PROCEEDINGS BOOK OF THE 7TH INTERCONTINENTAL GEOINFORMATION DAYS

18-19 NOVEMBER 2023

Peshawar, PAKISTAN

MERSIN UNIVERSITY-ENGINEERING FACULTY
DEPARTMENT OF GEOMATICS ENGINEERING

ISBN: 978-605-72800-6-0 https://igd.mersin.edu.tr/

7th Intercontinental Geoinformation Days

igd.mersin.edu.tr

Logging methodology decision-making with the new high-resolution DEM of Türkiye

Arif Oguz Altunel*[1], Oytun Emre Sakici[1]

[1]Kastamonu University, Faculty of Forestry, Department of Forest Engineering, Kastamonu, Türkiye

Keywords
DEM
Slope
Topographic roughness
Acreage

Abstract

There are many ways one can decide if an engineering related undertaking would be feasible and productive when the topography is thoroughly and precisely investigated before it takes shape. Forestry is just one profession that proper planning is of the essence when it comes to the logging phase of the entire production process. Logging in Türkiye is primarily handled over an ever-growing forest-road network. Although the specialized equipment e.g. yarders, tractor-winches, are also put into the works, their share and production capacity is limited and confined to certain parts of the country. Thus, timber production primarily revolves around direct tractor-skidding throughout the forest floor, taking the felled log from the stump to the nearest road. Here, topography is the real constraint in production method decision-making. Topographic maps have long been used to extract topographic parameters. However, Türkiye recently announced the completion of first national high-resolution digital elevation model, 5 m DEM. High precision, which would be achieved utilizing this DEM, reemphasized the importance of slope and topographic roughness in primary transport planning. In this study, we calculated the amount of slope and topographic roughness acreages in two forest planning units based on elevation differences. Both yielded enough extreme surface acreages, which would question the expansion of road building and justify the adoption of specialized equipment.

1. Introduction

Digital elevation models (DEM) since the global dissemination of SRTM data in 2005 have come a long way. It was plagued with voids at the beginning, and studies showed how they could effectively be patched (Grohmann et al. 2006; Ling et al. 2007; Gallant and Read, 2009). Announcement of the first version of Aster GDEM in 2009 provided additional support for further strengthening SRTM's later versions (Reuter et al. 2007; Altunel, 2018). As time passed, it proved its worth in every corner of the Earth paving way to devise new methodologies in engineering, hydrology, urban planning, etc. (Alsdorf et al. 2007; Lehner et al. 2008; Altunel, 2023). Although rather satisfactory in spatial positioning and elevation accuracy, they do not provide enough ground resolution for specialty works. Roughly, 30 m (1 arc-second) spatial resolution in each data generalizes the average surface facades excessively to perform precision works. Later, TanDEM-X global DEM of 12 m (0.4 arc-second) and recently Copernicus European DEM of 10 m (0.3 arc-second) raised the bar even further to better represent the surfaces. Although technology has enabled us to further improve the ground resolution to even higher levels with UAV and LIDAR (Akturk and Altunel, 2019; Muhadi et al. 2020), they are most of time not feasible and easily available everywhere. Thanks to its long experience of aerial stereo photo capture, Türkiye recently announced a 5 m national DEM, which means that it provides 36 and 4 times better earth representation than SRTM and new Copernicus DEMs, respectively.

In Türkiye, long-time accepted practices for primary transport are direct tractor skidding, tractor drum winching and yarders in timber production process. The major criteria to decide the primary transport method has been topography of the region and standing volume to be harvested. For instance, 55% gradient or more definitely requires special equipment such as yarders alongside the existing forest road network.

Although the elevation accuracy of a DEM is of the essence in the first glance, practicality of such a high resolution DEM highlighted the importance of topographical parameter extraction (Mukherjee et al. 2013) that is presented in this study as a firm foundation when deciding what type of logging equipment/infrastructure might be preferred while reaching out to the stands to be harvested.

* **Corresponding Author**

*(aoaltunel@kastamonu.edu.tr) ORCID ID 0000-0003-2597-5587,
(oesakici@kastamonu.edu.tr) ORCID ID 0000-0003-4961-2991

Cite this study

Altunel, A. O. & Sakici, O. E. (2023). Logging methodology decision-making with the new high-resolution DEM of Türkiye. Intercontinental Geoinformation Days (IGD), 7, 176-179, Peshawar, Pakistan

2. Method

Kastamonu Regional Directorate of Forestry (RDF) has been the leading contributor in Turkish timber production. The study was devised within Daday Planning Unit in Daday Forest Enterprise (FE) and coastal Doganyurt Planning Unit in Inebolu Forest Enterprise, both within Kastamonu RDF to see the elevation and resulting slope variations (Figure 1). The existence of treacherous topographies due to coast-parallel running mountain ranges throughout Inebolu FE make it a prime candidate for suitable technologies, not only a forest road network. Besides, inland Daday FE was also selected because of the existence of a new generation Tajfun MOZ 500 GR yarder in their machinery park. Although yarders are the preferred specialized equipment used in logging when forests on difficult topographies need to be harvested, they have only been effectively used in Northeast Türkiye, as if the rest of Turkish forests were on favorable grounds.

New 5 m national Turkish DEM, produced by General Directorate of Mapping (GDM), and 2014 geodatabase of Kastamonu RDF were used. DEM was produced utilizing the stereo captured air photos. After Yilmaz and Erdogan (2018) showed over some sample locations placed in various parts of the country that such a national DEM could be generated, GDM with its immense stereo air photography achieve, which have also been used to produce the topographic maps in various scales for 6 decades, actually attempted and successfully produced it. DEM was acquired as elevation values reduced to ortometric heights and projected to UTM-WGS84 projection. DEM was a representation of the land, through which the slope at any given location could be calculated. Later, land forms depicted in 5x5 m grid cells in the DEM were characterized based on the variability of the slope in their surroundings.

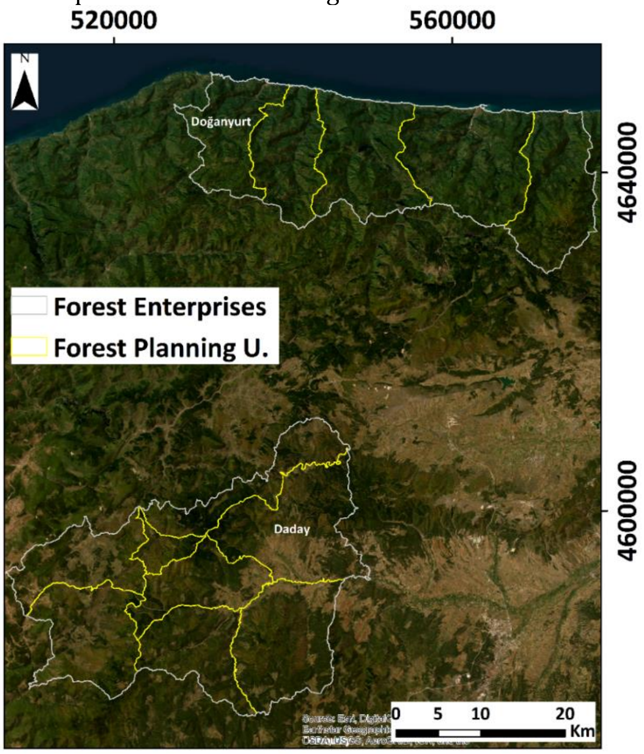

Figure 1. Studied planning units

Topographic roughness is just another topographical parameter, which can be added to the long list of what one could produce with an elevation data. Practicality of it was highlighted in this study because DEMs, especially the recently introduced high-resolution ones, have started providing unprecedented detail, which could easily be translated to whatever is intended.

Topographic roughness is another parameter which could be calculated over a DEM, showing if the calculated slope value of a cell is uniform throughout a neighborhood or not. It could very well define not only the slope but also how that slope stays the same or changes in a region (compartments or sub-compartments in a forestry setting). Given the amount of how favorably or steeply slope values are assigned to those 25 m^2 DEM cells and how varied those slope values are, foresters can decide which equipment or infrastructure might be appropriate to effectively manage and harvest the forests. To do this, 5 m DEM was first converted to slope on a projected flat plane using a 2D Cartesian coordinate system, specifying the inclination of the slope as percent rise. Then, the resulting slope map was reclassified defining equal intervals at 1%. Finally, statistics were performed on the reclassified slope map, using a 3x3 cells configuration, calculating the slope varieties (the number of unique values) of the cells within their immediate neighborhoods. The results showed how each and every cell in the finalized map was rated in terms of terrain roughness between 1 and 9 (1-3, rather flat surfaces; 4-6 moderately varied surfaces; 7-9 excessively varied surfaces), depending upon the changing slope values (Figure 2). Analyses were performed by using ArcGIS 10.8.

This study was conceptualized on the existence of both such a DEM, and a known and long-neglected, but reintroduced new machinery to Turkish forestry, yarder. Two forest planning units from Daday and Inebolu FEs, Daday and Doğanyurt were selected based on the elevation differences acquired by subtracting the lowest elevation measurement from the highest one (Table 1).

Table 1. Elevation differences within planning units of Daday and Inebolu and timber production figures of 2022

Forest Enterprise	Planning Unit	Low	High	Difference	Production (m^3)
Daday	Karacaoren	900	1640	740	22299
	Saricam	820	1519	699	20729
	Camkonak	761	1585	824	15331
	Camlibel	889	1491	602	12592
	Yayla	860	1677	817	15856
	Daday	802	1744	942	15212
	Ballidag	896	1739	843	18500
Inebolu	Doganyurt	0	1176	1176	8344
	Gemiciler	0	687	687	14074
	Inebolu	0	415	415	8011
	Ozluce	0	1047	1047	9849
	Altinkum	0	400	400	9855

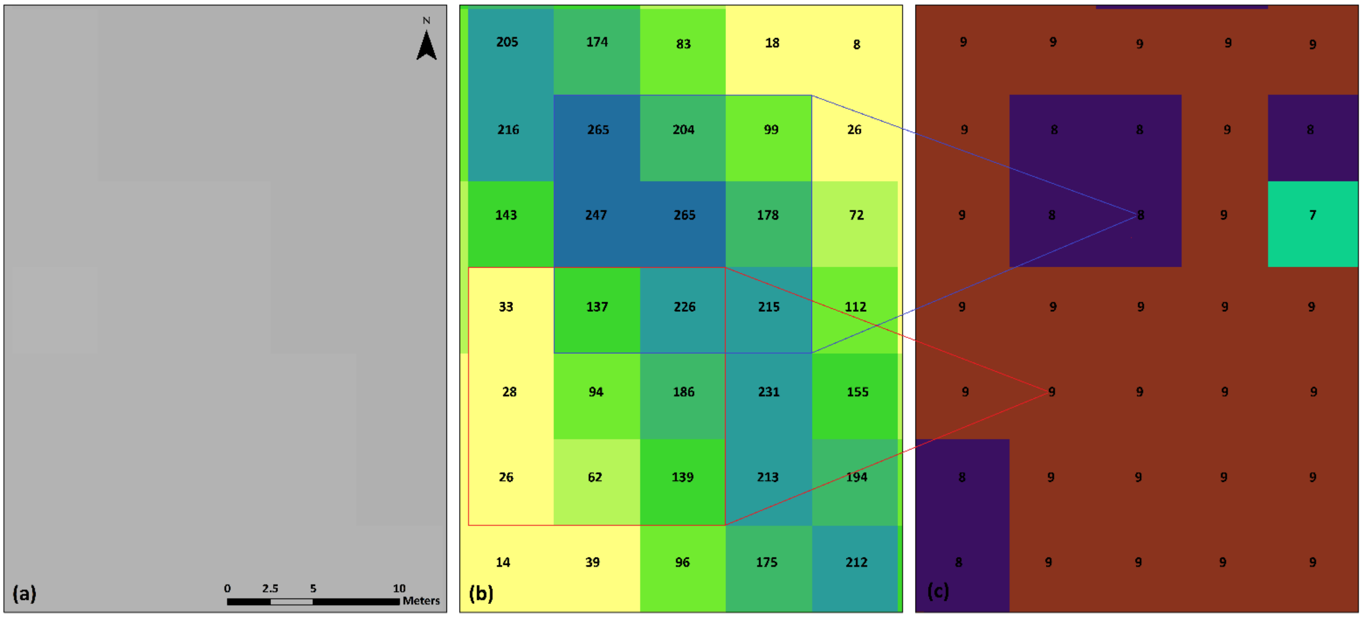

Figure 2. 5 m national DEM (a), reclassified slope map at 1% intervals (b), calculated terrain roughness values (c)

Both Daday and Doganyurt planning units yielded the highest elevation differences among the others in their respected FEs.

3. Results and Discussion

5 m national DEM custom tailored to Daday and Doganyurt planning units' administrative forestlands produced the following acreages. When investigated through the current Kastamonu RDF geodatabase, it was observed that Daday and Doganyurt planning units spanned over 16808 ha and 10228 ha land areas, respectively. Compared to Daday's moderately expanding land area over 55% gradient, 13.2 %, Doganyurt's land area amassed 41.4 %, which was rather steep in a considerably less administrative domain. 2022 production figures showed that Daday planning unit almost doubled the amount produced in Doganyurt. One might think how much of this production was done using ground skidding and winching, and how much using the yarder. In either case, a proper and sufficient road infrastructure is needed for forest management, but a threshold should not ever exceed if proper mechanization is simultaneously integrated. No further detailing was performed, but it was concluded that given the absence of a yarder, Doganyurt's forest land area would have been furnished with forest roads if production were to continue. Roads were regarded as techno-ecosystems, which require in-depth analyses of their would-be effects prior to laying them down (Lugo and Gucinski, 2000). Jordan et al. (2010) stated that risk assessments should be carried out before forest roads are actually placed especially in steep topographies. Thanks to the high-resolution, such assessments could surely be considered and evaluated through the 5 m national DEM, because 5 m width and length of a cell could perfectly align with the proposed road platform of a type-B forest road, and upslope and downslope areas around the platform could be further investigated before the actual road construction begins.

We also checked how the slope values of each 5 m cell varied with respect to the neighboring ones. Grohmann et al. (2010) defined the topographic roughness as a representation of the variability of topographic surfaces, e.g. changing slope values in the surfaces expressed in 5 m cells in this study. DEMs are used to extract numerous topographic parameters (Woodrow et al. 2016; Kruk et al. 2020). High resolution in DEMs provided improved flood inundation predictions (Saksena and Merwade, 2015). We calculated both topographic roughness acreage (ha) and percentage (%) for Daday and Doganyurt planning units (Table 2).

Values affirmed the hardship experienced in Doganyurt with respect to those displayed for Daday. Difficult topography might require specialized equipment to do logging and timber production. Depending upon the findings materialized in this study, there must be many planning units across the country seeking more than ground skidding and excessively and unnecessarily built forest roads to manage their forests. It is also obvious that the new 5 m national DEM of Türkiye is more than capable of producing detailed topographical works, which were impossible to accomplish in the past.

Table 2. Topographic roughness acreage and percentage by planning units

Planning Unit		Flat surfaces	Moderately varied surfaces	Excessively varied surfaces
Doganyurt	ha	162	1684	8382
	%	1.6	16.4	82
Daday	ha	2102	4690	10016
	%	12.5	28	59.5

Acknowledgement

We thank Kastamonu Regional Directorate of Forestry and General Directorate of Mapping for supplying their valuable data.

References

Alsdorf, D. E., Rodríguez, E., & Lettenmaier, D. P. (2007). Measuring surface water from space. Reviews of Geophysics, 45(2), RG2002.

Altunel, A. O. (2018). Suitability of open-access elevation models for micro-scale watershed planning. Environmental Monitoring and Assessment, 190(9), 512.

Altunel, A. O. (2023). The effect of DEM resolution on topographic wetness index calculation and visualization: An insight to the hidden danger unraveled in Bozkurt in August 2021. International Journal of Engineering and Geosciences, 8(2), 165-172.

Akturk, E., & Altunel, A. O. (2019). Accuracy assessment of a low-cost UAV derived digital elevation model (DEM) in a highly broken and vegetated terrain. Measurement, 136, 382-386.

Gallant, J. C., & Read, A. (2009). Enhancing the SRTM data for Australia. Proceedings of Geomorphometry, 31, 149-154.

Grohmann, G., Kroenung, G., & Strebeck, J. (2006). Filling SRTM voids: The delta surface fill method. Photogrammetric Engineering and Remote Sensing, 72(3), 213-216.

Grohmann, C. H., Smith, M. J., & Riccomini, C. (2010). Multiscale analysis of topographic surface roughness in the Midland Valley, Scotland. IEEE Transactions on Geoscience and Remote Sensing, 49(4), 1200-1213.

Jordan, P., Millard, T. H., Campbell, D., Schwab, J. W., Wilford, D. J., Nicol, D., & Collins, D. (2010). Forest management effects on hillslope processes. Compendium of forest hydrology and geomorphology in British Columbia. BC Min. For. Range, pp. 275-329.

Kruk, E., Klapa, P., Ryczek, M., & Ostrowski, K. (2020). Influence of DEM elaboration methods on the USLE model topographical factor parameter on steep slopes. Remote Sensing, 12(21), 3540.

Lehner, B., Verdin, K., & Jarvis, A. (2008). New global hydrography derived from spaceborne elevation data. Eos, Transactions American Geophysical Union, 89(10), 93-94.

Ling, F., Zhang, Q. W., & Wang, C. (2007). Filling voids of SRTM with Landsat sensor imagery in rugged terrain. International Journal of Remote Sensing, 28(2), 465-471.

Lugo, A. E., & Gucinski, H. (2000). Function, effects, and management of forest roads. Forest Ecology and Management, 133(3), 249-262.

Muhadi, N. A., Abdullah, A. F., Bejo, S. K., Mahadi, M. R., & Mijic, A. (2020). The use of LiDAR-derived DEM in flood applications: A review. Remote Sensing, 12(14), 2308.

Mukherjee, S., Mukherjee, S., Garg, R. D., Bhardwaj, A., & Raju, P. L. N. (2013). Evaluation of topographic index in relation to terrain roughness and DEM grid spacing. Journal of Earth System Science, 122, 869-886.

Reuter, H. I., Nelson, A., & Jarvis, A. (2007). An evaluation of void-filling interpolation methods for SRTM data. International Journal of Geographical Information Science, 21(9), 983-1008.

Saksena, S., & Merwade, V. (2015). Incorporating the effect of DEM resolution and accuracy for improved flood inundation mapping. Journal of Hydrology, 530, 180-194.

Woodrow, K., Lindsay, J. B., & Berg, A. A. (2016). Evaluating DEM conditioning techniques, elevation source data, and grid resolution for field-scale hydrological parameter extraction. Journal of Hydrology, 540, 1022-1029.

Yilmaz, A., & Erdoğan, M. (2018). Designing high resolution countrywide DEM for Turkey. International Journal of Engineering and Geosciences, 3(3), 98-107.