Automated detection and classification of invasive *Cardiospermum grandiflorum* using multispectral orthophotos and deep learning

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The Project

- Interreg FAST Project: Fight Alien Species Transborder

- Aims to combat the introduction, naturalization and spread of Invasive Alien Species.

- Work Package 3 : Focus on Non-Indigenous species monitoring

- Deliverables D.T1.2.2: Datavideo immagini drone

  - Detection and monitoring of Non-Indigenous species.

  - Monitoring of Invasive Alien Plant species using drones with spectral sensors.

- Case study: Monitoring spatial distribution of an IAPs in a Protected Natura 2000 site.

The Site

- Rdumijiet ta' Malta: Ir-Ramla taċ-Ċirkewwa sal-Ponta ta' Bengħisa SAC

  - Area of High Landscape Value

  - Area of Ecological Importance

  - Special Areas of Conservation - International Importance

- Locality of Wied Babu
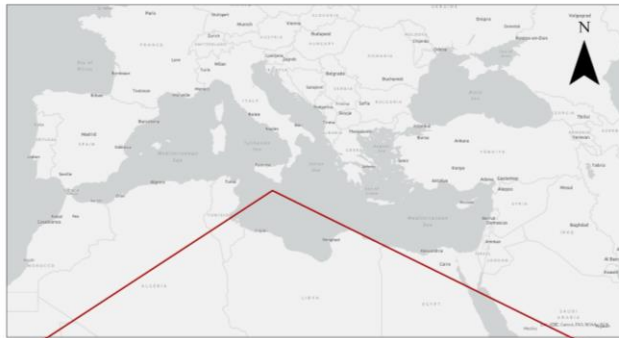
The Site

- Locality of Wied Babu
  - Mediterranean wadi: Valley system with temporary regime
  - Typical coastal thermophilous vegetation colonising on the limestone steep.
  - Maquis at the bottom of the valley.
  - Patches of garrigue on the upper part of the slope
  - Thermo-Mediterranean and pre-desert scrub (Annex I 5330)
  - West Mediterranean clifftop phrygana (Annex I 5410)
  - Calcareous rocky slopes with chasmophytic vegetation (Annex I 8210)
- Presence of strict endemic species
  - Maltese Rock-Centaury (*Cheirolophus crassifolius*)
  - Maltese Pyramidal Orchid (*Anacamptis urvilleana*)

The problem

▶ Introduction of *Cardiospermum grandiflorum* Swartz,1788.

   ▶ Perennial, semi-woody vine-like climber, forms dense draping carpets.

   ▶ Self-compatible seeds, large seed bank, anemochory & hydrochory.

   ▶ Estimated the late 50s, using military imagery.

   ▶ Introduction point identified upper, northern area of the Wied Babu watershed.

Joseph Buhagiar, Reeya Ghose Roy, Arthur Lamoliere, Marco Iannaccone (2021)

▶ Suspected, yet unassessed impact on the Maquis.

   ▶ High propagule pressure, Light competition.

   ▶ Spread downstream during the winter period.

   ▶ Known Invasive Plant : EPPO A2 list & EU IAS of Union concern

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The Aim

▶ How can we quantify the spread dynamics of *Cardiopermum grandiflorum* ?

   ▶ Limited accessibility due to dense topography & vegetation:

      ▶ Limits reliability of survey, detection bias.

   ▶ Limited Spatial & Temporal resolution of satellite imagery:

      ▶ Limits traditional remote sensing and mapping.

   ▶ Limited Spectral resolution of Drone Imagery:

      ▶ Poor Discrimination of vegetation cover at the species level.

   ▶ **The 50 shades of green problem.**

   ▶ The Solution ?

      ▶ High-Resolution drone for Visual Survey.

      ▶ Multispectral Drone for Mapping.

      ▶ Deep Learning model for Automated Classification.

The Team

- Key Word: **Multidisciplinarity**
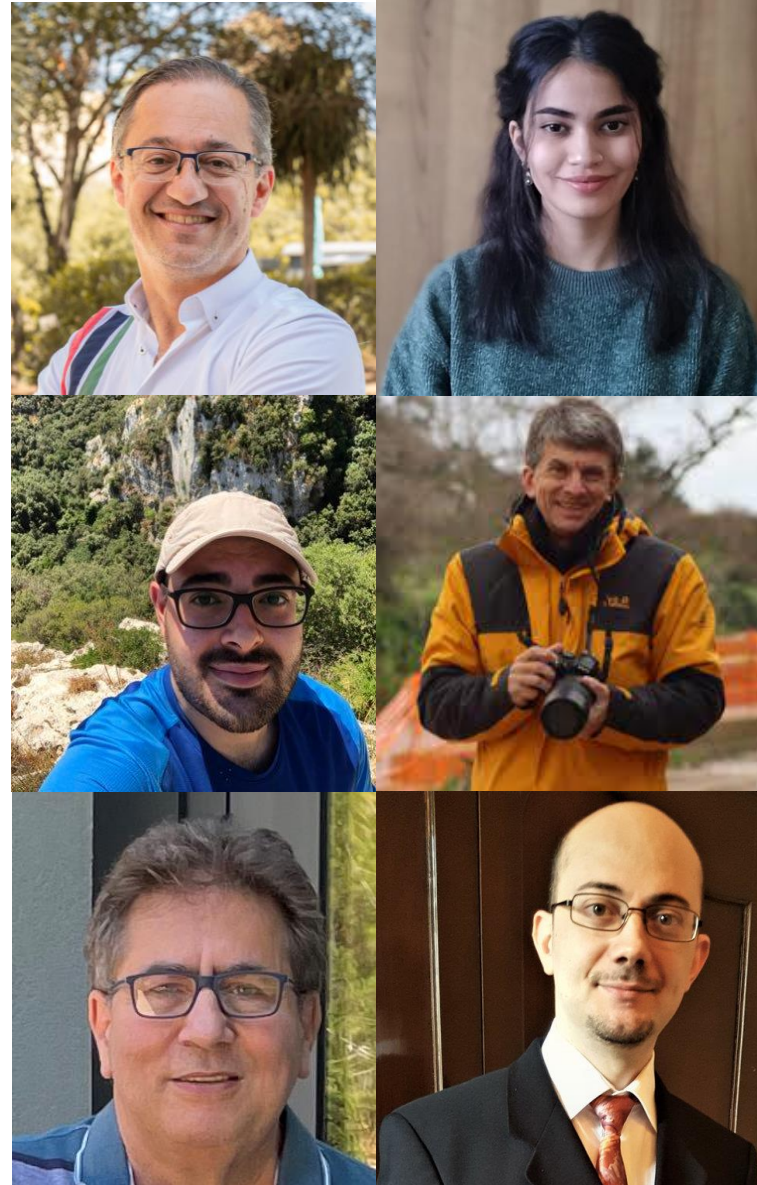 - **Dream Team**
    - Field ecologists:
      - Ms Reeya Ghose Roy
      - Prof David Mifsud
    - GIS specialists and Drone pilots:
      - Mr Gianmarco Tavilla
      - Prof Sandro Lanfranco
    - AI specialists:
      - Mr Mark Mifsud
      - Prof John Abela

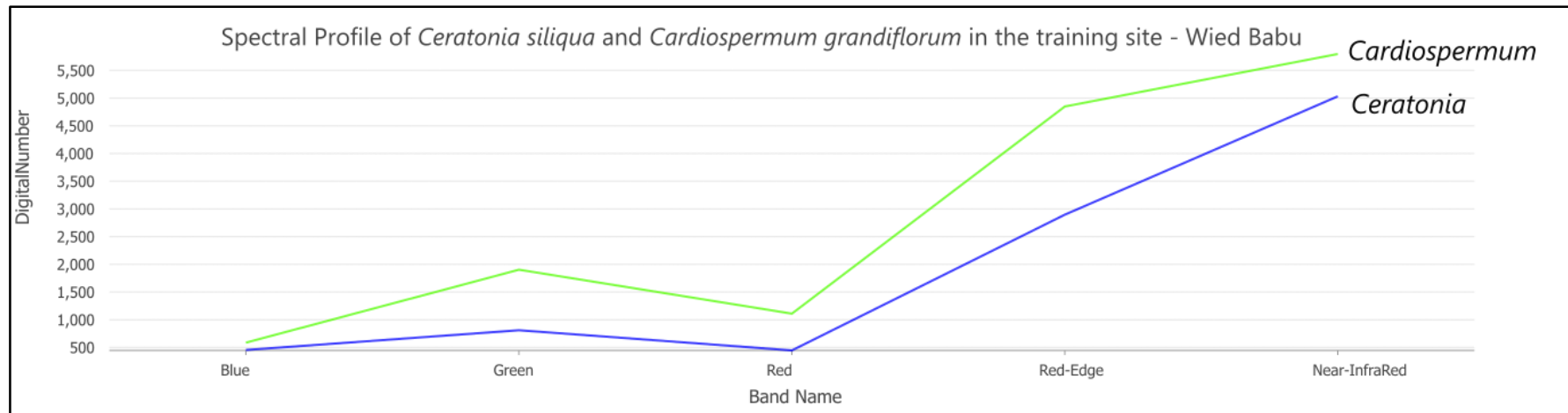# The Method

- Site Assessment & Ground Survey
  - Extensive cover, Dense mat at the introduction point
  - Sporadic records downward the valley
- Aerial survey using drones
  - Mavic Mini
    - Low altitude, High Spatial Resolution, RGB imagery.
    - Processed in WebODM.
    - Great output for visual interpretation, limited use for classification.
  - Phantom 4 Multispectral
    - Low altitude, High Spectral resolution, RGB + 2 Infra Red bands.
    - Processed in Aegisoft Metashape.
   - Great output for classification, limited for human interpretation!

The Method

- Data Analysis: The 50 shades of green

  - *C.grandiflorum* has a brighter, paler shade of green than the surrounding vegetation, including *Ceratonia siliqua*.

  - Isolation based on the spectral signature, notably in the IR range.

Spectral Profile of *Ceratonia siliqua* and *Cardiospermum grandiflorum* in the training site - Wied Babu

- Several attempts using traditional classifiers

  - Unsupervised: K mean: Unsuccessful

  - Random forest: Poor discrimination

The Method

- ▶ The Ultimate Solution: Deep Learning Models
  - ▶ Moved away from GIS-based method to Machine Learning
- ▶ Identification and labelling of training sites
  - ▶ 3 Categories
    - ▶ *Cardiospermum* (10)
    - ▶ *Ceratonia* (1)
    - ▶ Other/Background (0)
- ▶ Training of the model
- ▶ Classification of each pixel using the Deep Learning Model
  - ▶ Different libraries explored
    - ▶ Open CV
   - ▶ TensorFlow
    - ▶ PyTorch
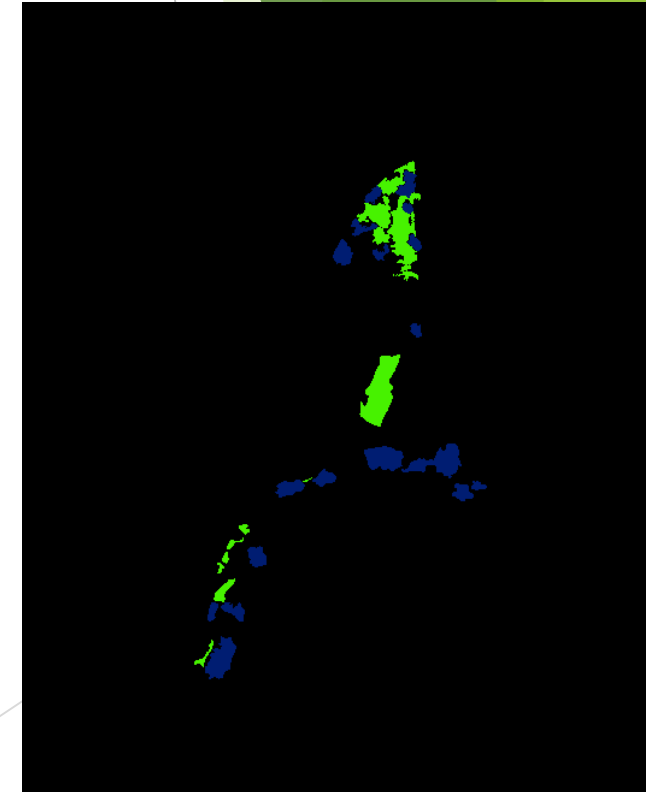
Preliminary results:

- Visual interpretation discriminates *Cardiospermum grandiflorum* based on pale light green foliage in visible light and high reflectance in the Red-Edge region.

- The Deep Learning model should be able to discriminate *Cardiopspermum grandiflorum*, *Ceratonia siliqua*, and the background.

- We anticipate the Deep Learning model to accurately detect the range of *Cardiospermum grandiflorum* within the study site.

- Provide a long-term solution to the ecological monitoring of the range of this Biological Invasion

The way forward

- Keep on training the selected model.

- Increase the extent of the study area.

- Validation of the model using ground truthing survey.
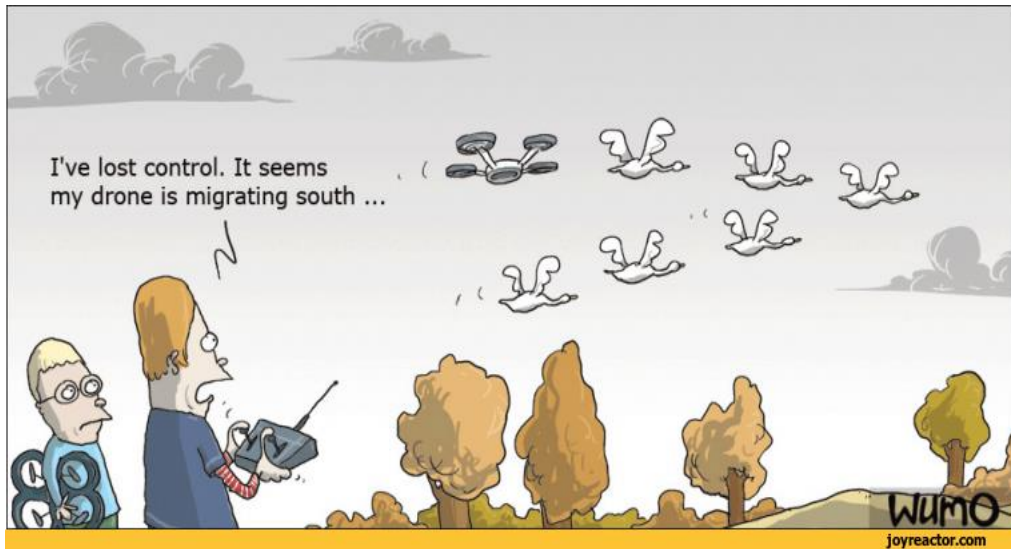
Thanks for you attention!

Any questions ?

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