Centro di Ricerca
Agricoltura e Ambiente

ISUM*mate*

User Manual

Version 1.0

October 2022

1. Introduction

1.1 Overview

ISUM*mate* is a MS Excel-based application designed to assist users of the ISUM method (Improved stock unearthing Method) in correctly and seamlessly elaborating field measurements to estimate soil erosion in vineyards.

The application has been developed with a sober design and an intuitive workflow, to speed up learning and use. By implementing the application into MS Excel avoids the user to learn how to handle the user interface, which is assumed to be known, to concentrate on the few commands to enter data and visualize results.

After a brief review of the ISUM method, this User Manual (UM) provides step-by-step instructions to run a typical ISUM*mate* working session.

1.2 The ISUM method in a nutshell

1.2.1 Basic principles

The Improved Stock Unearthing Method (ISUM) (Rodrigo-Comino and Cerdà, 2018) was developed as a practical tool to experimentally quantify the volume of soil mobilized by erosion after vineyard planting, based on the comparison between the initial soil surface at planting and the current soil surface level. Elaboration of this measure provides reasonable estimate of the erosion rate and ultimately to design protective solutions to preserve vineyard soil.

The key assumption which makes the method possible, is that the initial soil level can be individuated thanks to the grafting point position, which is assumed to remain stable over the years because the original vine stock does not grow vertically (Brenot et al., 2006; Casalí et al., 2009).

In practice, the method consists in measuring the current soil surface at sampling points to build a model of the actual soil surface, to be compared to an analogous model of the initial topsoil surface based on the grafting points.

Measurements consist in recording height distance from a reference line, which is represented by a fixed rod placed transversally to the vine rows (Fig. 1).

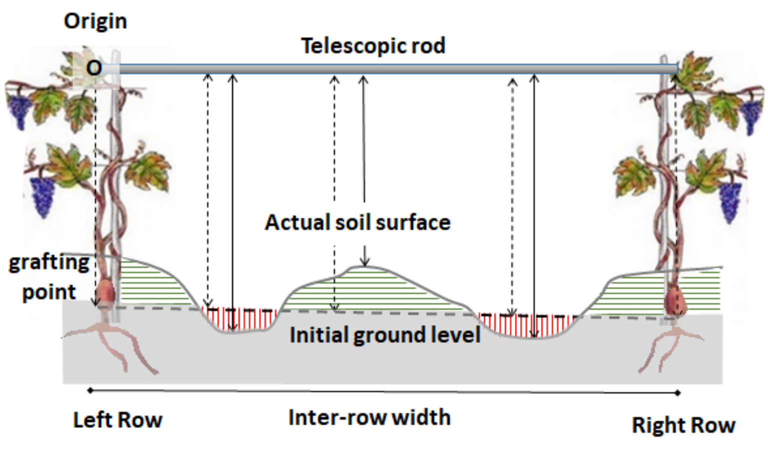


Figure 1. Scheme of surface survey on a transect of the vineyard inter-row: erosion and accumulation areas are identified by vertical and horizon hatch, respectively. The origin of the coordinate system is set in O.

1.2.2 Estimation procedure

Definitions

A special terminology has been adopted to describe the ISUM method. Table 1 reports the key definitions.

Term	definition
Interrow	Portion of vineyard comprised between to contiguous vine rows.
Subzones	Portions of the interrow created by the differential pressure on the soil caused by the passage of operating machines in the field. Typically they consist into two wheel tracks, a central zone between them and two lanes between the vine rows and the tracks (Fig. 2).
Transect	Transversal section of an interrow, i.e. the surface which crosses two contiguous vine rows at 90°.
Sector	Portion of the interrow comprised between two consecutive transects.
Original topsoil	The soil surface at planting time. It is modeled as the plane which intersects the grafting points.

Table 1. Glossary of key terminology adopted in the ISUM method.

Data processing

The first step of the analysis is the 2D modelling the topsoil and the actual ground surface at each transect, which considers a coordinate system with origin in O (Fig. 1).

The initial soil surface is modeled as a line connecting grafting points at transect extremes, which is given by the following *y(x)* function:

$$y(x) = y_1 + \frac{y_2 - y_1}{x_2 - x_1} * (x - x_1) \qquad \textit{(equation 1)}$$

Where (x_1,y_1) and (x_2,y_2) are the coordinates of the two grafting points.

The present soil surface is modelled by fitting a 9th degree polynomial function to data points, which is given by the following *Y(x)* function:

$$Y(x) = c_0 + c_1x + c_2x^2 + \cdots + c_9x^9 \qquad \textit{(equation 2)}$$

According to the ISUM method, the higher the distance between the two curves, the higher is soil mobilization; in particular, where $y(x) > Y(x)$ soil erosion has occurred (vertical hatch), while where $Y(x) > y(x)$ soil has accumulated.

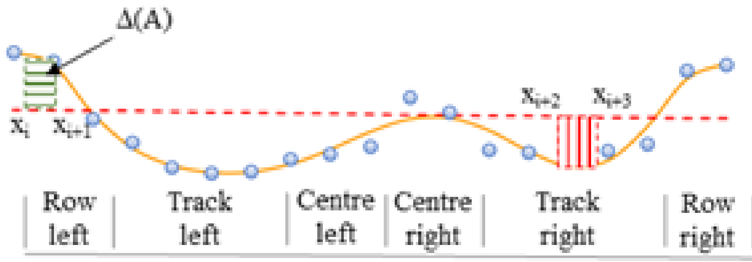


Fig. 2. Scheme of calculation of erosion and accumulation areas along a transect: dashed line is the initial soil level (y), circles are experimental data, solid line is the fitting curve Y(x).

The amount of erosion/deposition at each transect is estimated by calculating the area included between the curves. Calculation is performed by numerical integration after approximation of the area to a Riemann sum. The interrow distance is divided into finite intervals $\Delta x = (x_i + 1 - x_i)$ and at the leftmost point of each interval (x_i) the distance between the curves is calculated as $d_i= [Y(x_i)-y(x_i)]$ so that to individuate elementary rectangles with base = Δx and height = d_i with area $\Delta A = \Delta x_i \times d_i$. Finally, soil erosion and accumulation areas are obtained by summation of all the rectangles with negative and positive d_i respectively. To better account for the effect of mechanization, erosion/accumulation areas are also calculated for the specific interrow portions, consisting (Fig. 2).

Similarly to the 2D modelling, the soil volume mobilized between consecutive transects can be approximated by a sum of finite longitudinal “slices”, with volume = ΔV. Each ‘slice’ is a trapezoidal prism, whose base is the trapezoid individuated by the points $Y(x_i)$, $y(x_i)$ at both transects, and the height is the Δx interval. The difference $d_i= [Y(x_i) - y(x_i)]$ calculated at both transect in correspondence of each Δx gives the two bases of the trapezoids. If d_1 and d_2 are the two bases of the trapezoid, and D is the distance between consecutive transects, the following equation holds:

$$\Delta V = \frac{(d_1 + d_2) \times D}{2} \times \Delta x \qquad \textit{(equation 3)}$$

The total erosion and deposition volumes are calculated by numerically integrating the elementary volumes (Fig.3).

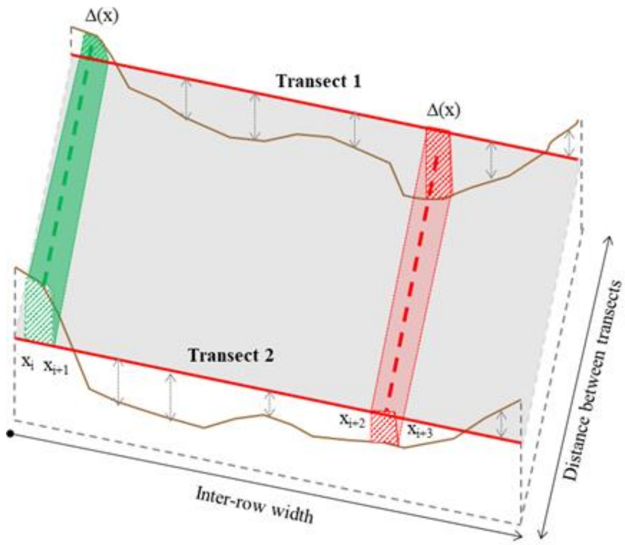


Fig. 3. Scheme of soil volume calculation between consecutive transects.

In order to obtain the total mobilized mass *M*, the total mobilized soil (eroded or accumulated) must be multiplied by the bulk density *BD*. Dividing *M* by the interrow surface *S* between the transect and the *age* of the vineyard, the mobilization rate *R*, expressed as soil mass mobilized per unit surface per year (tMg ha-1yr-1) is obtained:

$$M = V \times BD \qquad \textit{(equation 4)}$$

$$R = \frac{M}{(S \times age)} \qquad \textit{(equation 5)}$$

Soil mobilization rate for the whole vineyard is obtained averaging *M* values for all the sectors.

2. Using the application

First of all, the application should be downloaded on the user's system. ISUM*mate* is a MS Excel file (.xlsm) containing VBA macros; so the application functions directly from the workbook interface. At application start, the user's system may detect the presence of macros, and request the user to enable them by clicking a specific button.

The workflow consists in few intuitive steps, which can be activated through an ordered set of commands and a display of worksheets:

- **Enter data**.

  Raw data must be manually entered by the user in the "main" worksheet. Formatting rules must be observed in order for the process to run smoothly.

- **Run the process**

  When data are correctly inserted into the application, the elaboration consist just in pressing one "RUN" button; this will trigger a sequence of calculation whose results will be displayed in dedicated separate sheets.

- **Get the results**

  After running the process, the output is made visible in the "erosion" and "deposition" worksheets.

- **Inspect graphics**

  Some elaborations of the process are displayed in graphical format, which can be optionally inspected to a more in-depth analysis or results.

The following sections illustrate in detail these steps.

2.1 Download the application

ISUM*mate* is maintained at a permanent GitHub public repository at this url:

https://github.com/SUVISA-project/ISUMmate

Download the application as the Excel file "ISUMmate_v1.xlsm". Since ISUM*mate* is an ongoing project, further development are expected, so the user is encouraged to visit the repository to check for the presence of more recent versions.

Further materials can also be downloaded from here, in particular:

- This User Manual and updated versions.
- Related publications
- Sample input files, to run demo case-studies.

2.2 General description

The application is organized into the following 7 worksheets (Table 2):

Worksheet	function
input_sheet	This is the principal sheet, where raw measurements are entered with appropriate format and which provide access to all the commands available.
adjusted_measures	Here are displayed the data after adjustment for the rod thickness. These are the data actually used by the calculation procedure.
vineyard info	Displays the relevant vineyard dimensions used in the calculations
transect graphs	Graphs of the 2D soil profile (actual and original) are displayed here for each transect.
erosion	This worksheet displays the raw erosion estimates.
deposition	This worksheet displays the raw deposition estimates.
net erosion	Here the net erosion (erosion – deposition) is displayed.

Table 2. List of the worksheets around which the ISUM*mate* interface is structured.

2.3 Starting the application and data entering

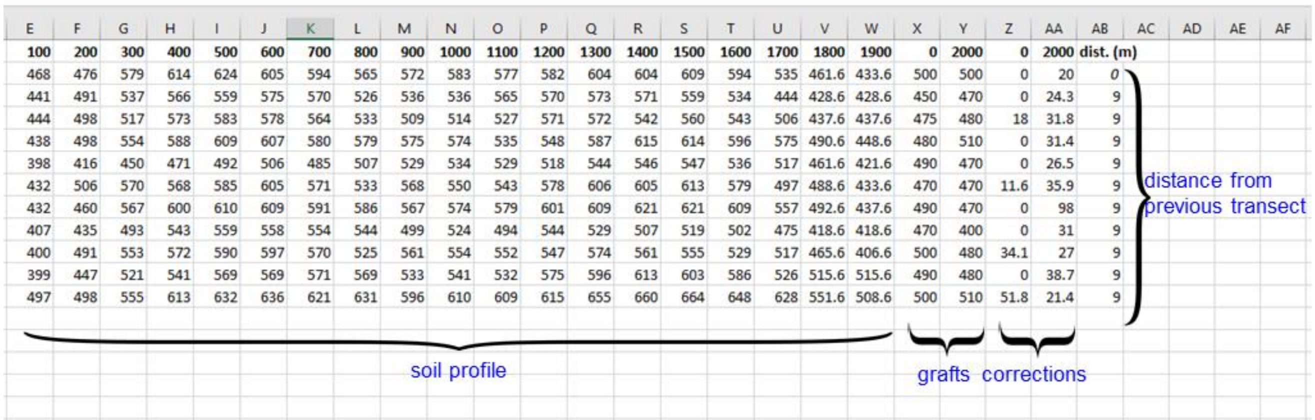
ISUM*mate* is activated just by opening the Excel file. At start, a title splash screen appears, hiding after clicking on it.

Raw measurement data must be entered into the “input_sheet” manually or by drag and drop from other files. Some rules must be observed to enter data.

Data must be entered observing the following formatting rules:

Input data formatting rules

- Data must be entered from column “E” to the right onwards.
- The columns “A:D” are reserved for the user control commands.
- Measurement units are always in mm, except for the distances among transects, which are in m.
- The first row must report the horizontal distance of the measurement point in the interrow.
- Columns with the same type of data must be contiguous.



E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**	**1300**	**1400**	**1500**	**1600**	**1700**	**1800**	**1900**	**0**	**2000**	**0**	**2000**	**dist. (m)**				
468	476	579	614	624	605	594	565	572	583	577	582	604	604	609	594	535	461.6	433.6	500	500	0	20	*0*				
441	491	537	566	559	575	570	526	536	536	565	570	573	571	559	534	444	428.6	428.6	450	470	0	24.3	9				
444	498	517	573	583	578	564	533	509	514	527	571	572	542	560	543	506	437.6	437.6	475	480	18	31.8	9				
438	498	554	588	609	607	580	579	575	574	535	548	587	615	614	596	575	490.6	448.6	480	510	0	31.4	9				
398	416	450	471	492	506	485	507	529	534	529	518	544	546	547	536	517	461.6	421.6	490	470	0	26.5	9				
432	506	570	568	585	605	571	533	568	550	543	578	606	605	613	579	497	488.6	433.6	470	470	11.6	35.9	9				
432	460	567	600	610	609	591	586	567	574	579	601	609	621	621	609	557	492.6	437.6	490	470	0	98	9				
407	435	493	543	559	558	554	544	499	524	494	544	529	507	519	502	475	418.6	418.6	470	400	0	31	9				
400	491	553	572	590	597	570	525	561	554	552	547	574	561	555	529	517	465.6	406.6	500	480	34.1	27	9				
399	447	521	541	569	569	571	569	533	541	532	575	596	613	603	586	526	515.6	515.6	490	480	0	38.7	9				
497	498	555	613	632	636	621	631	596	610	609	615	655	660	664	648	628	551.6	508.6	500	510	51.8	21.4	9				

Fig. 4. Screenshot of a correctly compiled input sheet.

After data have been transcribed on the sheet, they must be “loaded” by specifying their typology choosing among soil profile data, grafting point, distance, corrections.

Each column, or group of columns belonging to a given type of data, must be selected with the mouse, then the corresponding button (e.g. “soil profile”) must be ticked. If the data are correctly loaded, the selected cells will change their background color.

Clicking the button “clear selections” will reset the loading, and remove cell colors already present.

In order to enable the calculation process, all types of data must be assigned.

Example: <u>Load soil profile measurements</u>

Step 1) select the columns with the mouse

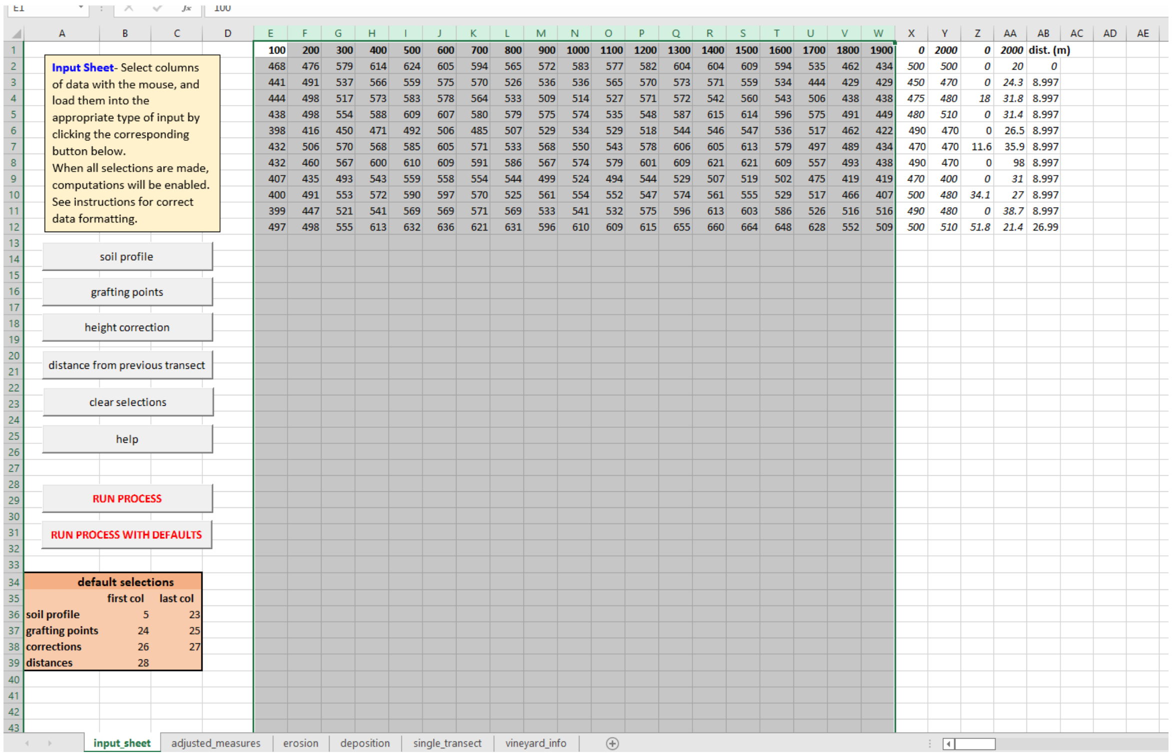


Fig. 5. Step 1) of data loading/selection: homogeneous group of data must be selected in one unique group with the mouse.

Step 2) click the "soil profile" button. After the button has been clicked, the selected cells change colour.

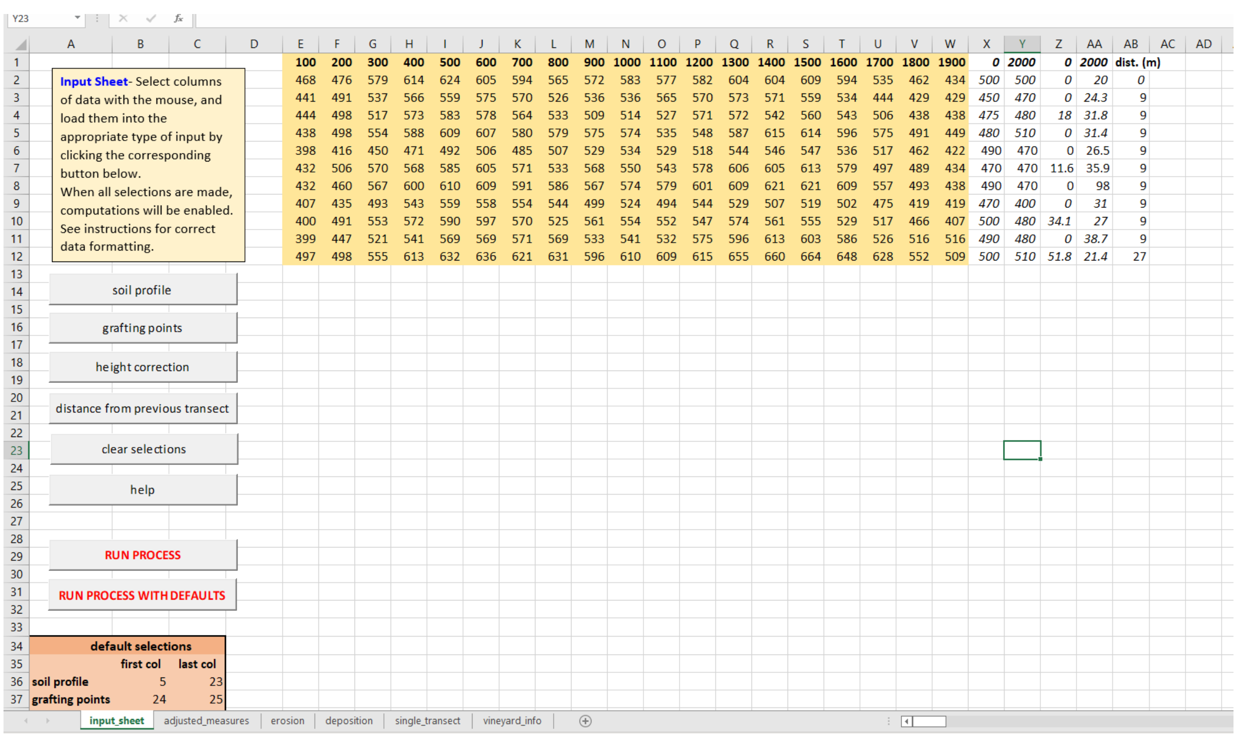


Fig. 6. Step 2) of data loading/selection: homogeneous group of data must be selected in one unique group with the mouse.

An alternative loading procedure is possible to save time, in case the user should be in the need to repeat the same selection configuration on different datasets.

By compiling the “default selections” table, in the low left position of the spreadsheet, the data are loaded into the specific sub-datasets without specifying them manually with the above procedure.

2.4 Running the process

Once data have been loaded, the system is ready to perform the calculations.

If data subsets have been specified manually, the process is activated simply by pressing the button “RUN PROCESS”.

Pressing the button “RUN PROCESS WITH DEFAULTS” obtains the same effects, but it considers the subsets as specified in the “default selections” table. This option is convenient when many datasets with the same structure must be processed, since it avoids repetitive manual input operations.

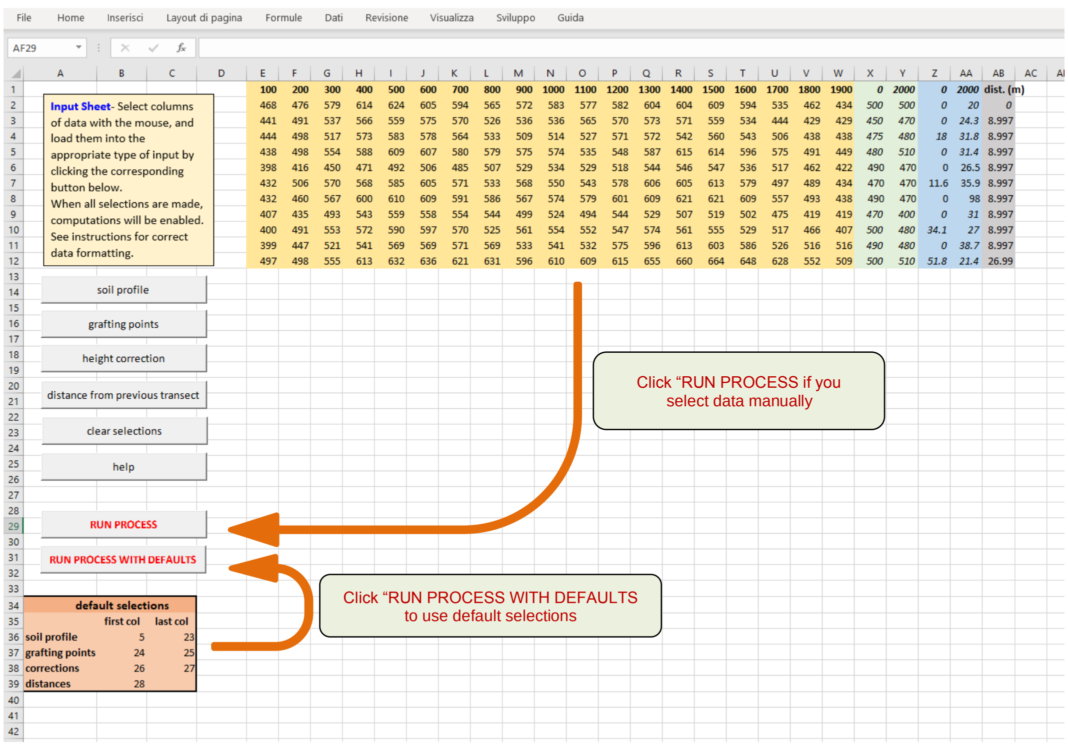


Fig. 7. Screenshot showing how to start data processing after data selection.

2.5 Inspecting the elaboration results

The process execution produces an array of different outputs, which can be accessed by inspecting the dedicated spreadsheets.

2.5.1 Erosion

Soil erosion data can be found in the “erosion” spreadsheet, where they are reported in two tables: i) the first table (on the left) reports erosion estimates in volume units, i.e. cubic meters (mc) ii) the second table (on the right) reports the results in erosion mass rate, i.e. the average amount of mass eroded each year per hectare (t/ha/year).

Both tables report in detail the values for each sector for each subzone of the interrow. Sectors are listed in column A, while subzones are reported in columns B:H (mc) and J:P (t/ha/year).

The totals for each subzone are reported on top of the columns in blue.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		mc								t/ha/year						
2		ROW SX	TRACK SX	CENTRE SX	CENTRE DX	TRACK DX	ROW DX	*TOTAL*		ROW SX	TRACK SX	CENTRE S)	CENTRE D	TRACK DX	ROW DX	*TOTAL*
3	TOTALS	0.04776	2.41356	2.57978	2.75246	2.30689	0.03705	***10.1375***		0.1816	7.91053	8.02348	8.44365	6.60774	0.04806	***31.2151***
4	(T2-T1)	0.01235	0.31042	0.27333	0.295896	0.176	0			0.46958	11.8022	10.3921	11.25	6.69147	0	
5	(T3-T2)	0.01715	0.25468	0.20768	0.239758	0.12009	0			0.65192	9.68301	7.8961	9.11559	4.56564	0	
6	(T4-T3)	0.00662	0.24455	0.20387	0.169438	0.15977	0			0.25154	9.29788	7.75124	6.44202	6.0743	0	
7	(T5-T4)	0.00141	0.12484	0.17067	0.159405	0.17366	0			0.05378	4.74652	6.48889	6.06057	6.6024	0	
8	(T6-T5)	0.00321	0.12136	0.15978	0.215857	0.17572	0			0.12209	4.61417	6.07495	8.20691	6.68088	0	
9	(T7-T6)	0.00696	0.27598	0.24045	0.249993	0.19209	0			0.26457	10.4929	9.14193	9.50475	7.30311	0	
10	(T8-T7)	6.7E-05	0.24878	0.25484	0.23703	0.17466	0.00016			0.00254	9.4586	9.68905	9.0119	6.64057	0.00618	
11	(T9-T8)	0	0.18522	0.20314	0.205185	0.13549	0.00024			0	7.04218	7.7232	7.80115	5.1513	0.00927	
12	(T10-T9)	0	0.14831	0.16184	0.182472	0.14604	3.2E-05			0	5.63867	6.15301	6.93757	5.55245	0.00123	
13	(T11-T10)	0	0.49941	0.70418	0.797426	0.85339	0.03661			0	6.32915	8.92431	10.106	10.8153	0.46394	

Fig. 8. Screenshot of the “erosion” spreadsheet after calculation.

2.5.2 Deposition

The “deposition” worksheet has the same structure as the “erosion” worksheet, but the results report the amount of soil material accumulated above the initial topsoil surface.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		mc								t/ha/year						
2		ROW SX	TRACK SX	CENTRE SX	CENTRE DX	TRACK DX	ROW DX	*TOTAL*		ROW SX	TRACK SX	CENTRE S)	CENTRE D	TRACK DX	ROW DX	*TOTAL*
3	TOTALS	0.64528	0.02791	0	0	0.02824	0.61479	***1.31622***		1.86455	0.08486	0	0	0.10737	2.3153	***4.37208***
4	(T2-T1)	0.01793	0	0	0	0.00791	0.08925			0.68166	0	0	0	0.30058	3.39325	
5	(T3-T2)	0.00719	0	0	0	0.01254	0.0969			0.27325	0	0	0	0.47666	3.68417	
6	(T4-T3)	0.01834	0	0	0	0.00224	0.08474			0.69731	0	0	0	0.08531	3.22194	
7	(T5-T4)	0.06326	0.00928	0	0	4.1E-06	0.06308			2.40518	0.35268	0	0	0.00015	2.39844	
8	(T6-T5)	0.05837	0.00867	0	0	0.00021	0.04987			2.21912	0.32954	0	0	0.00805	1.89605	
9	(T7-T6)	0.0371	0	0	0	0.00267	0.07402			1.4105	0	0	0	0.1016	2.81439	
10	(T8-T7)	0.05666	1.9E-05	0	0	0.00132	0.06352			2.15425	0.00074	0	0	0.05002	2.41487	
11	(T9-T8)	0.0699	0.00054	0	0	0.0005	0.0478			2.65765	0.02037	0	0	0.01918	1.81753	
12	(T10-T9)	0.08423	0.00102	0	0	0.00084	0.03687			3.20254	0.03888	0	0	0.03211	1.40184	
13	(T11-T10)	0.2323	0.00839	0	0	0	0.00872			2.94403	0.10636	0	0	0	0.11056	

Fig. 9. Screenshot of the “deposition” spreadsheet after calculation, which has the same structure as the “erosion” spreadsheet.

2.5.3 Net erosion

The worksheet “net erosion” has the same structure as the two previous result worksheet, and it displays the net erosion results, calculated as the difference between erosion and deposition.

3. Credits

ISUM*mate* was developed within SUVISA, which is a sub-project of the AGRIDIGIT project (https://www.crea.gov.it/-/agridigit).

The research around ISUM method was carried out by Maria Costanza Andrenelli (mariacostanza.andrenelli@crea.gov.it), Nadia Vignozzi and Sergio Pellegrini.

The ISUMmate application was developed by Maria Costanza Andrenelli and Gianni Fila (gianni.fila@crea.gov.it).

4. References

Brenot, J., Quiquerez, A., Petit, C., Garcia, J.-P., & Davy, P. (2006). Soil erosion rates in Burgundian vineyards. Bollettino Della Societa Geologica Italiana, Supplemento, 6, 169–173.

Casalí, J., Giménez, R., de Santisteban, L., Álvarez-Mozos, J., Mena, J., & del Valle de Lersundi, J. (2009). Determination of long-term erosion rates in vineyards of Navarre (Spain) using botanical benchmarks. Catena, 78(1), 12–19. https://doi.org/10.1016/j.catena.2009.02.015

Rodrigo-Comino, J., & Cerdà, A. (2018). Improving stock unearthing method to measure soil erosion rates in vineyards. Ecological Indicators, 85, 509–517. https://doi.org/10.1016/j.ecolind.2017.10.042

Appendix A: Record of Changes

This section provides information on the development and distribution history of ISUM*mate* development and of the accompanying manuals.

Version Number	Date	Description of Change
1.0	10/01/2022	First release