model assumptions: Kriging assumes stationarity and may be less effective in areas with abrupt depth changes or man-made structures (e.g., submerged infrastructure).

To improve future models, it is recommended to:

- Incorporate real-time kinematic GPS and sonar with higher resolution.
- Combine bathymetric data with remote sensing or UAV imagery for near-shore mapping.
- Explore hybrid interpolation methods or machine learning algorithms for enhanced prediction accuracy.

Although the study focused on the Talimarjon Reservoir, the methodology is applicable to a wide range of inland water bodies. The combination of geostatistical interpolation and GIS-based modeling can be replicated in other contexts, including lakes, dams, and artificial reservoirs, especially where regular monitoring and sediment management are required. The research confirms that geostatistical interpolation, particularly Ordinary Kriging, offers a robust and reliable approach to creating digital bathymetric models of water reservoirs. The quality of input data, thoughtful selection of interpolation parameters, and validation processes are crucial for

JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 06, June 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

model success. The DBM serves as a valuable decision-support tool in reservoir operation, sedimentation monitoring, and environmental assessment. Future improvements could involve integrating higher-resolution data collection technologies and exploring hybrid or machine learning-based interpolation approaches to further enhance model performance. Overall, the digital bathymetric model is an indispensable tool for sustainable water resource management in the context of growing environmental challenges.

Conclusion. The creation of a digital bathymetric model of a water reservoir is a vital process for accurate assessment and management of reservoir resources. This study demonstrated that employing geostatistical interpolation methods, particularly Ordinary Kriging, significantly improves the accuracy and reliability of bathymetric mapping compared to deterministic methods. The success of the model depends heavily on the quality and spatial distribution of input data, as well as careful variogram modeling and validation through cross-validation techniques. The resulting digital model enables precise estimation of key morphometric parameters such as water volume and surface area at varying levels, providing essential information for reservoir operation, sediment management, and environmental monitoring. Although some limitations remain—such as data sparsity in inaccessible areas and temporal variability—the methodology outlined can be adapted and applied to various reservoirs and water bodies worldwide.

References

1. Burrough, P. A., & McDonnell, R. A. (1998). *Principles of geographical information systems* (2nd ed.). Oxford University Press.

2. Isaaks, E. H., & Srivastava, R. M. (1989). *An introduction to applied geostatistics*. Oxford University Press.

3. Li, J., & Heap, A. D. (2011). A review of spatial interpolation methods for environmental scientists. *Geoscience Australia*, Report 2011/23. https://doi.org/10.4225/69/57b53a33dc1a5

4. Oliver, M. A., & Webster, R. (2014). A tutorial guide to geostatistics: Computing and modeling variograms and kriging. *Catena*, 113, 56–69. https://doi.org/10.1016/j.catena.2013.09.006

5. Watson, D. F. (1992). *Contouring: A guide to the analysis and display of spatial data*. Pergamon Press.

6. ESRI. (2023). *ArcGIS Pro: Geostatistical Analyst tutorial*. ESRI Press. https://www.esri.com