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VISUALIZATION OF GEODYNAMIC CHANGES OF TERRAIN USING GOOGLE EARTH PRO AND QGIS

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ABSTRACT

The paper presents a way of visualizing terrain changes in the observed time period, caused by natural disasters such as landslide. The application of the Google Earth Pro application for generation of DSM (Digital Area Model) data is presented, and the software package Qgis with accompanying tools was used for analysis, modelling and visualization of the obtained data. The settlement of Umka in the city municipality of Čukarica in Belgrade was adopted as an area of interest. Part of Umka territory is a landslide, a geodynamic process which is considered a natural disaster. Thus, as such, it is interesting to monitor changes in the terrain over time period. Changes were monitored within intervals of 8 years, for a period of 2011 to 2019. In Google Earth Pro, DSM was generated via isohypses. Data were generated for different dates using Historical imagery option and compared over time. Obtaining DSM through isohypses in this manner is an efficient and cheap way to obtain terrain data. Therefore, despite certain inaccuracies compared to standard practice, it can be applied in cases where a high level of accuracy is not required, and it is necessary to prepare data in a short time. The method presented in this paper is suitable for a preliminary review of the condition of the terrain, without the need for more demanding procedures.

The processing of the generated DSM was performed with Qgis software application. For the selected area of interest, the DSM data was exported from Google Earth Pro and loaded into Qgis. By applying the existing tools, additional terrain analyzes of the area were performed. As a result, terrain models are presented, showing clearly visible changes that occurred within a given time period. The described procedure itself provides several important advantages compared to standard procedures: the use of freeware, rapidity of obtaining results, simultaneous visualization of changes, simplicity of the procedure and obtaining results accurate enough for immediate evaluation of the situation on site. In addition, due to its illustrative nature, this method can be used for educational purposes.

Keywords: DSM, isohypses, Qgis, Google Earth pro, landslide

1. INTRODUCTION

The surface of the planet Earth is constantly changing due to the action of various atmospheric and geodynamic processes, such as erosion, volcanism, tectonic disturbances, etc. Since these processes have been active, practically since the formation of the Earth as a planet, there is a need to register changes, learn and understand their tendencies, in order to prevent possible catastrophes.

Topographic bases and Digital Surface Model (DSM) usually represent input data for analysing geodynamic processes (landslides, floods, etc.). However, such information has its limitations and most users rely on official topographic bases and ready-made digital surface models, most often by state institutions. In the last decade, images obtained from satellite images are more and more used as topographic bases. The development of computers and high-performance computer systems has contributed to the increasing use of high-resolution images and geographic information systems that are used as security intelligence, marketing products, but also in scientific research (Gorelick et al., 2017).

Google Earth Pro has positioned itself at the forefront of this wave of spatial information by providing free access to high-resolution images through a simple, user-friendly interface (Fisher et al., 2012; Mutanga et al., 2019). The use of high-resolution images is very common in search of tourist places, education and space visualization. However, studies that use high-resolution images to gain quantitative insight into the processes and mechanisms that act on the Earth's surface over time, are not abundant. When it comes to the accuracy of satellite imagery used by Google Earth Pro, (ANATUM, 2019; Goudarzi et al., 2017) state that the accuracy of aerial imagery in urban areas could average about 0.5 m. In rural areas, the accuracy could be on average 1 to 1.5 m, or even lower. In Gorelick et al. (2017) examine the accuracy, which examines the accuracy of Google Earth Pro images across the city of Montreal, Canada, and the authors found that the accuracy in some parts of the city is about 0.1 m, but in other parts of the city even 2.7 m. Also, in research Zomrawi et al. (2013) shows Root Mean Square Error (RMSE) which is calculated by comparing the measured coordinates of points with the geodetic Global Positional System (GPS) receiver coordinates that provide accurate coordinate measurement on the same ellipsoid as Google Earth. This information can be used to verify the accuracy of Google Earth. RMSE was computed for horizontal coordinates and was found to be 1.59 m. For height measurement RMSE was computed to be 1.7 m.

This paper presents a research on a zone of the settlement of Umka, which belongs to the Belgrade municipality of Čukarica and represents a zone of pronounced landslide that endangers the infrastructure and built facilities of this place. Therefore, as such, it is an interesting area to monitor and track changes that are taking place. The changes were monitored in an interval of 8 years, for the period from 2011 to 2019. Based on previously conducted research (Erić et al., 2015; Samardžić-Petrović et al., 2020; Abolmasov et al., 2017; Abolmasov et al., 2020) in the area of the Umka landslide, permanent GNSS monitoring shows horizontal and vertical displacement. During the first time period (March 2010 - December 2013), the total 2D shift was 84 cm to the northwest, and the vertical shift was almost -30 cm. During the second time period (September 2014 - December 2018), the point of the object moved 63 cm to the northwest, and the vertical movement was almost -16 cm. In general, the Umka landslide moves continuously and significantly towards the northwest, ie towards the Sava River. The average annual 2D displacement was approximately 22 cm and 15 cm, for the first and second time periods, with the same direction of movement.

This paper proposes an alternative method of obtaining DSM data for a wide area as opposed to traditional geodetic methods that involve time-consuming and expensive work. The application of Google Earth Pro for generating DSM data is presented, and the software package Qgis with accompanying tools was used for analysis, modelling and visualization of the obtained data. The advantage of this application is reflected first of all in the facility of its usage, and also in its public availability.

2. METHODOLOGY

The Umka landslide (*Fig 1*) was chosen as the study area due to its geodynamic nature, and for many years the landslide flow has been monitored by various geodetic methods. Traditional geodetic methods include terrestrial data collection methods, but also include the processing of aerial and satellite images.

In recent years, the landslide has been monitored using high-resolution digital terrain models obtained by processing aerial images. One of the methods of visualizing geodynamic changes in the terrain is the generation of DSM based on satellite images from which data on the height of the terrain are collected and loaded into the appropriate CAD or GIS software.

The Umka landslide is a very old landslide and its origin and development is related to the geological structure of the terrain and the centuries-old evolution of the Sava River. It is positioned between two cities in Serbia: Belgrade, the capital city, and Obrenovac, of just over 70,000 inhabitants, settled along the right bank of river Sava. The speed and magnitude of terrain deformation is complex and closely related to the shapes and depths of the landslide body, the depth of the Sava riverbed, and the groundwater and surface water regime. As a rule, the largest and fastest deformations follow the parts of the coast where the depth of the Sava riverbed is about 20 m (Mitrović et al., 2006).

This area includes the settlement of Umka, which is dominated by built and agricultural land. Also, a state road of the first order passes through this settlement, which connects Belgrade with Podrinje and, further, with Sarajevo in Bosnia and Herzegovina. The effects of landslides on this area rich in agricultural land are of great importance for monitoring the direction in which the landslide is moving. For the selected area in this study, it was necessary to collect terrain elevation data based on Google Earth Pro images for the mentioned period.

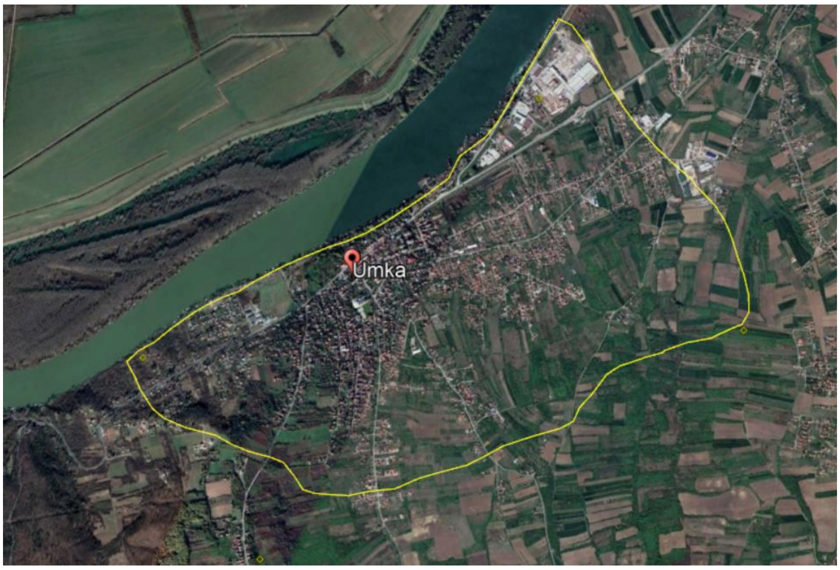
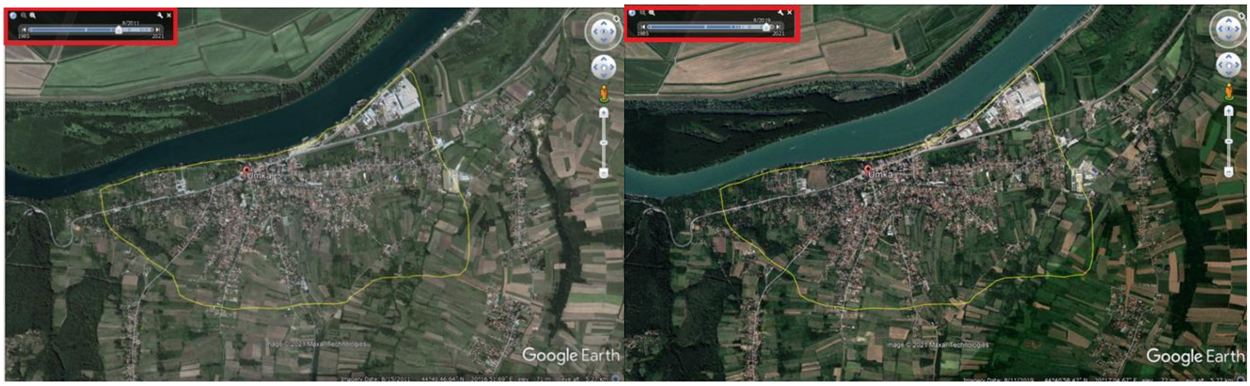


Figure 1: Boundary of the Umka area

Landslides can be observed through developed landslide identification criteria from Google Earth Pro and a method for estimating accuracy has been introduced (Rabby et al., 2019), this paper presents a similar approach that has an advantage in the availability of high-resolution images in Google Earth Pro allows visual interpretation, but also alternative collection of terrain data.

The basic principle of this method is the identification of landslides and the collection of data on the height of the terrain. Terrain identification was done by forming a polygon that includes a landslide and drawing a dense network of nets through the terrain profile, in order to collect terrain height data. Changes in the field can be tracked based on satellite images for specific periods. There is a *Historical Images* option in Google Earth Pro that allows one to view older satellite images (at one-month intervals). Data is generated for time period 08/2011 (*Fig 2a*) and 08/2019 (*Fig 2b*), to monitor changes in terrain height based on DSM and terrain isohypses.



(a) (b)

Figure 2: (a) Area of Umka landslide from 08/2011 (b) Area of Umka landslide from 08/2019

The plot profile was drafted by drawing lines (*Path* command) approximately parallel to the boundaries of the chosen landslide area, so that the entire area of interest is covered with a grid, in order to achieve as much detail as possible. The denser the grid, the greater the accuracy of the collected data for the DMS formation is obtained. For each plotted profile within Google Earth Pro, a display with data on altitude, distance (from the starting point of the trajectory), maximum slope and averaged terrain slope is automatically obtained (*Fig 3*).

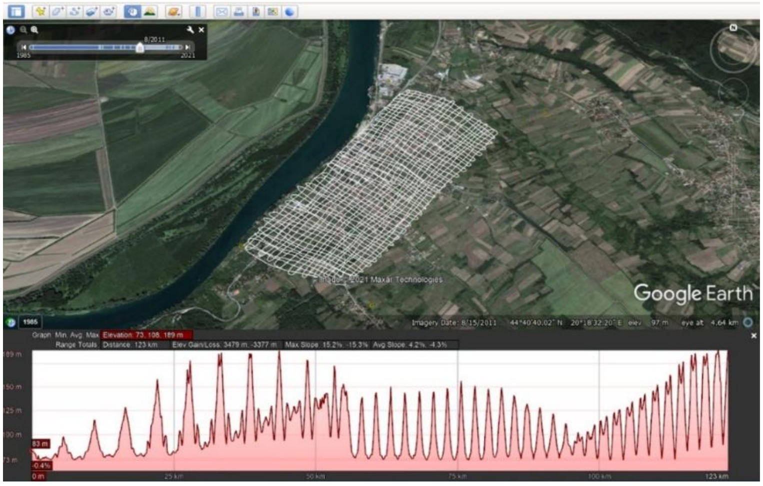


Figure 3: Histogram with data from 08/2011 on terrain height, distance and slope

The generated data is saved within a *.kml* file and then loaded into the Qgis software as characteristic terrain profile points. Each of the points has position and altitude coordinates and as such is used as input data to create the DSM (*Fig 4*).

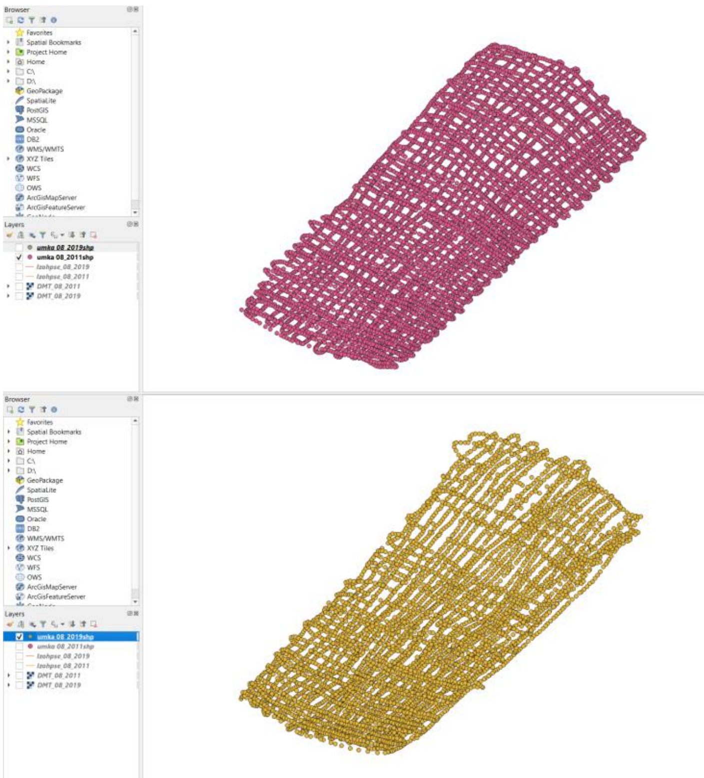


Figure. 4: Characteristic profile points for 08/2011 (top) and 08/2019 (bottom)

To create DSM in Qgis software, the *Natural Neighbour* [5] function was used (*Fig 5*), where the input data is a *.shp* file with characteristic profile points, an attribute by which interpolation is performed (terrain height) together with the size of the output cell (*Fig 6*).

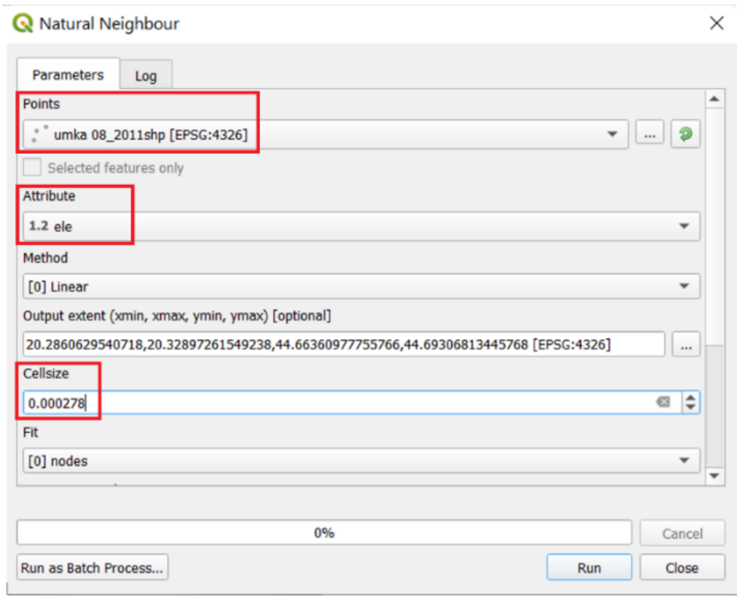


Figure 5: Natural Neighbour

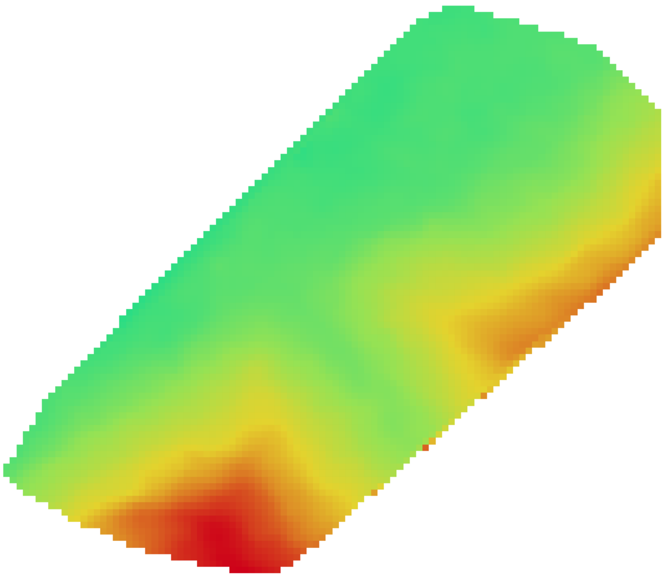


Figure 6: Generated DSM 08/2011

Fig 7 shows the generated DSM for the 08/2011 time period, which resulted in a range of terrain heights from 67.12 m to 187.66 m. Also, the DSM generated for the 08/2019, resulted in an identical terrain height range. The DSM served as a basis for extracting the isohypsis of the terrain, which allows a clearer idea of the height of the terrain.

[5] Natural Neighbour method for grid interpolation from irregular distributed points.

Extraction of terrain isohypses was performed using the *Contour* function, which requires DSM and isohypsis equidistance as input data (*Fig 8*).

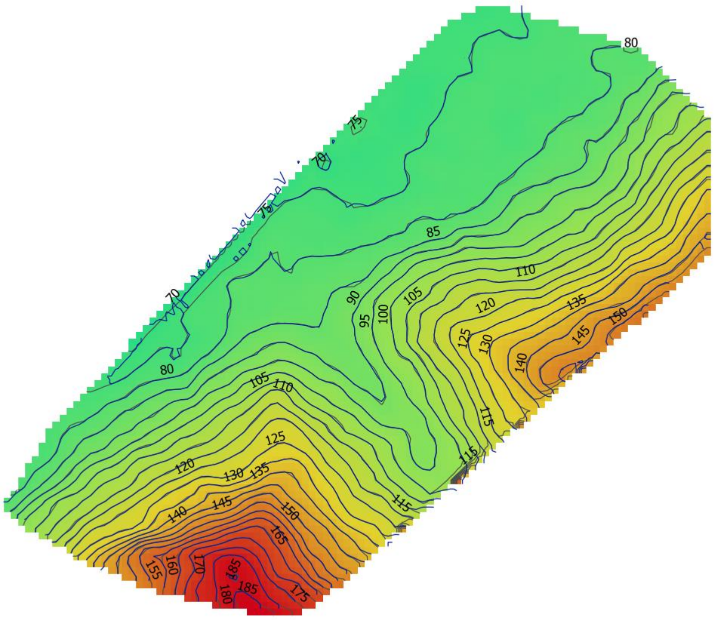


Figure 7: DSM and isohypses

3. RESULTS

The extracted isohypses for both periods are shown on the DSM base. Isohypses are different because they are generated on the basis of DSM which has different height values at identical points of different periods. Thus, it can be concluded that in certain parts of the area there is a mismatch of isohypses (*Fig 8*), which can be interpreted as a consequence of moving the landslide itself, but it should be borne in mind that the results are burdened by path creation error in Google Earth Pro and DSM generation error.

The difference between isohypses can be approximated by the minimum distance between the same isohypses for the two periods 08/2011 and 08/2019. *Fig 9* shows an example of a possible displacement of the terrain, from which we can see globally that in this part there was a displacement of the terrain at the meter level (specifically, 1.798 m was measured). Such data must be taken with a grain of salt because, depending on the input data, the accuracy of the DMS development also depends. Certainly, we see that the aberrations exist and that such large deviations surely signal the movement of the soil and consequently the shift of isohypses that describe it.

The advantage of the applied methodology is that in a short time interval we get information on whether there are terrain changes in an area, which is of great importance due to the disturbance of terrain morphology, and it affects the construction potential of the area, agricultural development, and many possibilities of such terrain.

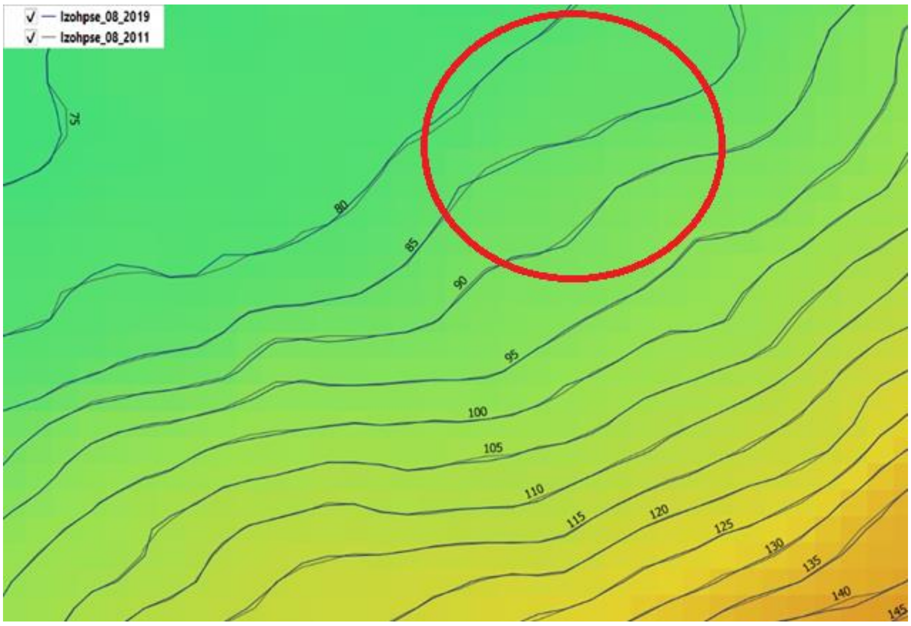


Figure 8: Isohypses from the periods 08/2011 and 08/2019 overlapped

Figure 9: Minimum distance between the same isohypses from the periods 08/2011 and 08/2019

By applying the described methodology, satisfactory results were obtained. Terrain models with clearly visualized changes in topography due to landslide shifts are displayed, observed within a given time period.

4. CONCLUSIONS

Based on the obtained results, it can be concluded that the use of Google Earth Pro in combination with Qgis software has a number advantages over standard procedures, when it comes to visualizing and presenting changes that occur in the field. The use of open source / freeware, high speed of obtaining results, simultaneous visualization of changes, as well as the simplicity of the procedure itself make this methodology acceptable and competitive for the mentioned purpose. In addition, due to its illustrative nature, this methodology can also be applied for educational purposes. On the other hand, the limiting factor in the application of this method is the somewhat lower accuracy of DSM generation.

Visual interpretation of the landslide using images taken from Google Earth Pro shows that the development of such a landslide in the future leads to great damage to human society, which is reflected in the infrastructure, then in arable land and roads. Applying this methodology, many professions can very quickly and efficiently have an insight into the areas affected by natural disasters, which is of great importance for companies that want to invest in an area.

Due to slightly lower accuracy compared to geodetic measurements, this method can be used as a preliminary testing phase, where only the landslide is determined and to what extent, which could be useful to the casual, non-professional user when choosing a location for their activity, e.g. construction, agriculture or similar without hiring expensive experts (for example, if you are just deciding to buy, in order to reduce the investment risk).

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REFERENCES

1. Abolmasov, B., Marjanović, M., Milenković, S., Đurić, U., Jelisavac, B. and Pejić, M., 2017. *Study of Slow Moving Landslide Umka Near Belgrade, Serbia (IPL-181). Advancing Culture of Living With Landslides,* Vol 1: Isdr-Icl Sendai Partnerships 2015-2025. pp 419-427.
2. Abolmasov, B., Đurić, U., Popović, J., Pejić, M., Petrović, M.S. and Brodić, N., 2020. *Results of Recent Monitoring Activities on Landslide Umka, Belgrade, Serbia—IPL 181. In Workshop on World Landslide Forum*. pp 225-234.
3. ATATUM, 2019. https://www.agsgis.com/Advanced-Mobile-Mapping-Series-Why-Does-My-GPS-Data-and-Imagery-Not-Line-Up_b_1062.html [Accessed: 31 st July 2021].
4. Erić, V., Božić, B., Pejić, M., Abolmasov, B. and Pandžić, J., 2015. Permanent geodetic monitoring of the Umka Landslide using GNSS technology and GeoMoss system. Abstract book / 2nd Regional Symposium on Landslides in the Adriatic-Balkan Region : 2nd ReSyLAB 2015. Vol. 1 University of Belgrade, Faculty of Mining and Geology, Belgrade. pp 39-39.
5. Fisher, G. B., Amos, B. C., Bookhagen, B., Burbank, W. D., and Godard, V., 2012. *Channel widths, landslides, faults, and beyond: The new world order of high-spatial resolution Google Earth imagery in the study of earth surface processes. Geological Society of America Special Papers 492,* no. 01. pp 1-22.
6. Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D. and Moore, R., 2017. *Google Earth Engine: Planetary-scale geospatial analysis for everyone. Remote sensing of Environment 202*. pp 18-27.
7. Goudarzi, M. A., and Landry, R. J., 2017. *Assessing horizontal positional accuracy of Google Earth imagery in the city of Montreal, Canada. Geodesy and Cartography*, 43(2). pp 56-65.
8. Mitrović, P. and Jelisavac, B., 2006. *Sanacija klizišta 'Duboka'. Materijali i konstrukcije,* 49(1-2). pp 46-59.
9. Mutanga, O. and Kumar, L., 2019. *Google Earth Engine Applications. Remote Sensing,* 11(5). pp 591.
10. Rabby, Y. W., and Yingkui, L., 2019. *An integrated approach to map landslides in Chittagong Hilly Areas, Bangladesh, using Google Earth and field mapping*. *Landslides 16*, no. 3. pp 633-645.
11. Samardžić-Petrović, M., Popović, J., Đurić, U., Abolmasov, B., Pejić, M. and Marjanović, M., 2020. Permanent GNSS monitoring of landslide Umka. XIV International Conference On Contemporary Theory And Practice In Construction XIV Stepgrad XIV Proceedings, 2020. University of Banja Luka Faculty of Architecture, Civil Engineering and Geodesy.
12. Zomrawi, N., Ahmed, G. and Eldin, M., 2013. *Positional accuracy testing of Google Earth. International Journal Of Multidisciplinary Sciences And Engineering*, vol. 4, no. 6. pp 6-9.