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PRELIMINARY GEO-MORPHOMETRIC ANALYSIS OF GLOBAL DIGITAL ELEVATION MODELS: NASADEM, COPERNICUS AND ALOS WORLD 3D

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KEY WORDS: Digital Elevation Model, NASADEM, Copernicus, ALOS World 3D, Geo-morphometry, Drainage, Stream Order.

1. INTRODUCTION

Morphometry encompasses the fundamental measurements and computational modelling of the soil's surface configuration, form, and landform features (Nwilo et. al. 2021). It plays an important role in hydrological and hydro-geological studies, and enhances the understanding of hydrological characteristics (Nwilo et. al. 2021). Geo-morphometric analysis is an important factor for studying and understanding the development of any river basin. These parameters give clear evidence for the evolution of the basins, including the denudation, surface runoff, and subsurface infiltration, as well as the impact of geological formations and structures on the basin evolution. Several factors control the accuracy of geo-morphometric analysis, including the method of data collection, source of data, digital elevation model (DEM) characteristics, and measurement technique.

Moreover, the origin, nature, and quality of DEMs are known to significantly impact hydrological patterns, making the study of DEM effects on hydrological tasks a central topic in the hydrological domain (Xiong et al. 2022). DEMs play a pivotal role in understanding and analysing the topographical features of the Earth's surface. With the advent of satellite technology, several open-access global DEMs have been introduced, each with its unique characteristics. This paper presents a preliminary geo-morphometric analysis and comparison of three prominent 30-metre global DEMs: NASADEM, Copernicus GLO-30, and ALOS World 3D (AW3D). By leveraging geographic information system (GIS) techniques, various terrain and geo-morphometric parameters of a selected drainage basin in Cape Town (South Africa) were assessed. Cape Town offers diverse geomorphological contexts suitable for this research.

2. METHODOLOGY

A script developed by Beg (2015) (employed in ArcGIS) was used to calculate the main geo-morphometric parameters including the stream order, basin area, basin length, channel length, basin width, drainage texture, drainage density, stream frequency, drainage intensity, height of basin outlet, and basin relief. These were then analysed to compare the suitability of the DEMs for geomorphometric analysis.

A reference LiDAR DEM acquired from the City of Cape Town (CCT) was downsampled from 2 m to a lower resolution of 30 m. This provides a good approximation of the original ground surface while enabling a fair comparison with the satellite DEMs. After some pre-processing to fill sinks in the DEMs, several geo-morphometric parameters were generated for comparison.

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3. RESULTS AND DISCUSSION

Table 1 presents the analysis of geo-morphometric parameters for the selected sub-basin. Generally, there is a close consonance in the computed parameters from the three global DEMs (NASADEM, Copernicus and AW3D). The highest drainage density is from the LiDAR dataset. With a drainage density of 29.5 km/km^2, Copernicus DEM is closest to the LiDAR estimate while NASADEM is furthest with a drainage density of 26.4 km/km^2. This corresponds with a previous DEM vertical accuracy assessment by Okolie et al. (2023) in which Copernicus DEM emerged with the least vertical error among four global DEMs. Copernicus DEM is comparable to the resampled LiDAR DEM in the drainage intensity and stream frequency. This suggests it is a better option for terrain analysis and hydrological modelling in regions with mixed land uses. However, it is not always possible to determine if the differences in the drainage network are caused by the DEM or other factors such as the drainage network algorithm (Polidori and El Hage, 2020). The analysis in this study provides a perspective on the hydrological conditioning of the global DEMs, including their suitability for flood modelling and watershed delineation. Figure 1 shows the drainage network in the 6th – 9th stream order range for the selected sub-basin.

4. CONCLUSION

Geo-morphometric analysis plays a pivotal role in understanding the hydrological behaviours and characteristics of a region. In this study, various DEMs were evaluated for their accuracy and reliability in representing the geomorphological features of Cape Town. The results revealed that while each DEM has its unique strengths and limitations, the Copernicus 30m DEM emerged as the most reliable, showcasing values closest to the resampled (reference) LiDAR 30 m DEM. This suggests that the Copernicus 30m DEM could serve as a valuable tool for geomorphometric analysis, especially in regions with diverse landscapes like Cape Town. Future research could delve into the integration of these DEMs to create a composite model that leverages the strengths of each DEM while mitigating their limitations. Additionally, as technology advances, periodic re-evaluation of these models is recommended to ensure their continued relevance in geomorpho-logical studies.

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Parameter	LiDAR 30 m (resampled)	NASADEM 30 m	Copernicus 30 m	AW3D 30 m
Drainage network				
Total no. of stream order	151353.0	195754.0	159253.0	171364.0
Total length of streams (m)	20373996.6	17679004.3	19790459.6	17842469.7
Geometry				
Total Basin Area (km^2)	673.3	670.4	670.4	670.4
Basin Length (km)	40.5	39.1	40.5	39.3
Main Channel Length (km)	79.8	72.0	74.2	70.3
Mean Basin Width	16.6	17.1	16.6	17.1
Drainage Texture	728.1	941.7	766.1	824.4
Drainage texture analysis				
Drainage Density (km/km^2)	30.3	26.4	29.5	26.6
Stream Frequency ($number/km^2$)	224.8	292.0	237.6	255.6
Drainage Intensity	7.4	11.1	8.0	9.6
Basin relief				
Maximum Height of Basin (m)	456.0	460.0	457.0	461.0
Total Basin Relief (H) m	457.0	460.0	457.0	461.0

Table 1. Analysis of geo-morphometric parameters for the selected sub-basin in Cape Town, South Africa

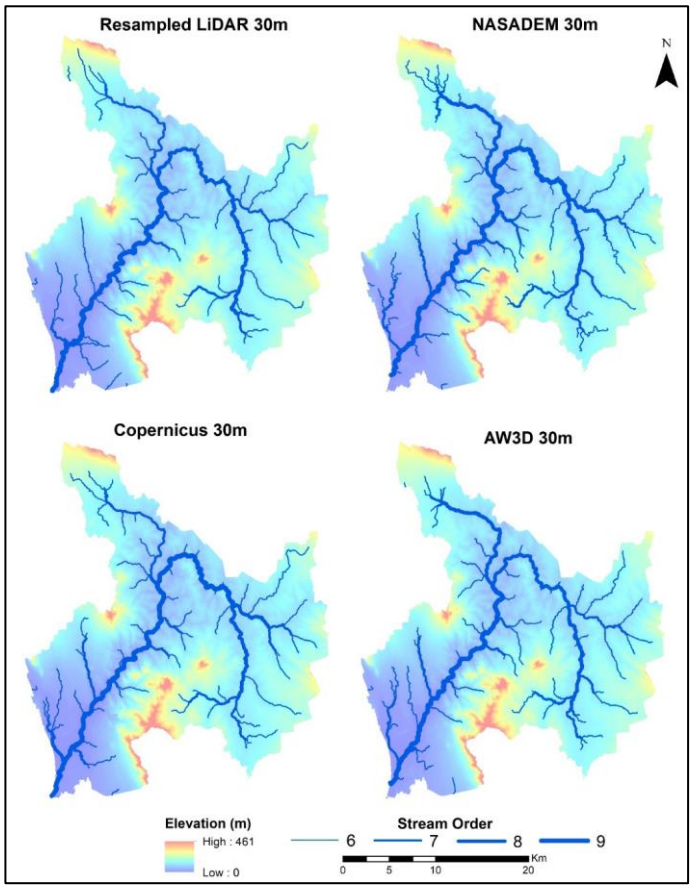

Figure 1. Drainage network in the 6th – 9th stream order range for the selected sub-basin in Cape Town, South Africa

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