Soil Erosion Assessment (satellite imagery based)

Scientific Background

Soil erosion is a severe threat to food production systems globally. Food production in farming systems decreases with increasing soil erosion hazards[1].

Soil erosion is a naturally occurring process that affects all landforms. In agriculture, soil erosion refers to the wearing away of a field's topsoil by the natural physical forces of water (Figure 1) and wind (Figure 2) or through forces associated with farming activities such as tillage.

Figure 1. The erosive force of water from concentrated surface water runoff.

Figure 2. The erosive force of wind on an open field.

[1] A Review on Assessing and Mapping Soil Erosion Hazard Using Geo-Informatics Technology for Farming System Management
Sumudu Senanayake 1,2, Biswajeet Pradhan 1,3,4,5,*, Alfredo Huete 1,6 and Jane Brennan 1,7

Slope gradient and length

The steeper and longer the slope of a field, the higher the risk for erosion. Soil erosion by water increases as the slope length increases due to the greater accumulation of runoff. Consolidation of small fields into larger ones often results in longer slope lengths with increased erosion potential, due to increased velocity of water, which permits a greater degree of scouring (carrying capacity for sediment).[2]

Water erosion begins when a water drop strikes the bare soil. Soil particles are then detached from the surface and subsequently transported down-slope by raindrop splash or by runoff (overland flow). If the runoff is in thin sheets, sheet flow and sheet erosion (or interrill) occur. Ellison [13] suggested that for water velocity above 0.3 m s^{-1} the flow becomes turbulent and causes the formation of soil rills. These processes occur by water drop impact originating from either rain or overhead irrigation. The sensitivity of soil to water erosion is enhanced by leaving the surface of cultivated soils bare. The common practice of intense tillage results in a break-down of the natural structure of the upper soil layer. Tillage is practiced in order to prepare seedbeds, weed control, sanitation, and application of organic manure and fertilizers [6, 14]. The more intensive the cultivation practiced, the more severe the expected destruction of the soil structure and soil aggregate stability.[3]

[2] Soil erosion: causes and effects, Ontario.ca

[3] Degradation of Agricultural Lands in Israel Gil Eshel, Elazar Volk, Alon Maor, Eli Argaman, and Guy J. Levy

Data Base

Our database is assembled from screenshots taken by us from the OpenStreetMap[4].

The format of the images is PNG, but jpg/jpeg is also acceptable.

It was then loaded into the tool, and as output we got was the percentage of brown pixels in the image.

The image was then manually measured for the horizontal distance between each elevation line (measure conducted on the OpenStreetMap website), sing the manual measurement, we calculated the gradient of the slope.

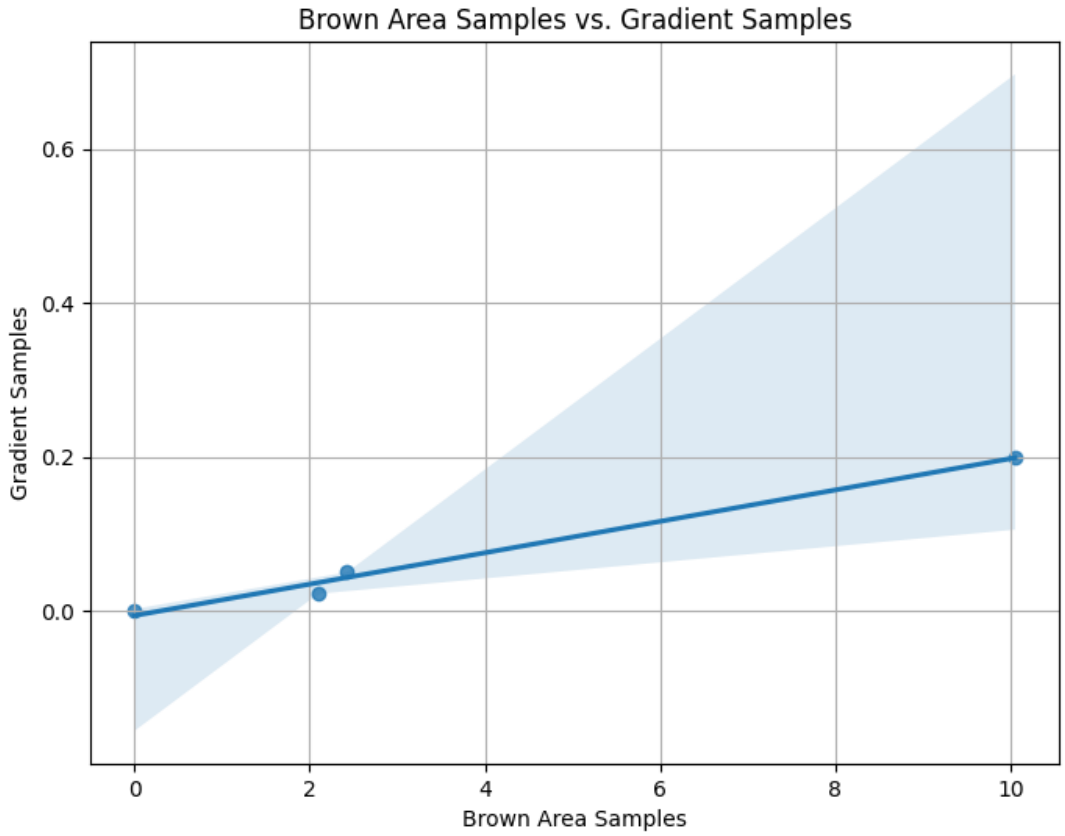
We then created the dataset from the data we extracted - brown pixels percentage and slope gradient.

Because of the time-consuming work this process requires, we only managed to create a database of 4 images.

Our goal is to widen this database for more credible result.

One problem we faced with, and is still present with a concern, is the fact that out images for the database, we used "optimal" images, meaning that the distance between all the lines in the images was almost identical, and in reality, many areas has different slope gradient in different areas of the field, and therefore it is hard to predict how accurate the model is when using those not-perfect images.

[4] https://www.openstreetmap.org/

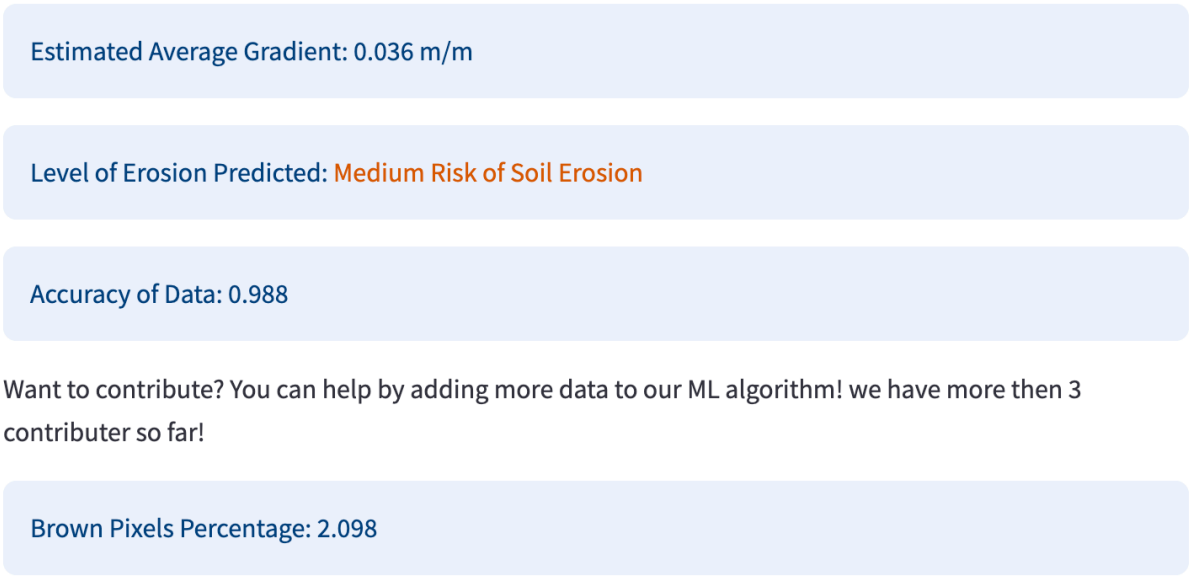


Graph 1 – Linear Regression Correlating the Gradient Samples and the Brown Pixels Percentage.

Database URL -
https://github.com/ranavner/Soil_Erosion_Assessment/upload/main/Database

Results

The results the tool provide are shown as here:



This is self-explanatory.

'Accuracy of Data' parameter is a statistical error because the model is trained only on 4 images, that are 'perfect' (see Data Base section), the R value of the correlation is very high.

In the future, when more images will be added to the data base, the R value will decrease (although it's kind of a paradox – you would think that more images = more accuracy, but in that case, it depends on which images we used at first).

Discussion and conclusions

Our project was driven from our field of study in soil and water.

We have a course named “Soil Preservation” and it made us want to create a tool that will help farmers and ecologists to face the problem of soil erosion.

Soil erosion obviously have many causes, and slope gradient is only one factor in those causes.

For a more suitable solutions, models such as RUSLE2 offer more precise and accurate data, but for every day and everyone use, special knowledge and skills are required.

Our tool offers a friendly and easy to use interface that provides with a simple output that can give a first impression on the subject and can be a good start when addressing the soil erosion issue.

The tool we created is of course just a POC (proof of concept) code, it doesn’t give an accurate output and is based on a very (very) small database on which it is hard to rely on.

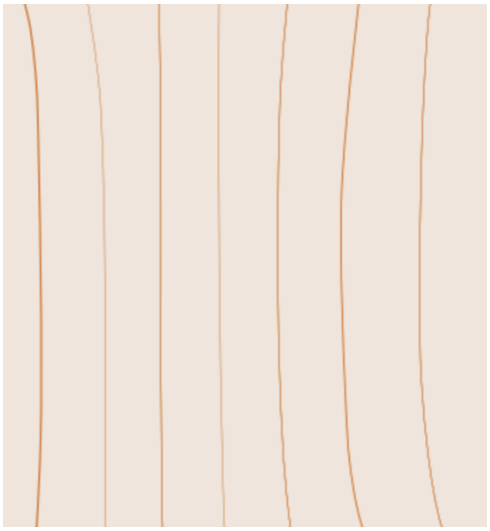
More data and more image processing algorithms, (such as elevation lines density) will allow to still offer a easy to use interface, but even more relevant and accurate outputs.

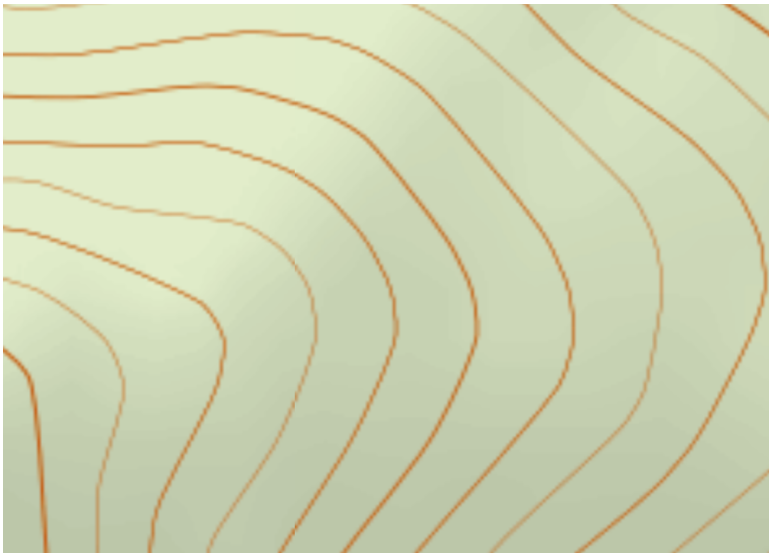
More data will also provide us with the option to give more useful outputs such as ‘High Risk’ areas and more.

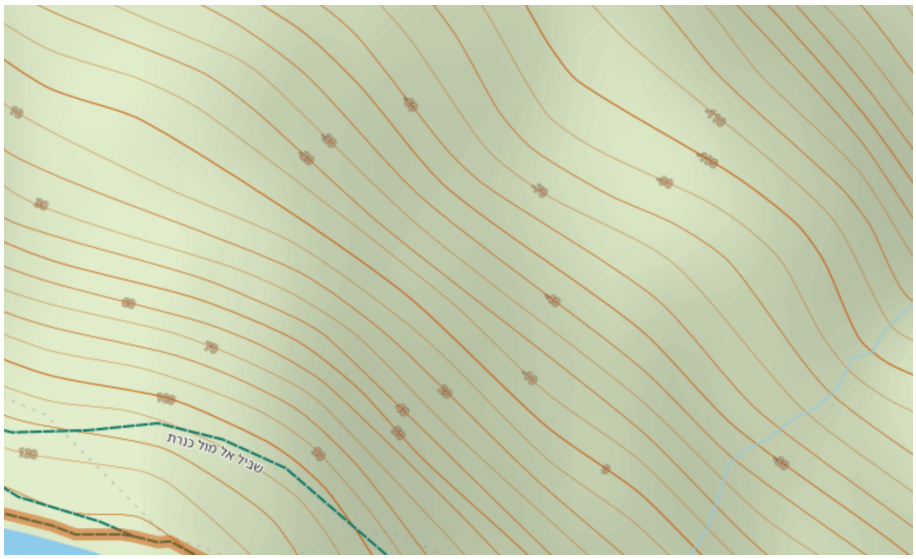
Also in the future, a good option is to give the user the option to add his own images, and thus help us broaden the database for the whole community, and by doing so, help everyone enjoy a better tool.

Appendix

Images from database:







Database URL –
https://github.com/ranavner/Soil_Erosion_Assessment/upload/main/Database

Code URL -
https://github.com/ranavner/Soil_Erosion_Assessment/blob/main/streamlit_app.py

Resources:

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