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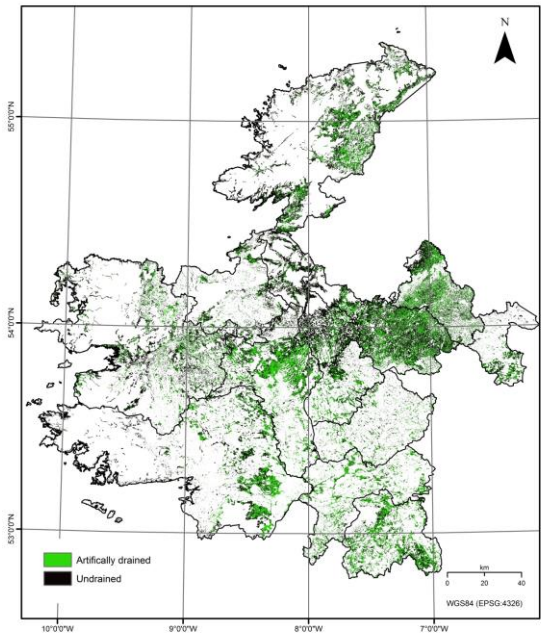
Drain-Map: Understanding the drainage status of Irish soils using remote sensing



Key external stakeholders:
Department of Agriculture, Food and Marine, Advisors and Surveyors

Practical implications for stakeholders:

Having a map of artificially drained soils allows for improved policy development in the land-use and Climate Change domains.

The project demonstrated the effectiveness of cheap off-the-shelf drones to map critical source areas in farms-thus providing another application for drones within advisory and farm surveying services

Main results:

- Map of artificially drained soils that naturally have poor drainage in the BMW region
- A method to detect underground drains at field scale using thermal imaging cameras mounted on drones
- A method to create surface run-off models with drones.
- Evidence of the extended, long term negative impacts of flooding on farm productivity.

Opportunity / Benefit:

The ability to map the extent and effectiveness of in-field drainage will allow for the development of effective policies around land-use and greenhouse gas emissions- focused on the land-use elements of the Teagasc MACC.

Growth in the use of drones on farms and by farm advisory services is rapid- here we show that they can play an important role in tailored water/pollution management plans with basic drone technology and open source software.

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Collaborating Institutions:

Maynooth University (MU)

Teagasc project team: Stuart Green (PI)
Robert O'Hara (Walsh Fellow)
Owen Fenton

External collaborators: Dr Tim McCarthy, MU

1. Project background:

The need for information on the national distribution and effectiveness of in-field drainage is pressing for a number of policy areas, including climate action. At the same time farmers and advisors need more tools to improve water management on the farm. This study is the first harmonized effort to map the location and extent of artificially-drained soils in Ireland using a suite of Earth Observation (EO) data and geo-computational techniques.

2. Questions addressed by the project:

Can EO technologies detect drainage and water management on Irish farms at multiple scales?

3. The experimental studies:

- Multi-temporal radar satellite (Sentinel 1) images mapped flood extents and the derived flood map was compared against ESA Emergency Monitoring Service maps and Teagasc advisor reports of flooded farms. Flood heights were estimated by combining digital elevation models and flood map compared.
- Two machine learning image classifiers (SVM and Random Forest) were assessed for accuracy in classifying drained and poorly drained pasture from satellite images (Landsat8 and Sentinel2). Accuracy was assessed using a random sample of photo-interpreted points.
- Drones were used to create Digital surface models (DSM) of farms and compared with digital elevation models from aerial LIDAR at plot level. Accuracy was assessed using GPS-surveyed ground control points with corresponding sward height measurements taken in the field.
- Thermal images from drones were compared with soil temperature measurements in the upper 10 cm of a field with known drainage installed. Location of thermal anomalies were compared with the location of known subsurface drains.

4. Main results:

- Surface water/flooding persistence and impact can be mapped with RADAR and optical sensors across catchments. The impact and recovery of grassland to specific flood events can be captured using satellite images. The impact on production of flooded farms can last months after the waters have receded.
- Cheaply acquired digital surface models from drones are as effective at modelling overland flow at field scale in managed grassland as expensively acquired high density LIDAR. This means farms can cheaply designs bespoke methods to control overland flow rather than one-size fits all approached such as fencing a buffer form all water courses on the farm.
- A 20m resolution map of drained fields in the BMW region has been produced and verified. Best overall accuracy was 89% for a random forest classification of only spectral data. The image above shows the area of "drained" grassland in the BMW which comprises approximately 352,500 hectares (43% of national (agricultural?) land area). This is the first time this has been done and allows now for planning around draining/re-wetting for landuse approaches to green house gas mitigation.

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- Thermal imagery from a drone was used to identify the locations of artificially drained areas. Using morning and afternoon images to map thermal extrema, significant differences in the rate of heating were identified between drained and undrained locations. Locations of tiled and piped drains were identified with 59% and 64% accuracy within the study area.

5. Opportunity/Benefit:

The creation of a map of artificially drained soils is potentially important in developing a land use policy around the national Climate Action Plan. Significantly the method allows for the monitoring of drainage on a year by year basis; identifying areas that have been newly drained and areas that have had drainage removed.

By demonstrating that inexpensive drones and free open-source software can provide survey quality DSM for the creation of run-off models should act as significant stimulus to the use of drones in the private advisory/survey sector for tailoring surface water plans on farm by farm basis (especially with respect to the identification of critical source areas).

6. Dissemination:

O'Hara, R., S. Green, and T. McCarthy. "The agricultural impact of the 2015–2016 floods in Ireland as mapped through Sentinel 1 satellite imagery." *Irish Journal of Agricultural and Food Research* 58.1 (2019): 44-65.

Oral presentations :
European Conference for Applied Meteorology and Climatology, Dublin, 2017- "Machine learning classification of soil drainage status using multispectral" Rob O'Hara, Stuart Green, Tim McCarthy, and Owen Fenton.

COST Action CA16219 Harmonization of UAS techniques for agricultural and natural ecosystems monitoring – R O'Hara member.

7. Compiled by: Stuart Green & Rob O'Hara

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