Remote Sensing-Based Assessment of Agroforestry Systems and Monocultures in Batken, Kyrgyzstan – Detecting Drought Stress and Water Availability

Florian Drebes[1], **Philip Schierning**[2], **Jannike van Bruggen**[2], **Valerie Graw**[1]
[1]Ruhr University Bochum, Department of Geography, Bochum, Germany
[2]Rhine-Waal University of Applied Sciences, Faculty of Life Sciences, Kleve, Germany

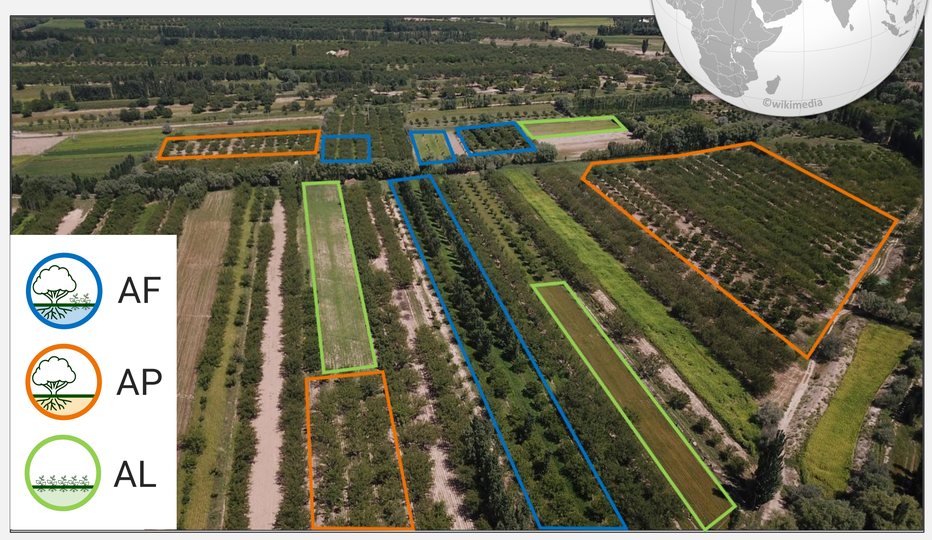
An Initiative of the Federal Ministry of Education and Research
CLIENT II International Partnerships for Sustainable Innovations
With funding from the: Federal Ministry of Research, Technology and Space
SUFACHAIN Sustainable Forest and Agroforestry Value Chains

1. Introduction

Agricultural systems in **semi-arid regions** are increasingly challenged by **water scarcity**, driven by **rising temperatures** and **declining precipitation**.
The **northern Batken region** in southwestern **Kyrgyzstan** (40.11847° N, 70.82031° E), along the Tajik border, exemplifies these conditions: hot, dry summers and a strong dependence on snowmelt- and glacier-fed irrigation shape local agriculture.

Agroforestry systems (AFS) – particularly **apricot-alfalfa combinations** – offer promising solutions through improved water use efficiency, enhanced soil health, diversified income opportunities. Their **share in the region** and **resilience remain unknown**.

Study objectives
1. Map **agroforestry (AF)**, **apricot (AP)**, and **alfalfa (AL)** monocultures in the Batken region.
2. Assess their response **to drought stress and water availability**.



The study area (154 km²) is a core zone of apricot production, and water limitations have become a major constraint for farmers, while different land use system are present.

2. Methods

Three-steps approach

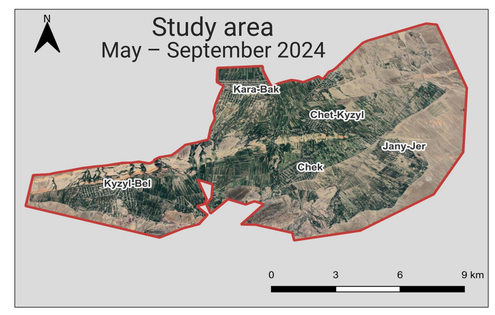
A. Field **Segmentation** using the *Segment Anything Model* (SAM)

B. *Spectral Time Series-Based* **Classification Model**
- Training Data: 66 AF, 88 AP, 59 AL fields
- NDVI, EVI, NDWI, BSI temporal profiles

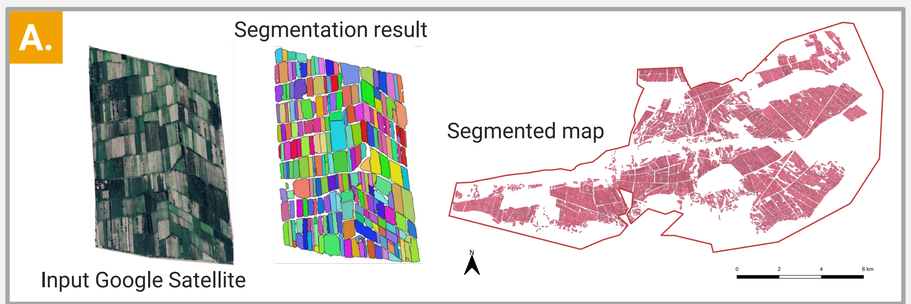
C. Multi-temporal **Drought Stress Analysis**
- *Normalized Difference Drought Index* (NDDI)

Data & Processing

Remote sensing data: Sentinel-2 time series from 2024 (25 images) acquired via Google Earth Engine.
Google Satellite imagery supported field delineation.
Data processed and analyzed by using Python and QGIS.

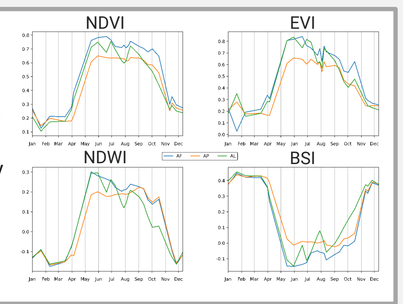


A.



Input Google Satellite

B.1



Comparison of indices per category

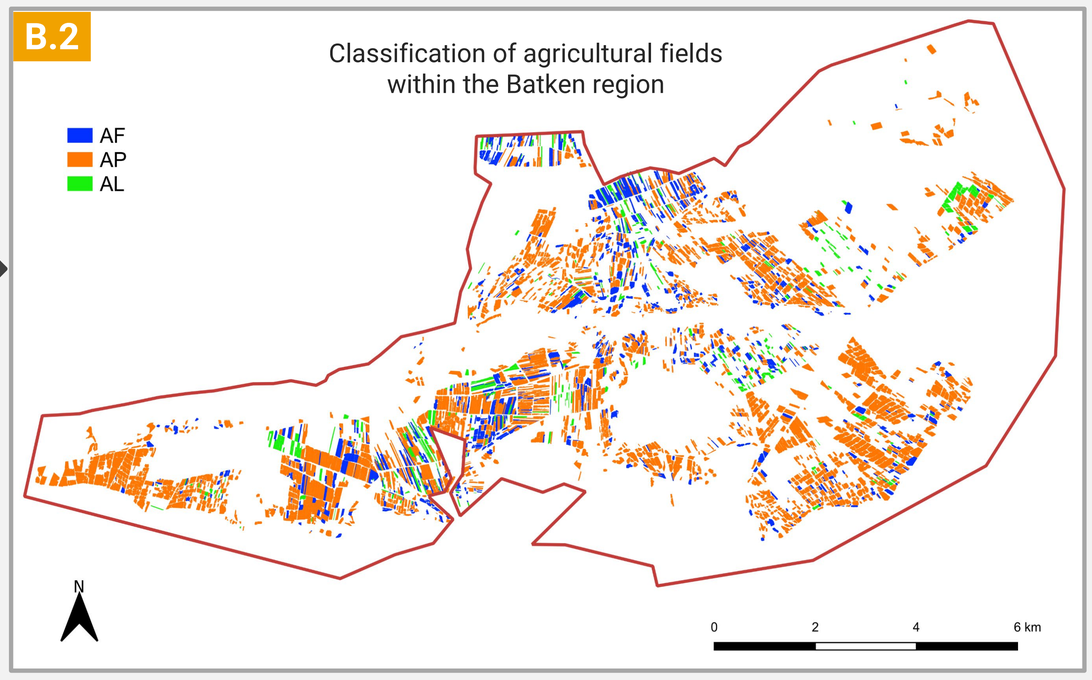
3. Results & Discussion

Land Classification

A total of **5,700 ha** of agricultural land were classified (**11,752 fields**):
- Agroforestry (AF) = 9 % Ø 0.33 ha
- Apricot (AP) = 35 % Ø 0.43 ha
- Alfalfa (AL) = 4 % Ø 0.31 ha
- Other agricultural land = 52 %

Classification accuracy: 65 % (Kappa = 0.53)

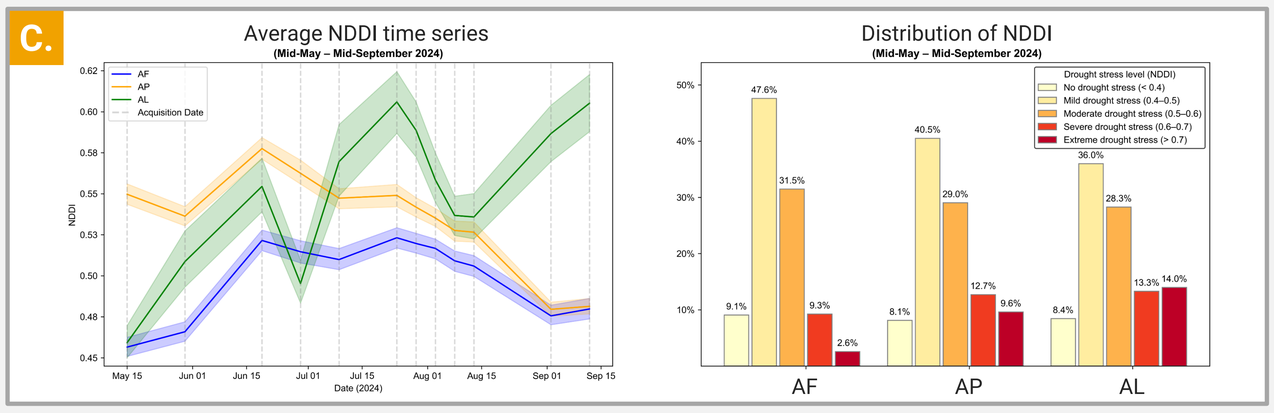
B.2



Drought Stress Assessment (NDDI, May–Sept 2024)
Significant differences emerged between systems:
- AFS had the **lowest mean NDDI** values
- AFS showed the **most stable drought stress** patterns

→ Indicating greater resilience to water scarcity.

C.



The **enhanced performance of AFS** can be discussed to several effects:
- Tree shade reduces soil temperature and evaporation
- Alfalfa benefits from cooler microclimates beneath trees
- Complementary root systems: deep- and shallow-rooting (tree & crop)
- Irrigation practice could differ per class, and cause distortion
- AFS presence depending on environmental factors (chicken/egg dilemma)

4. Conclusions

AFS combining apricot trees and alfalfa show strong potential for climate-resilient agriculture in the semi-arid Batken region.
Remote sensing effectively enabled:
- Large-scale **land segmentation & classification**
- **Drought stress monitoring**

→ Providing valuable insights into system performance under water-limited conditions.

Future Research Priorities
- Field validation of drought stress results
- Multi-year analyses to track AFS expansion and resilience
- Integration of high-resolution irrigation and soil data
- Automated classification workflows for regional monitoring

Contact
Florian Drebes & Philip Schierning
florian.drebes@rub.de
philip.schierning@hsrw.eu

Project´s website

This study is part of the SUFACHAIN project on Sustainable Forest and Agroforestry Value Chains in Central Asia, funded by the Federal Ministry of Research, Technology and Space under the Client II Programme. www.sufachain.org

RUB Geographisches Institut
Sustainable Food Systems
HOCHSCHULE RHEIN-WAAL Rhine-Waal University of Applied Sciences

presented 10/25