AERIAL PHOTOGRAPHY USING UNMANNED AERIAL VEHICLE (UAV) FOR TOPOGRAPHIC MAPPING AND DAM ANALYSIS (CASE STUDY: KARANGNONGKO DAM PACKAGE ONE)

Shafa Nabila Prawitasari[1]*, Ayu Raina Nabilah[1]

[1] Department of Geomatics Engineering, Institut Teknologi Sepuluh Nopember, Surabaya Indonesia
E-mail: 5016211110@student.its.ac.id

Received: January 4, 2025 | **Accepted:** March 1, 2025 | **Published:** March 3, 2025
DOI: 10.12962/j27745449.v5i2.2722 | **Issue:** Volume 5 Number 2 2024 | **E-ISSN:** 2774-5449

ABSTRACT

Water is a natural resource that is crucial for survival and various industrial, fishery, and agricultural activities. In the use of water, there is often a lack of care in its use and utilization so that efforts are needed to maintain a balance between the availability and needs of water through development, conservation, improvement and protection. The construction of dams, such as the Karangnongko Dam, aims to improve community welfare by providing irrigation water and raw water, as well as potential as a tourist destination. Visualization of the Slope Map, Aspect Map, and Contour Map shows the progress of the Karangnongko Dam construction in August 2024. These maps indicate the dominance of flat areas, the direction of the excavation tends to the northwest, and the contours are tight at the edges and looser in the middle area of the dam.

Keyword: Water, Dam, Development, Topography

Introduction

Water is a natural resource that is very important for the survival of all living things. Water is also very necessary for industrial activities, fisheries, agriculture and other businesses. In the use of water, there is often a lack of care in its use and utilization so that efforts are needed to maintain a balance between the availability and need for water through development, conservation, improvement and protection. Water development through dam construction where development aims to improve the quality of all aspects of community life, namely social, cultural and economic aspects in order to realize social welfare. However, in its implementation, instructions or information are needed regarding information on the surrounding area.

In this case, what is meant specifically is the Slope Map in the Karangnongko Dam area. This map itself is used to see the level of land slope in general.

Karangnongko Dam is a dam located in the border area between Blora Regency, Central Java and Bojonegoro Regency, East Java. The construction of this dam began in 2023 and is included in the construction of the National Strategic Project (PSN) in collaboration with WIKA-HK-PP KSO in the framework of flood control infrastructure for Bengawan Solo.

The presence of the Karangnongko Dam has the potential to provide benefits as a supply of irrigation water and raw water in the river basin to meet the raw water needs for Bojonegoro Regency, Blora Regency, Tuban Regency, and Ngawi Regency of 1,155 liters/second and also as a new tourist destination that can improve the economy of the surrounding community.

Some of the advantages of this research are that students will develop a sense of professional responsibility and increase their skills in field practice. The advantage for companies/industries is that institutions can meet the needs of freelance workers with academic insight from the work practice. In this case, WIKA-HK-PP KSO will obtain workers who are in accordance with their fields. Then the field work practice report can be used as one source of information regarding the general situation of the institution where the practice takes place.

Methodology

Tachymetry Method

Tachymetry method is a measurement using optical, electronic, and digital instruments. Tachymetry method is based on the principle that in similar triangles, the corresponding sides are proportional. Tachymetry method is most useful in determining the location of a large number of topographic details, both horizontally and vertically.

In measuring detailed points, the principle is to determine the coordinates and height of the detailed points from the tie points. The measurement of detailed points using the tachymetry method is relatively fast and easy because what is obtained from the field is the reading of signs, horizontal angles (magnetic azimuth), vertical angles (zenith or inclination) and the height of the tool. The results obtained from tachymetry measurements are the planimetric positions X, Y, and height Z.

Most tachymetry measurements are with oblique sight lines due to the diversity of topography, but the intersection of the stadia threads is read on a perpendicular marker and the oblique distance is reduced to horizontal and vertical distances (Purwaamijaya, 2008).

Photogrammetry Methods

Photogrammetry is the art, science and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring and interpreting photographic images and recorded electromagnetic radiation patterns (Wolf P. R, 1993).

There are two types of photo-taking techniques used in photogrammetry, the first is terrestrial and aerial. In large-scale mapping, the technique used is aerial photography. In its implementation, vertical or oblique aerial photography models can also be used. Vertical photos are taken with the camera axis placed on a plane in the most vertical position possible. If the camera axis is placed vertically when lighting is carried out, the resulting photo will have the same datum as the field and the photo will be vertical. In practice, the camera axis is very rarely vertical because of the unavoidable tilt on the plane. When the camera axis is slightly tilted, the resulting photo is called a tilted photograph. The tilt that occurs is usually less than 1° and rarely more than 3° (Wolf and Dewitt 2000).

Result and Discussion

GCP Measurement Results

From the Horizontal Control Framework measurements that have been carried out, the results of the abscissa coordinates (X) and ordinate coordinates (Y) at each point are presented in the following table.

Table 1. Results of Abscissa and Ordinate Coordinates

Point	X Coordinate	Y Coordinate
Rang 3	550262,9600	9197583,509
Rang 2	550132,3490	9197550,917
GCP 1	550047,7132	9197559,706
BM 4	549999,6649	9197557,821
GCP 3	550192,0535	9197201,770

With linear tolerance the measurement is as follows:

$$\frac{\sqrt{{c_x}^2 + {c_y}^2}}{\Sigma d} \leq \frac{1}{orde}$$

$$\frac{\sqrt{(0{,}1139)^2 + (-0{,}0497)^2}}{1.061{,}228} \leq \frac{1}{8000}$$

$$\frac{1}{8541} \leq \frac{1}{8000}$$

where, ${c_x}^2$ = abscissa square correction (m), ${c_y}^2$ = quadratic ordinate correction (m), orde = following the measurement accuracy level of 8000. The calculation results obtained show that the measurement results carried out are within tolerance.

Topographic Analysis Results

From the data processing and analysis that has been carried out, several types of maps have been produced as follows:

Digital Elevation Model (DEM) Map

Digital Elevation Model (DEM) is a three-dimensional representation of the earth's surface relief model that reflects real conditions and contains information about the elevation of the land or the earth's surface, without taking into account the elements above it such as vegetation, buildings, and other structures. This DEM data is used for contour, slope, and surface aspect analysis on a map.

In the Karangnongko Dam construction project area, DEM data was obtained from orthophoto data processing using Pix4DMapper software.

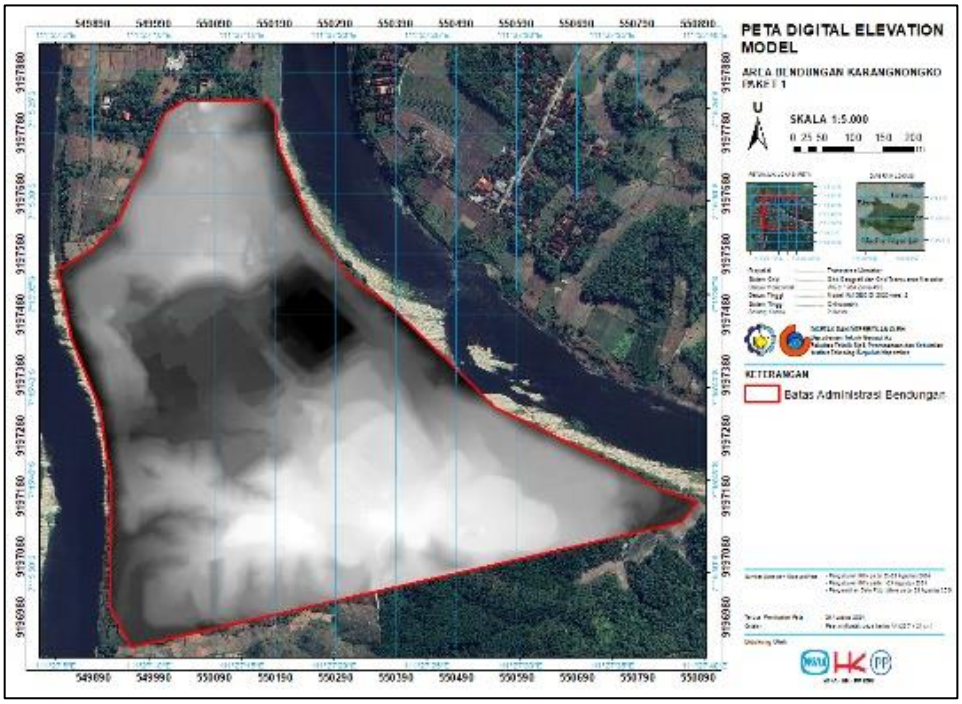

Figure 1. Digital Elevation Model (DEM) Map of Karangnongko Dam

From Figure 1, it shows that the area visualized in black shows the area with the lowest elevation with a value of 17.5017 m. While the area visualized in white shows the area with the highest elevation with a value of 67.354 m.

Digital Terrain Model (DTM) Map

Digital Terrain Model (DTM) is a 3-dimensional relief model depicting the actual condition that provides information about morphological elevation and surface layers (Duantari & Cahyono, 2017). This DTM data can be used to form contours, aspects, and surface slopes on a map. The difference with DSM (Data Surface Model) data is that DTM data depicts the relief of the earth or land surface without including objects, such as buildings or vegetation, on its surface.

In the Karangnongko Dam construction project area, DTM data was obtained from the DSM data filtering process using ArcGIS software.

Figure 2 shows the area visualized in red indicating that the area has a high ground surface elevation, in contrast to the area visualized in green. The black color is a shadow of the morphological form of the ground surface that shows the difference (gap) in elevation between surfaces.

Digital Surface Model (DSM) Map

Digital Surface Model (DSM) is a 3-dimensional relief model depicting the actual condition containing information about the elevation of the earth's surface features including vegetation, buildings, and other features. This DTM data is used to form contours, aspects, and surface slopes on a map.

In the Karangnongko Dam construction project area, DTM data was obtained from the orthophoto data processing process using Pix4DMapper software.

Figure 3 shows the area visualized in red indicates that the area has a high elevation of the topographic feature, in contrast to the area visualized in green. The black color is the shadow of the shape of the topographic feature that shows the difference (gap) in elevation between the features.

Slope Map

A slope map is a map that shows the slope or gradient of a region or the surface of the earth. This map visualizes the comparison between the height difference (vertical distance) of a land and its horizontal distance. The magnitude of the slope can be expressed in several units, including % (percent) and ° (degrees).

Spatial slope information describes the condition of the land surface, such as flat, sloping, or steep. This map is usually created using DEM (Digital Elevation Model) or DSM (Digital Surface Model) data that represents the elevation or height at each point on the earth's surface.

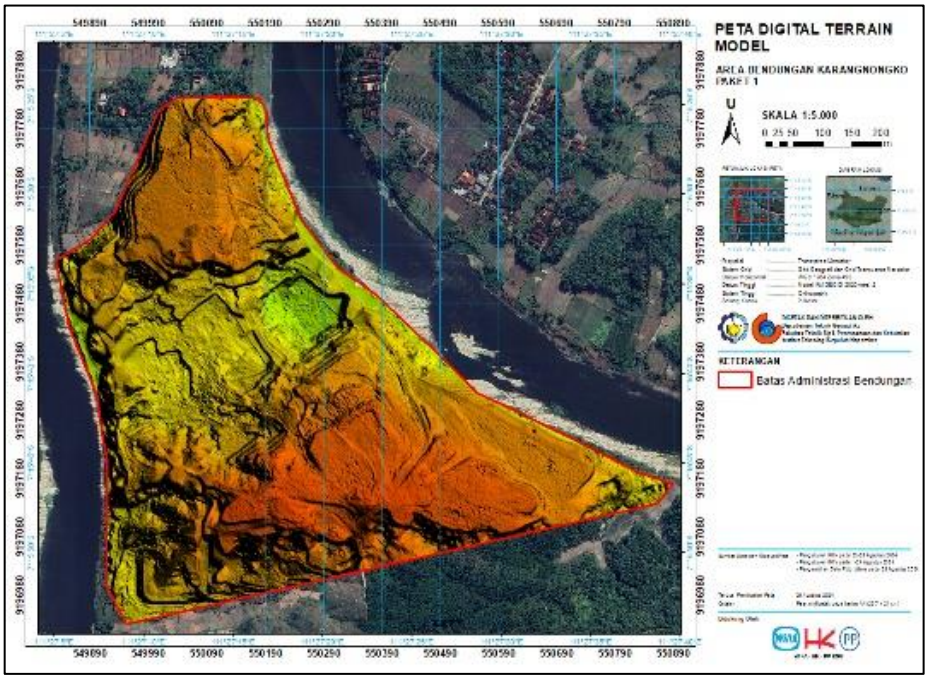

Figure 2. Digital Terrain Model (DTM) map of Karangnongko Dam

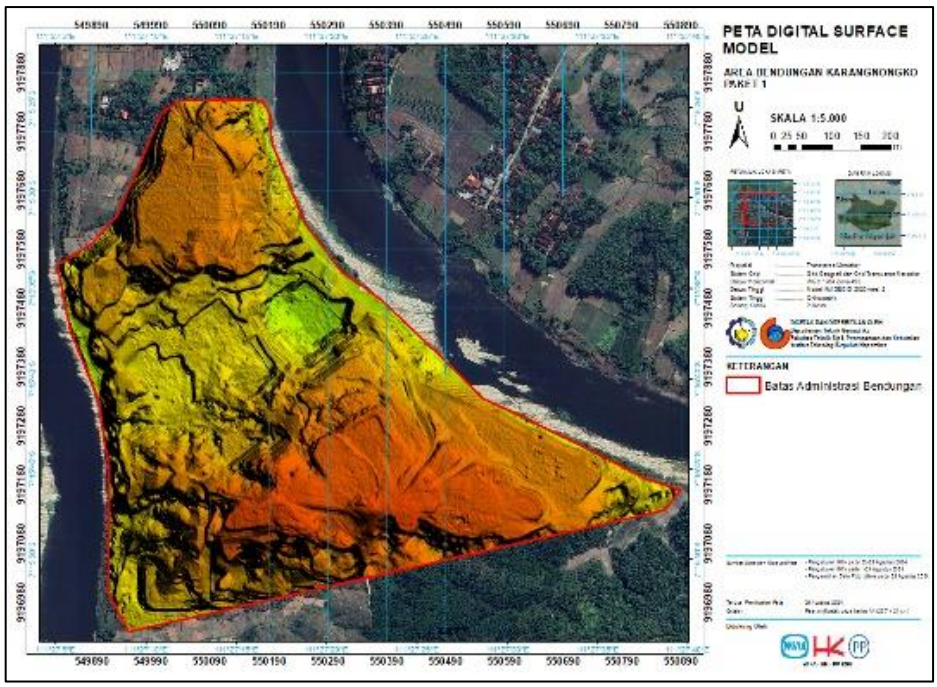

Figure 3. Digital Surface Model (DSM) Map of Karangnongko Dam

Slope maps usually use color gradations to indicate the level of slope in an area. In the map above, sloping or flat areas are shown in light green, while the steeper or steeper the area, the color gradation is displayed in red (towards red). This allows users to visualize the differences in height and slope in a particular area more easily. Slope maps are very useful in topographic analysis and land use planning.

In the case study of the Karangnongko Dam construction project area, the slope map taken is the progress of the excavation work for the dam construction in August 2024.

It can be seen from Figure 4 above that the green area dominates, which means that the flat area of the dam still dominates.

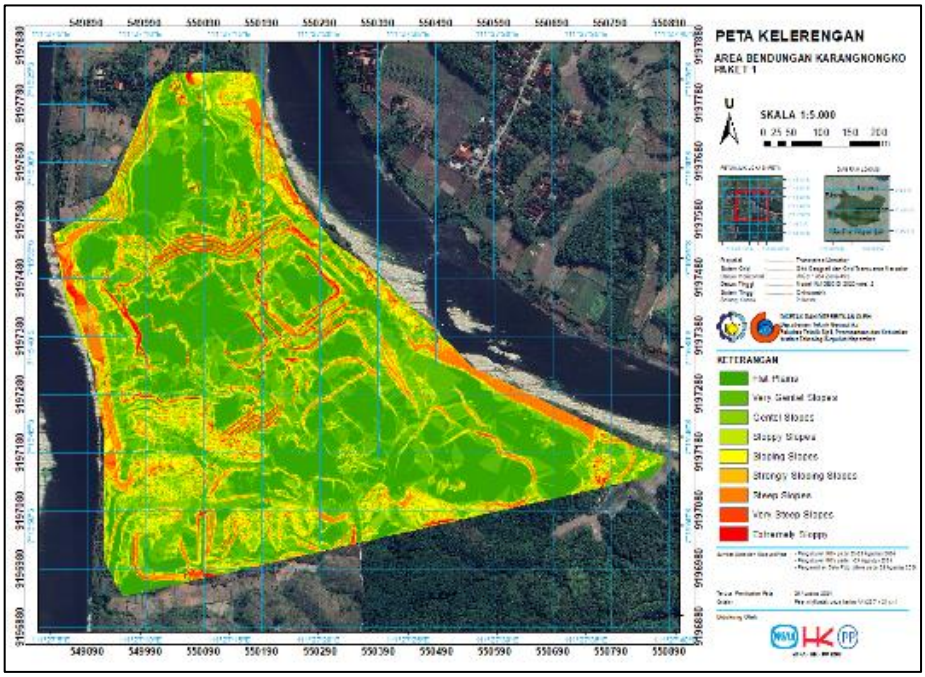

Figure 4. Karangnongko Dam Slope Map

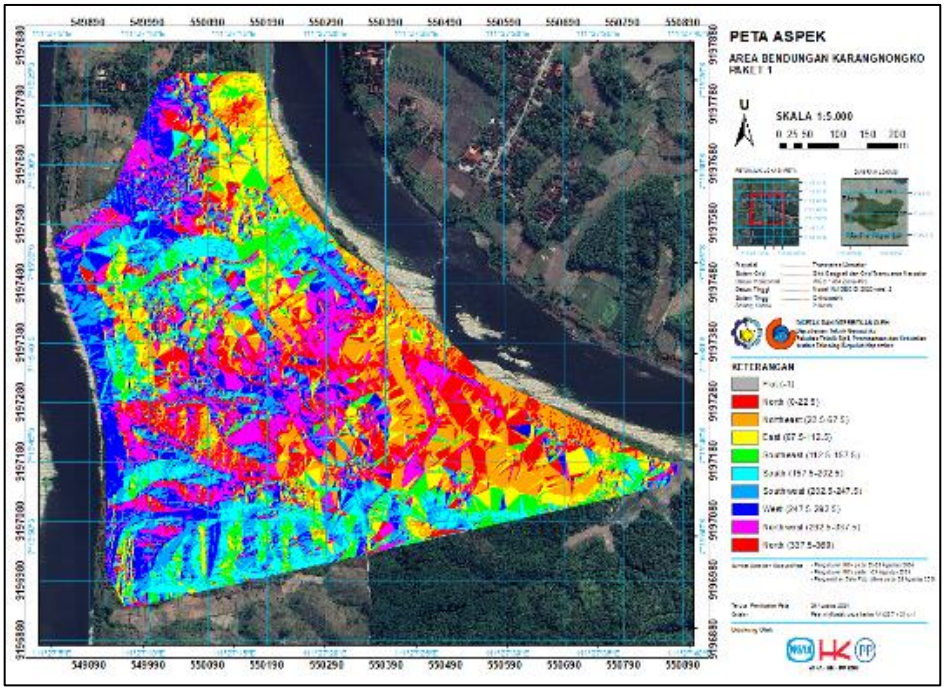

Figure 5. Aspect Map of Karangnongko Dam

Some areas are red, which means they are very steep and accompanied by yellow around them, which means that the slope is still quite gentle. It can be analyzed that the red color is the excavation area where the material or part of the puddle is taken.

Aspect Map

An aspect map is a map that shows the direction of the slope of a region or the surface of the earth. This map shows the direction or orientation of the slope of the earth's surface, whether facing north, south, east, or west. In an aspect map, each slope direction is given a different color or a different color gradation. Aspect maps are usually created using DEM (Digital Elevation Model) data or DSM (Digital Surface Model) data that represents the elevation or height at each point on the earth's surface or a picture of an object on the earth's surface. Aspect maps are used in topographic analysis, especially in environmental science and soil science.

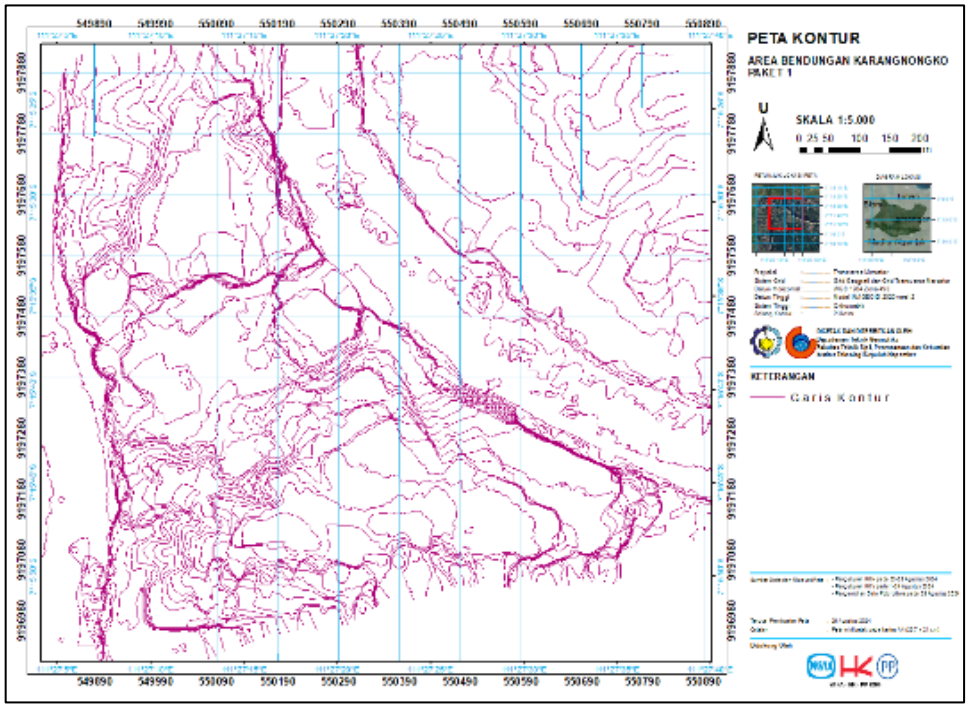

Figure 6. Contour Map of Karangnongko Dam

This map can be used to visualize the slope and orientation of the earth's surface, which can provide information about water flow patterns and areas prone to erosion. Aspect maps can also assist in land use planning and natural resource management.

In this case study, the aspect map of Karangnongko Dam is used to observe the slope and water flow patterns.

It can be seen from Figure 5 above that on the aspect map of Karangnongko Dam is dominated by a slope to the northwest marked by the color pink and interspersed by the color of the sea blue or the west direction. And some of its locations are dominated by the northeast direction represented by the color orange and interspersed with the color light blue which means the slope is oriented to the south. This can indicate the upstream and downstream parts of the water at Karangnongko Dam.

Contour Map

A contour map is a topographic map that shows the difference in elevation between points on the earth's surface using contour lines. Contour lines are lines that connect points of equal elevation on the earth's surface. Each contour line is usually labeled with the elevation associated with that line. Contour maps are very useful in topographic analysis and navigation. This map can provide information about elevation, surface shape, and slope in an area. Contour maps can also be used to determine the best route for travel, including climbing routes, hiking routes, and routes over water. Contour maps are made based on DEM (Digital Elevation Model) data or DSM (Digital Surface Model) data that represents the elevation at each point on the earth's surface and/or a picture of an object on the earth's surface.

It can be seen from Figure 6 above that the contour lines that are increasingly close together indicate that the area has an increasingly steep height. While the contour lines that are increasingly far apart indicate that the area is a sloping or flat area. It can be seen in the figure above that in the case study of the Karangnongko Dam construction project area, there are several areas with very close contours and in the middle there are sloping contour lines. It can be analyzed that in areas with close contour lines, it indicates that the area is an area with a steep height, namely the boundary area or around the dam. While the part with the loose contour is an area with a sloping height or is the excavation / base area of the dam.

Conclusion

This research produces several conclusions as follows:

1. The progress of the construction (excavation) of the Karangnongko Dam in August 2024 is presented in the Slope Map visualization. It can be

seen that the progress of the construction (excavation) of the Karangnongko Dam is dominated by the color green, which means that the flat area of the dam still dominates. Accompanied by a dark red or very steep area in the middle and yellow around the red area.

2. The progress of the construction (excavation) of the Karangnongko Dam in August 2024 is presented in the Aspect Map visualization. It can be seen that the direction of the dam excavation is dominated by the northwest direction as indicated by the color pink and interspersed with the color sea blue or west. And some of the locations are dominated by the northeast direction which is represented by the color orange and interspersed with light blue which means the slope is oriented towards the south. This can show the upstream and downstream parts of the water in the Meninting dam.
3. The progress of the construction (excavation) of the Karangnongko Dam in August 2024 is presented in the Contour Map visualization. It can be seen that in the Karangnongko Dam, there are several areas with very close contours and in the middle, there are sloping contour lines. It can be analyzed that in areas with close contour lines, it indicates that the area is an area with a steep height, namely the boundary area or around the dam. While the part with a loose contour is an area with a gentle height or is the excavation / base area of the dam.

References

[1] [1] Badan Informasi Geospasial, Peraturan Kepala Badan Informasi Geospasial No. 6 tahun 2018 Tentang Perubahan Atas Peraturan Kepala Badan Informasi Geospasial No. 15 tahun 2014 Tentang Pedoman Teknis Ketelitian Peta Dasar, Cibinong, Bogor, 2018.

[2] A.B. Cahyono, H.H. Handayani, N. Nurwatik, Analisis Pemetaan Skala 1:1000 Menggunakan Data Unmanned Aerial Vehicle (UAV) (Studi Kasus: Waduk Selorejo-Kabupaten Malang), GEOID. 18(2) (2023) 221–228.

[3] D.N. Martiana, Y. Prasetyo, A.P. Wijaya, Analisis Akurasi DTM Terhadap Penggunaan Data Point Clouds dari Foto Udara dan LAS LiDAR Berbasis Metode Penapisan Slope Based Filtering dan Algoritma Macro Terrasolid, Jurnal Geodesi Undip. 6(1) (2017) 293-302.

[4] H. Gularso, S. Subiyanto, L. Sabri, Tinjauan Pemotretan Udara Format Kecil Menggunakan Pesawat Model Skywalker 1680, Geodesi Undip. 2(2) (2013) 78-94.

[5] I.Y.N. Afani, B.D. Yuwono, N. Bashit, Optimalisasi Pembuatan Peta Kontur Skala Besar Menggunakan Kombinasi Data Pengukuran Terestris dan Foto Udara Format Kecil, Jurnal Geodesi Undip. 8(1) (2019) 180-189.

[6] M.Y. Laksono, Profil Bendungan Karangnongko, Proyek Strategis Nasional Baru, KOMPAS.com, 2023. Diakses dari: https://www.kompas.com/properti/read/2023/01/23/053000021/profil-bendungan-karangnongko-proyek-strategis-nasional-baru.

[7] Purwaamijaya, Teknik Survei dan Pemetaan Jilid 3, Direktorat Pembinaan Sekolah Menengah Kejuruan, Bandung, 2008.

[8] M. Rifaan, Foto Udara Menggunakan Unmanned Aerial Vehicle (UAV) untuk Pemodelan 3D Jalan Raya (Studi Kasus: Jalan Golf Kampus ITN 2), Skripsi, ITN Malang, 2019.

[9] B. Suyudi, T. Subroto, Fotogrametri dan Penginderaan Jauh, Sekolah Tinggi Pertanahan Nasional, Yogyakarta, 2014.

[10] J.P. Wilson, J.C. Gallant, Terrain Analysis Principles and Applications, John Wiley & Sons, New York, 2000.

[11] P.R. Wolf, Elemen Fotogrametri dengan Interpretasi Foto Udara dan Penginderaan Jauh, Gunadi, Gunawan, T. Zuharnen (Eds.), Edisi Kedua, Gadjah Mada University Press, Yogyakarta, 1993.

[12] P.R. Wolf, B.A. DeWitt, Elements of Photogrammetry with Application in GIS, McGraw-Hill Higher Education, 3rd Edition, 2000.