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STUDY ON THE USE OF LAND SCANNING IN SOIL EROSION INVENTORY WORKS FOR SUSTAINABLE AGRICULTURE IN AGRITOURISTIC FARMS

Jenica CĂLINA, Aurel CĂLINA, Marius MILUȚ, Gabriel BĂDESCU, Marius CIOBOATĂ

University of Craiova, Faculty of Agriculture, 19 Libertatii Street, Craiova, Romania

Corresponding author email: aurelcalina@yahoo.com

Abstract

The paper presents a modern, precise and fast method of lifting land areas affected by deep soil erosion, from an agritourism farm, by using land scanning technology. The method allows to take as much information as possible about the object to be scanned, and based on the records made is obtained the so-called "point cloud", which is a collection of points, defined as position by the coordinates X, Y, Z in a common reference system, which reveals to the observer information on the shape, position, and spatial distribution of an object or group of objects. From the point cloud with the help of the specialized program, based on the coordinates you can easily and accurately calculate the size and shape of land areas affected by erosion, thus creating a complex database of land that may be affected by this phenomenon. Also, from the database obtained, thematic maps can be created that can be used in other works on agricultural farms, in order to practice a modern agriculture such as precision agriculture, which would effectively contribute to soil conservation and protection, so to practicing sustainable agriculture.

***Key words**: coordinates, inventory, land scan, point cloud, sustainable agriculture.*

INTRODUCTION

It is known from the literature that the soil is subjected to a series of degradation processes. Some of these processes are closely related to agriculture: water erosion, wind erosion and agricultural soil preparation works; compaction; decrease in the amount of organic carbon in the soil and soil biodiversity (Răduţoiu et al., 2013, 2018). In the factsheets, special attention is paid at European level to water erosion and compaction, the reduction of soil organic matter, as well as salinisation and sodisation. Soil degradation processes involve the need to protect, maintain and improve soil quality (Burghilă et al., 2016). Soil properties, as well as soil formation factors such as climate, land use or soil management determine the degree of soil degradation (Călina & Călina, 2019).
Cross-compliance is part of the common agricultural policy, with many implications for soil conservation and refers to the requirement to keep land in good agricultural and environmental condition (BCAM). This applies to direct income support payments, as well as to most environmental payments applied in rural development. The BCAM requirement refers to a number of standards related to protection against soil erosion, conservation of organic matter and soil structure, avoidance of habitat damage and water management. Reducing the area of barren soil and terracing the land for consolidation directly contributes to preventing soil erosion (Iagăru et al., 2016).
Given the above and the fact that erosion processes tend to have a negative impact on ecosystems and in land use decision-making, the team of researchers set out to conduct this study, which will assess the erosion process using old and new data, state-of-the-art topo-geodetic methods and data, such as land scanning that have been introduced into a complex but easy-to-use mathematical system to calculate affected agricultural land areas.
This new laser scanning measurement method involves sampling or scanning a field surface using laser technology. It analyzes a real world environment or an object in order to collect information from its surface and possibly from its appearance (eg color). The collected information can then be used to construct two-dimensional representations or three-dimensional models, usable in a wide variety of applications (Pop et al., 2019).
Through this study we want to highlight the large areas of land that are removed from the

agricultural circuit by soil erosion, due to irrational exploitation by practicing a super-intensified agriculture. From the previous studies we found that this phenomenon is also manifested in agritourism farms, because so far and here the aim has been to obtain high yields at the expense of sustainable agriculture (Adamov et al., 2020) with a crop technology environmentally friendly, which will preserve the soil and even improve some agroproductive properties (Călina & Călina, 2019).

MATERIALS AND METHODS

In solving the approached topic, the technology of Terrestrial Laser Scanning (S.L.T.) was used, which tends to "revolutionize" the measurement techniques in Topography and Engineering Topography (Calinovici & Călina, 2008). The use of this technology allowed the rapid and accurate determination of the surface of a formation that appeared on an agricultural surface, following deep erosions. As with any measurement process encountered in the technique of topographic measurements and in this case the planning or preliminary design is an extremely important step, decisive in obtaining the results, respectively the information needed to describe the object to be scanned (Kolbe et al., 2011).

The design stage is indispensable for the measurement process and due to the fact that in this stage the shape and size of the object are balanced, its position in the environment and last but not least, the requirements of the beneficiary regarding the accuracy to be obtained in the end at the object reprezentation (Li et al., 2009).

After a rigorous design, it was concluded that the following phases must be completed: - definition of the area to be scanned and preliminary investigations; - determining the resolution and accuracy required for the points that make up the point clouds, depending on the beneficiary's sorting; - selecting the type of laser scanner to be used, depending on the specifics of the work we intend to perform; - designing the optimal positions of the station points for scanning, starting from the premises of providing the necessary coverages to ensure the accuracy and the need to scan the entire object; - the choice of the type of targets to be used in the georeferencing registration operations and of the positions in which they will be located, in such a way as to ensure the premises of an optimal geometric configuration for georeferencing; - estimating the volume of data that will be acquired during the scanning process (Remondino et al., 2010).

In the case of the relief form studied, it was considered that the use of terrestrial laser scanning is the most optimal due to the following reasons: - very complex surface structure; - presentation of the final 3D product; - measuring the surface instead of measuring the individual points; - the recorded data can be used by multidisciplinary teams, for different purposes; - archiving data without having a priori knowledge, regarding their future use (Mihai et al., 2015).

Stage I. *Analysis of the area to be scanned*

Retrieving as much information as possible about the object to be scanned can provide information about the complexity and time required for such an operation. Field information, reports, existing maps, photographs or video images of the location of the object to be scanned can greatly help determine the possible risks when scanning the object (Paunescu et al., 2020). However, it is also very important to analyze the area, the surroundings of the respective location. Possible obstructions determine the choice of station point positions. Possible time constraints are also decisive in choosing the methods and timing of the scan. Indirectly, the positions of the station points determine the minimum and maximum distances that the scanner could record.

Stage II. *Determining the optimal positions for scanning*

Once the site documentation has been analyzed and laser scanning has been chosen as the most effective recording technique, the scanning positions and those in which the aiming targets will be placed must be designed (planned). The choice of the optimal positions of the station points must guarantee maximum coverage and accuracy but also a minimum number of station points.

When designing the optimal positions of the station points, the following basic rules must be observed: - the positions are chosen that offer a good (wide) coverage of the scanning area, without obstructions on the line of sight, which could produce the shading effect; - it is checked whether the distance limits are met, in order to increase the accuracy; - decrease in the number of scanning stations; - choosing scanning positions in places that ensure comfortable measuring conditions, free from vibrations and the influence of wind; - ensuring a convenient height of the device and ensuring visibility to natural and artificial targets.

Of particular importance in the measurement design phase, in addition to the optimal scanning positions, is the choice of target types, their position and / or geometric configuration. An important remark regarding the use of aiming targets is that they, placed in position, must have a large opening in all three directions of the axes (X, Y, Z).

Stage III. *Data management*

Given the very large amount of data that is collected during the scanning process, it is very important to scan the data so that it is ensured throughout a working day. The positioning accuracy of the image points, defined in the reference system of the station by spatial coordinates X, Y, Z is accredited at ± 6mm / 50m, considering the fact that at this distance the laser spot maintains its point diameter of 6 mm. Currently, there is no standard procedure for scheduling the terrestrial laser scanning session. Based on the records made, the so-called "point cloud" is obtained, which is a collection of points, defined as position by the coordinates X, Y, Z in a common reference system, which reveals to the observer information on the shape, position, and the spatial distribution of an object or group of objects (Călina et al., 2020). It may contain additional information, such as intensity. It can be concluded that the point cloud contains two types of information: - metrics, which describe the geometry of the object and its spatial relationships with the environment; - thematic, which are used to describe the surface properties of the scanned objects and to estimate the confidence given to the acquired data.

RESULTS AND DISCUSSIONS

The actual fieldwork began with the preparation phase of the measurements which includes the decision regarding the recording technique to be used. These techniques fall into three categories: free station, using the 3D intersection of visas to scanned targets, station at known coordinate points, and recording using constraint points from different point clouds.

The first operation performed in the field involved the placement of the scanner in the station, which generally follows the same procedures as in the case of any topogeodesic device: - placement of the tripod at a convenient height; - placing the scanner on a tripod; - centering, if necessary, using the optical centering device; - leveling the instrument.

Before setting up the scanner, it must be connected to the computer (laptop) that receives and stores all the data from the scanner and conducts virtually all scanning operations. Turns on the scanner and waits for it to acclimatize. The software component on the laptop starts. The connection is established between the computer and the scanner and between the controller and the scanner (using the IP address, USB cable, wireless connection, etc.).

After that, scan parameters were set by defining the 3D sections to be scanned using the scanner control options in the software component. This procedure involves taking a picture of the entire space (scan scene), which then allows you to select the scan area.

Choosing the right resolution is the key issue in carrying out a terrestrial laser scanning project. The resolution is defined as the distance between the points to be measured later, which ultimately determines the density of points in the point cloud. It should be noted that by choosing a high resolution it is necessary to scan more points and - consequently - increase the scanning time. Subsequently, the primary filtering was performed to ensure that the collected data falls within the accuracy limits of distance measurement, characteristic of the scanner. The other points, considered not to fall within the limits of accuracy, will be eliminated, due to the low values of the reflectance. After completing these steps, the scanning operation is conducted entirely by the specialized software of the instrument, without the need for operator intervention. Scanning in progress can be viewed on the computer screen. After the section is fully scanned, the data is saved in files created for that job.

Data acquisition, once the scanning area and the corresponding resolution have been established, can start the scanning operation. This process, as mentioned before, takes place completely automatically, led by the software component. After starting the scanning process, the scanner automatically goes to the starting point, starts purchasing points and - via the laptop - stores the data in the internal memory. Depending on the resolution chosen and the target area, the scanning process can take from a few minutes to hundreds of minutes. During this time, observations, descriptions and sketches of the area to be scanned can be made, which were not performed when designing the measurements.

Data collection and processing (3D point cloud) - modeling and visualization

Following the georeferencing recording operations, the resulting common point cloud enters the modeling process. The final product of this operation is represented by the 3D model of the scanned object (Călina et al., 2018). Point cloud processing involves the transformation of the raw point cloud into a final product, according to design requirements. These final products can be presented in a multitude of forms consisting of: cloud of points cleaned of noise, standard 2D representations (plans, elevations, profiles), complete 3D models suitable for various purposes.

In general, point cloud processing can be divided into two categories:-extracting the final products directly from the point clouds, without further processing;-first creating the 3D model of the surface from the point clouds and extracting the final products from this model (Vosselman & Maas, 2010).

The choice of one of the two methods depends largely on the final products required. For example, if a limited number of profiles is required, it is preferable that they be extracted directly from the point cloud. However, if a larger number of profiles is required (over 50, for example), the second method is more efficient, as there are options for automatically generating multiple profiles from a processed model. In addition, a surface pattern contains more information than a simple raw point cloud.

Representation of the point cloud

The result of the scan is an impressive number of points in space, each being characterized as a position by the X, Y, Z coordinates and - usually - by the value of the reflectance of the laser beam. A number of scanning systems even provide color information in the form of RGB values (Red, Green, Blue). The point cloud can be represented by projecting all these points on the screen (display), but this creates a first impression of chaotic image and the user finds it very difficult to recognize the structures or shapes in the point cloud. If each point is additionally characterized by reflective or color, the entire structure of the point cloud becomes virtually incomprehensible (Figure 1). Since the vast majority of measurement systems scan object space (the so-called scan scene) in columns and rows, one way to represent the point cloud could be - in the simplest possible way - as a projective view or as a map in depthmap (Sala et al., 2020).

Due to the fact that this type of representation also incorporates a lot of information about the neighboring environment / objects, it is useful to use point cloud processing algorithms that lead to its so-called organization. By using the complex triangulation algorithm (meshes), the neighboring points can be connected to the surfaces of the shape. It provides a closer representation of reality, because the structures of the surface or mesh are not transparent, therefore, the points behind others cannot be seen. By calculating the normal local directions of the surface, the artificial shadow can be used to highlight the details of the surface (Figure 1).

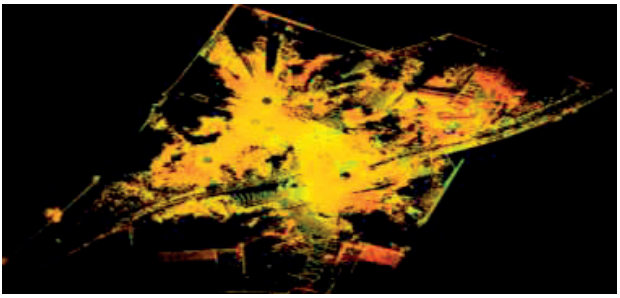

Figure 1. The point cloud of the surface

Improving data

The first step in the geometric modeling process using a polygonal network is to remove noise-containing data from the point cloud. If the noises were generated by the influence of the wind, poor quality reflection on the surface, etc., the polygonal network will contain triangles that connect the points affected by the noises with the correct ones. This results in the appearance of irregularities (peaks) in the 3D geometric model of the surface. It is very important to eliminate these point noises in the first steps of processing. Currently, an operator can easily identify portions of the scanned area that are not needed in the final product. Therefore, it is recommended that the operator make a first analysis of the point cloud and manually remove all unnecessary points from the data set (Chiabrando et al., 2009).

The automatic algorithm for eliminating points that are affected by noise is based on two principles: the first principle is based on the fact that points that have few or no other points in the immediate vicinity are considered erroneous (useless) (Rosca et al., 2020). These algorithms try to match (adjust) plans locally, on the points in the point cloud. If the center point is very far from the right plane, it is moved to the plane so as to ensure greater consistency of neighboring points. There are other noise filters, some specialized depending on the scanning system or others that eliminate systematic errors. It is of course necessary to consider the precautions when eliminating the points affected by noise, as the characteristics of the details may be lost in the event of over-uniformity of data or too many points may be eliminated.

Opening the point cloud

After the actual scan, the files are saved in the control unit (in our case, laptop) so that they can be opened and modified later.

To start working with scanned data in software such as Leica Cyclone, make a connection between the scan database containing the scanned information and Cyclone, - open Cyclone; - right-click on the (unshared) icon in the server list and select **Databases**. In the dialog box, click on the **Add** button, then on the **Database File name** and search to scan the database named: Ravine - Tutorial Inside –start - Reduced. imp or– Ravine Tutorial Inside - start.imp (full dataset). Select the "* .imp" file and press the **Open** button. Back in the previous dialog, just press the **OK** button and then click **Close** in the dialog. This takes us back to the Cyclone Navigator (Figure 2).

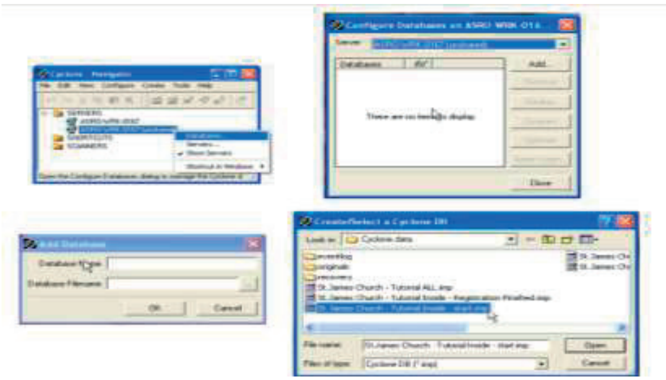

Figure 2. Uploading a database file to Cyclone

The Scans file contains each scan separately as raw information. Here, even scans made from the same position, but with different settings, are separated. The two most important files are: ControlSpace and ModelSpace. These files contain the data you are working with. Controlspace is the space that actually contains the data from the raw scan. Controlspace is used in all calculations, for example in recording. However, a security measure must be taken. A user cannot directly modify ControlSpace. It must modify ModelSpace and then copy the changes to ControlSpace. Modelspace is actually a photo of Controlspace. This gives 'View' on the control space at a certain time. It is impossible to have multiple Modelspaces performed at different times from a single Controlspace, (www.3driskmapping.eu).

Referencing scans from different angles

In most cases, scans are performed from multiple angles to obtain a complete scan of the object. Referencing consists of "gluing" scans from various angles to obtain the complete point cloud of the object, so that it can be used further (Figures 1 and 2). To combine (assemble) different scanner positions, the orientation and positions of the coordinate system relative to a local / global coordinate system in the area must be known.

In principle, each scan operation generates a cloud of points whose positions are characterized by coordinates (X, Z, Y) in an internal system of the scanner (Doneus et al., 2005). The scan was performed from several positions, it was necessary to represent it in a unique coordinate system (local system). Aiming targets are ideal accessories for overlapping images taken from different stations and quality assurance.

They are used for accurate georeferencing of scanning at checkpoints. Using the Create - Registration command, we will be able to reference the 2 scans.

We open the newly created referencing and add the 2 scans to the referencing. After adding the 2 scans to the referencing, we need to define a minimum of 3 common points of the 2 scans (targets) (Figures 3 and 4).

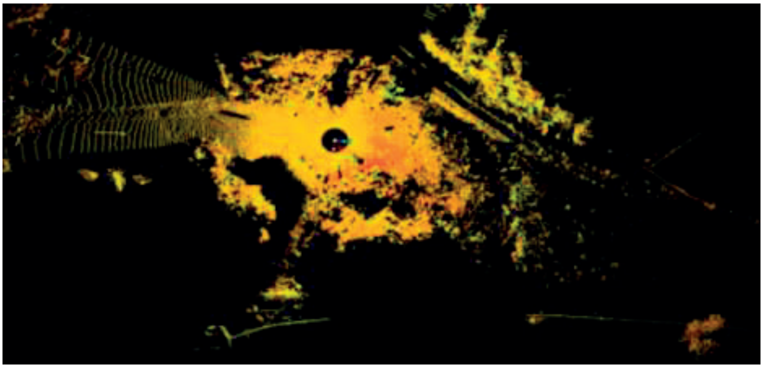

Figure 3. Scanning view from station 1

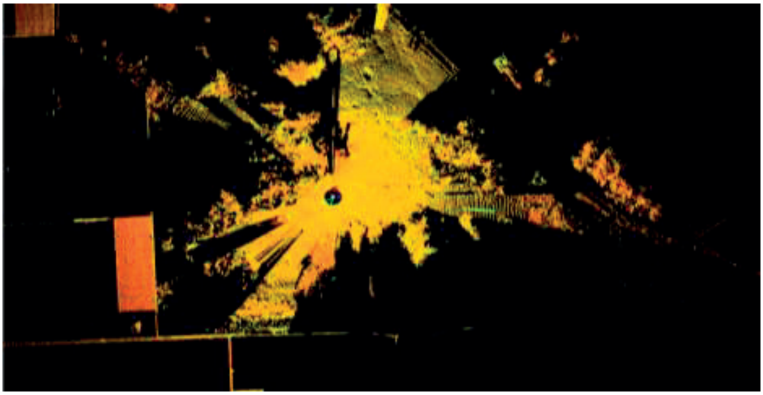

Figure 4. Scanning view from station 2

The common points of the scans must meet an important condition: they must be well defined in the point cloud, so that they can be easily identified in both scans (Figure 5). Generally, the corners or tips of the object are chosen. After choosing the common points and checking the object through the preview option, we can compile the two point clouds into one, to be used more easily.

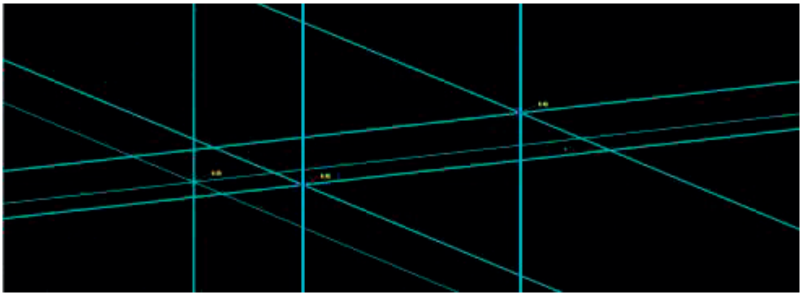

Figure 5. Viewing targets from 2 stations

When registering / georeferencing, there must be certainty that the error values of the whole process are at least equal to the required geometric accuracy of the final products. When targets are scanned at a very sharp angle, automatic target recognition features should not be used because they generate poor quality results.
The distribution of control points must correspond to an optimal geometry, their location must be as uniform as possible in the scanning space, otherwise situations of incompatibility may occur during the transformation.
The quality of the point clouds can influence the final result of the recording, for this reason it is necessary to filter through a preprocessing of the data sets, of the noise and of the gross errors. Finally, the 2 scans were 'glued', obtaining the overall image of the relief form as in Figures 6 and 7.

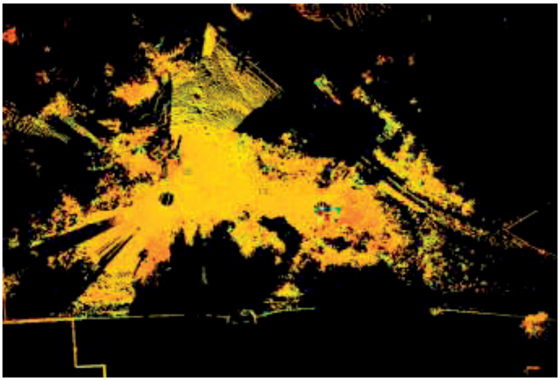

Figure 6. Recording of 2 scans: the point cloud in station 1, referenced with the one in station 2

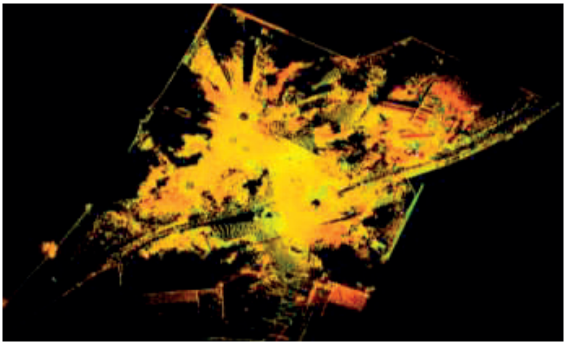

Figure 7. The point cloud of the relief form

Calculation of point coordinates in the local system

We worked in the local reference system, this explains the negative coordinates of the points. It was decided to work in this system because the purpose of the work was to determine the surface of the entire form of relief, and this is done equally regardless of the chosen reference system. It should be specified that due to the very large volume of points it was chosen to present only a small part of them, in facsimile (Tables 1 and 2).

Table 1. Target coordinates in relation to the local reference system X, Y, Z = 0.000 m

Target	Coordinates (m)		
	X	Y	Z
T1	-55.562	-30.563	-1.803
T2	-50.615	-14.576	-1.579
T3	-550.291	-31.294	-1.599
T4	-0.0168	-25.997	-1.087
T5	-0.144	-26.800	-0.680
T6	-1.575	-28.350	-0.980

Table 2. Scan point coordinates

Point no.	Point coordinates (m)			Point no.	Point coordinates (m)			Point no.	Point coordinates (m)		
	X	Y	Z		X	Y	Z		X	Y	Z
1	-60.0518	-46.0209	-2.5567	83	-60.1324	-46.0257	-2.5631	165	-60.030	-46.1105	-2.4730
2	-60.0721	-46.0165	-2.5596	84	-60.1395	-46.0352	-2.5656	166	-60.0410	-46.1086	-2.4705
3	-60.0956	-46.0115	-2.5631	85	-60.1027	-46.0537	-2.5624	167	-60.0453	-46.0971	-2.4736
4	-60.1063	-46.0092	-2.5598	86	-60.1165	-46.0509	-2.5606	168	-60.0559	-46.1058	-2.4703
5	-60.1179	-45.9957	-2.5667	87	-60.1324	-46.0477	-2.5610	169	-60.0340	-46.1205	-2.4738
6	-60.1240	-46.0054	-2.5610	88	-60.1453	-46.0451	-2.5596	170	-60.0500	-46.1176	-2.4665
7	-60.1629	-45.9970	-2.5642	89	-60.1515	-46.0328	-2.5639	171	-60.0640	-46.1150	-2.4647
8	-60.1601	-45.9754	-2.5651	90	-60.1448	-46.0231	-2.5616	172	-60.0589	-46.0945	-2.4727
....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
35	-60.0483	-46.1180	-2.5455	117	-60.1371	-46.0466	-2.5056	199	-60.1346	-46.1019	-2.4749
36	-60.0867	-46.1109	-2.5577	118	-60.1335	-46.0584	-2.5027	200	-60.1847	-46.1259	-2.4725
37	-60.0670	-46.0931	-2.5571	119	-60.1776	-46.0273	-2.51059	201	-60.1799	-46.0935	-2.4730
38	-60.0410	-46.1300	-2.5495	120	-60.1537	-46.0322	-2.5068	202	-60.1793	-46.0825	-2.4736
39	-60.0411	-46.1405	-2.5399	121	-60.2021	-46.0335	-2.4963	203	-60.1792	-46.0826	-2.4646
40	-60.0542	-46.1276	-2.5476	122	-60.1496	-46.0662	-2.5018	204	-60.1899	-46.0917	-2.4607
....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
75	-60.0794	-46.0475	-2.5600	157	-60.0186	-46.1128	-2.4755	239	-60.5266	-45.8072	-2.5417
76	-60.0980	-46.0328	-2.5623	158	-60.0284	-46.1321	-2.4701	240	-60.5407	-45.8037	-2.5391
77	-60.0974	-46.0438	-2.5607	159	-60.0186	-46.1339	-2.4736	241	-60.5832	-45.8061	-2.5567
78	-60.0776	-46.0262	-2.5527	160	-60.0185	-46.1444	-2.4727	242	-60.5955	-45.7904	-2.5545
79	-60.1203	-46.0392	-2.5636	161	-60.0310	-46.1422	-2.4704	243	-60.5998	-45.7766	-2.5487
80	-60.1161	-46.0181	-2.5637	162	-60.0461	-46.1502	-2.4696	244	-60.5946	-45.8033	-2.5529
81	-60.1182	-46.0286	-2.5637	163	-60.0386	-46.1196	-2.4686	245	-60.6141	-45.7858	-2.5538
82	-60.1186	-46.0176	-2.5572	164	-60.0336	-46.0993	-2.4754	246	-60.6156	-45.7727	-2.5465
								247	-60.6391	-45.7927	-2.5634

Area calculation

Due to the fact that the relief form is made up of several valleys, in order to arrive at the total calculation of the area, it was necessary to first calculate the area of each valley separately. In order to achieve this, each valley was divided into elementary geometric shapes (cylinders). Thus, the elementary cylinders and the base areas of these valleys resulted, the data being processed in the Cyclone program (Barazzetti et al., 2010). Having the areas of the bases of the elementary cylinders in each valley, the surface area of each valley was calculated, and finally that of the negative relief form, which appeared on the agricultural land of the agrotourism farm, on whose territory this study was conducted (Table 3, Figure 8).

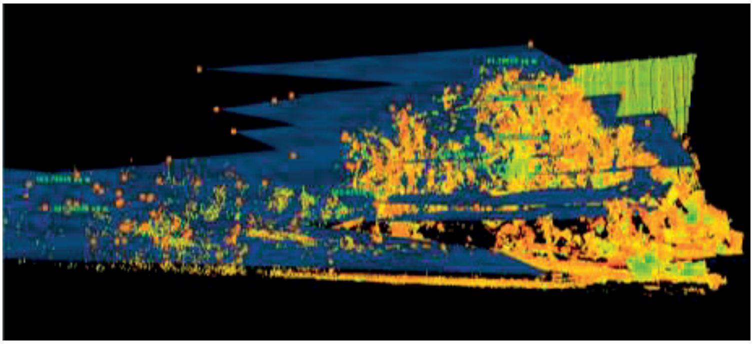

Figure 8. Values elementary cylinder base areas (image superimposed with the point cloud)

As can be seen from Table 3, the area of agricultural land affected by erosion is very significant, as it has over 1.13 ha. Therefore, it is very important that through specific topo-geodetic methods we permanently monitor the situation of lands degraded by surface and deep erosion, in order to be able to intervene in time to stop or fully combat it.

Table 3. Calculation of partial and total areas of the negative relief form

Plan no.	Surface 1 (m^2)	Surface 2 (m^2)	Surface 3 (m^2)	Surface 4 (m^2)	Surface 5 (m^2)	Surface 6 (m^2)	Surface 7 (m^2)	**TOTAL SURFACE**
1	103.795	3.5	99.86	174.04	11.69	3.86	8.04	
2	179.087	17.17	135.81	199.49	17.53	21.33	119.63	
3	241.092	41.99	6.79	237.46	128.48	104.51	134.38	
4	762.625	45.66	17.02	341.22	246.23	153.91	229.32	
5	313.227	49.3	27.03	516.08	409.9	198.18	300.17	
6	236.31	296.62	53.87	587.11			494.8	
7	152.63	298.37					566.34	
8	117.026	12.044						
9	75.711	569.84						
10	91.299	635.93						
11		674.93						
12		763.77						
Total	2.272,802	3.409,124	340,38	2.055,4	813,83	481,79	1.852,68	**11.226,006**

CONCLUSIONS

Combating soil erosion is very important in the practice of sustainable agriculture because it removes large areas of land from the agricultural circuit and removes a large amount of fertile soil and with it significant amounts of organic matter and thus carbon. In order to be able to take timely measures to stop or combat this extremely negative phenomenon, agricultural landowners must constantly carry out an inventory study of areas prone to such phenomena.

In order to meet the needs of farmers who also own land affected by this phenomenon, we have developed a very precise, fast and suggestive method for determining the size and shape of land areas affected by erosion. The method involves the use of terrestrial or 3D scanning that provides accurate and complete data about the scanned objects, allowing the visualization of real field conditions and design according to these conditions, using specialized software. The use of laser scanning systems requires minimal intervention on the part of the operator, focusing on the instrument, setting and setting the scanning parameters.

The data recording time is considerably reduced, which is also found in the costs of the survey work, and the remote data recording contributes to increasing the efficiency and safety of topographic surveys. The high density of points ensures the complexity of topographic surveys and helps to interpret very correctly the scanned objects even if they are small. Operation of such a system is easy and very accurate because it has processing software, both for registration, but also for analysis, interpretation and evaluation, being usually modular without requiring special resources.

The information gathered from the field by terrestrial laser scanning is very complex and diverse and can be accessed from a computer or laptop, thus allowing a greater freedom of view than in reality. Based on them, a series of optimizations of the point cloud processing process can be made, as well as of the 3D object, which can lead to the improvement of the transformation efficiency from point cloud to 3D object and obtaining small files, with the possibility automatic determination of the areas of the scanned areas and finally the creation of thematic digital maps, which can be used for various purposes in sustainable agriculture.

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