Estimating the economic value of soil erosion using drones

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1. Context

- **Erosion of fertile topsoil** poses **significant environmental impacts** globally (Smith et al., 2016) as this can result in lowered crop yield, decreased water quality and heightened flood risk (Mahabaleshwara and Nagabhushan 2014; Lal 2014; Pierce and Lal 2017; Koirala 2019).
- The Environment Agency (EA) in England (2016) declared **soil erosion** and sediment management an **important research priority** with the government's **25 Year Environment Plan** stating all UK **soils must be sustainable by 2030.**
- **Research gap** – limited literature addressing the **financial implications** to farmers in **replacing lost fertiliser** due to soil erosion. **Drones** can quantify soil **erosion volume** (Báčová et al., 2019), **soil tests** and laboratory analysis determine soil **nutrient content** (and therefore can estimate amount of nutrients lost due to erosion), and knowledge of **fertiliser market value** allows for **calculations** of **replacing** these **lost nutrients**. Together, this method will assess the economic impact of soil erosion on farmers.

2. Aim

To develop a method to **estimate financial losses** to the farm business as a result of **field scale soil erosion**.

3. Site Details

This research was undertaken at a farm with soil erosion issues in Worcestershire, UK.

Figure 1. Photograph of the gully mapped for this research (captured: November 2022).

4. Research Design

The **method** of this research is seen in figure 2:

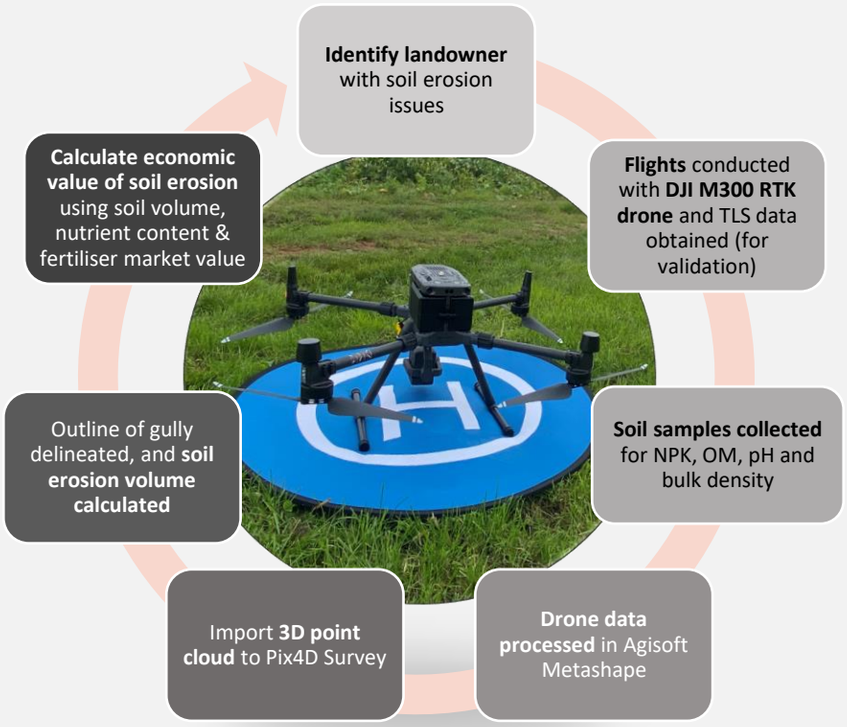

Figure 2. Method undertaken for this research.

5. Analysis and Findings

- A **high-resolution Digital Elevation Model** (DEM) (figure 3) and **orthophoto mosaic** at 0.54cm/pix are **produced from drone imagery**, as well as a **3D point cloud**.
- This data is used for **quantifying** the **volume** of **soil eroded** with **post-erosion data** only.

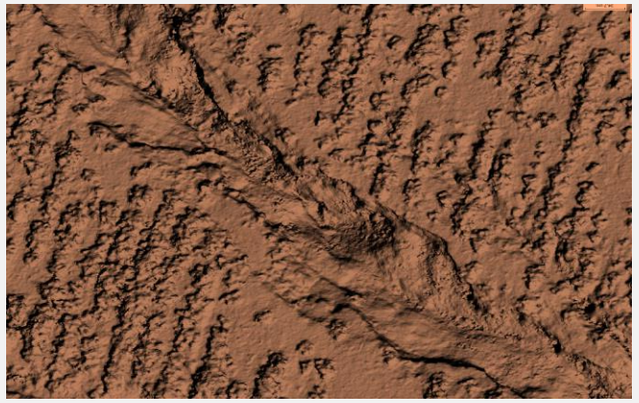

Figure 3. DEM of gully obtained with a drone with 0.54 cm /pix GSD (Agisoft Metashape (2024).

The **gully edge** is **delimited** in Pix4D Survey (figure 4) and the potential original soil surface is modelled. This allows for volume of gully to be calculated.

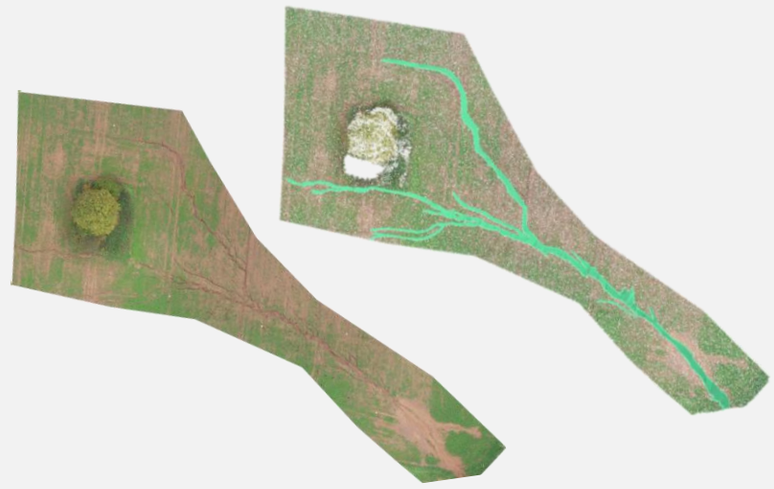

Figure 4. (Left) orthophoto mosaic of gully and (right) 3D point cloud with gully area delineated to estimate soil erosion volume (Pix4D Survey 2024).

Preliminary results: Estimated that **39.7m^3** of soil has been eroded in the gully displayed in figure 4.

6. Conclusions and Next Steps

Conclusion: This study provides findings of the **volume** of **soil eroded** (**39.7m^3**) from a **single gully** in one field in Worcestershire; imagine the **cumulative impact** of **soil erosion** on a local, national or global scale.

Next steps:

1. Soil nutrient content **laboratory results** from Catchment Sensitive Farming **pending**. The **financial implications** of soil erosion at this site **can then be quantified**.
2. Analyse **Terrestrial Laser Scanner** data collected as reference data to **validate** the estimated soil erosion volume.
3. Apply this method **to other farms** in Worcestershire and Shropshire supported by the CSF team.

Reference list: AgiSoft (2020) AgiSoft Metashape Professional Version 1.5.3. Available at: https://www.agisoft.com (Accessed: 2nd May 2022); ArcMap (2020) ArcMap 10.7. Available at: https://desktop.arcgis.com/en/arcmap/ (Accessed: 2nd May 2022); Báčová, M., Krása, J., Devátý, J., Kavka, P., (2019). A GIS method for volumetric assessments of erosion rills from digital surface models. European Journal of Remote Sensing, 52(sup1), pp.96-107; DJI (2020) Phantom 4 RTK. Available at: https://www.dji.com/uk. (Accessed 2nd May 2022); Hugenholtz, C.H., Walker, J., Brown, O., Myshak, S., (2015). Earthwork volumetrics with an unmanned aerial vehicle and softcopy photogrammetry.Journal of Surveying Engineering,141(1), p.06014003; Koirala, P., Thakuri, S., Joshi, S., Chauhan, R., (2019). Estimation of soil erosion in Nepal using a RUSLE modeling and geospatial tool. Geosciences, 9(4), p.147; Lal, R., (2014). Soil conservation and ecosystem services. International Soil and Water Conservation Research, 2(3), pp.36-47; Mahabaleshwara, H., Nagabhushan, H.M., (2014). A study on soil erosion and its impacts on floods and sedimentation. International Journal of Research in Engineering and Technology, 3(3), pp.443-451; Pierce, F.J., Lal, R., (2017). Monitoring the impact of soil erosion on crop productivity. In Soil erosion research methods (pp. 235-263). Routledge; Wheaton (2008). Geomorphic Change Detection Software. Available at: http://gcd.riverscapes.xyz. (Accessed 4th May 2022); Woodget, A.S., Carbonneau, P.E., Visser, F., Maddock, I.P., (2015). Quantifying submerged fluvial topography using hyperspatial resolution UAS imagery and structure from motion photogrammetry. Earth Surface Processes and Landforms, 40(1), pp.47-64.