DETECTION AND ASSESSMENT OF AGROFORESTRY SYSTEMS (AFS) AND MONOCULTURES IN NORTHERN BATKEN (KYRGYZSTAN)

Fig. 1: Agricultural land in the northern Batken region (Schierning 2024)

FLORIAN DREBES (MASTER'S THESIS)

LATINET ENVIRONMENTAL CONFERENCE 2025

SUFACHAIN
Sustainable Forest and Agroforestry Value Chains

Climate Change and Water Scarcity in Agriculture

- Rising temperatures, changes in precipitation, extreme weather events
- Increasing water scarcity
  → Threatening agriculture
- Affecting particularly (semi-)arid regions such as Kyrgyzstan (Abella & Ahn 2024)

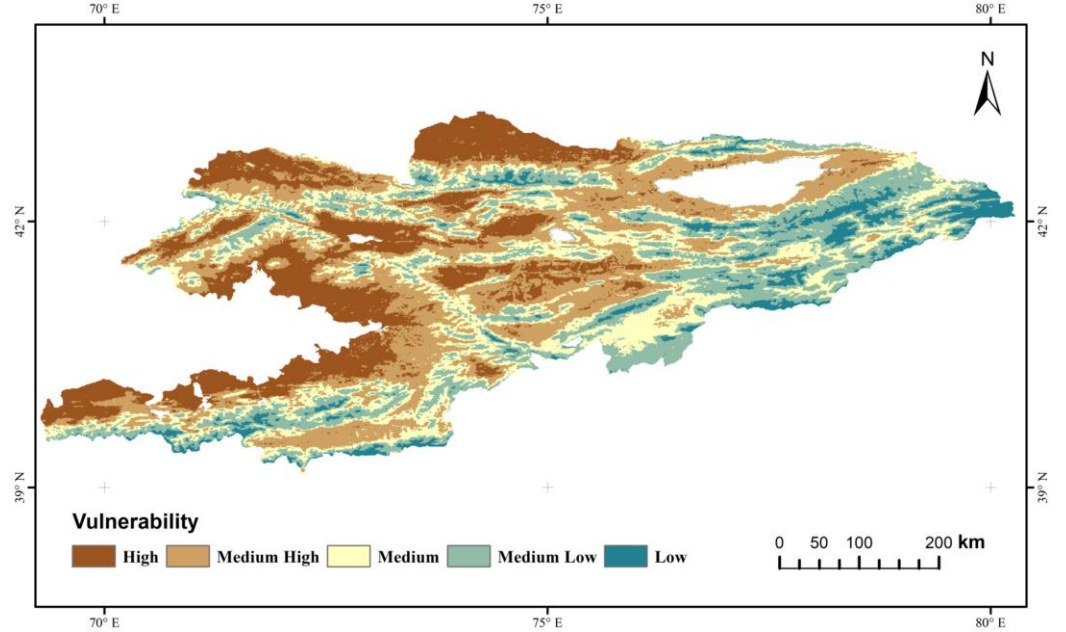


Fig. 2: Map of the drought exposure of Kyrgyzstan's agricultural systems (Liang et al. 2021)

Apricot Cultivation in Batken

Batken region

- Apricot cultivation = high importance
- Water scarcity and inefficient irrigation systems
- Dependence on the Isfara river

  and glacial meltwater (Djanibekov et al. 2016)

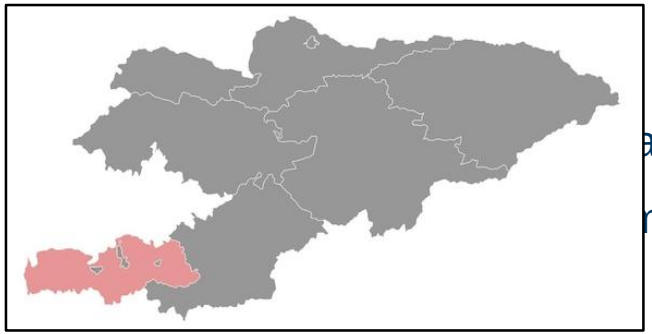
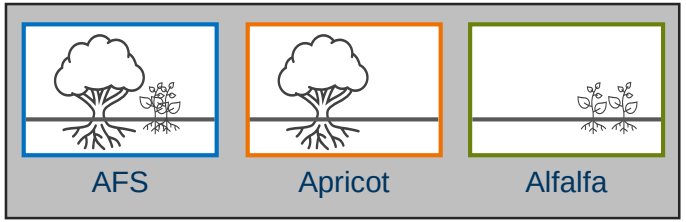


Fig. 4: Map of Kyrgyzstan with Batken region highlighted

Fig. 3: Dead apricot tree in Batken (Schierning 2024)



Research Question

Lack of knowledge about the distribution and potential benefits of AFS in Batken

Can AFS and monocultures

(apricots and alfalfa)

in the northern Batken region

be accurately distinguished and

classified using remote sensing data?

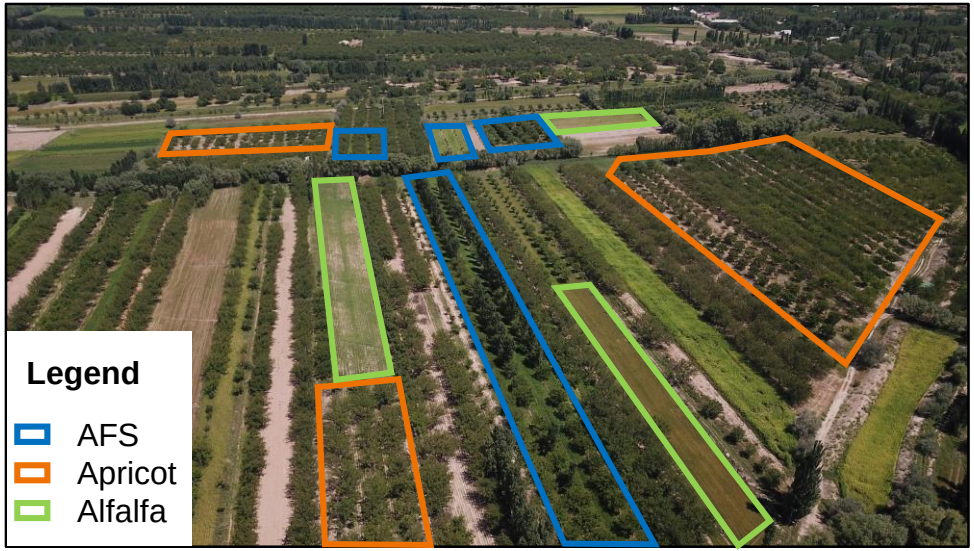


Fig. 5: Drone image with examples of the three land use categories (Schierning 2024)

Study Area

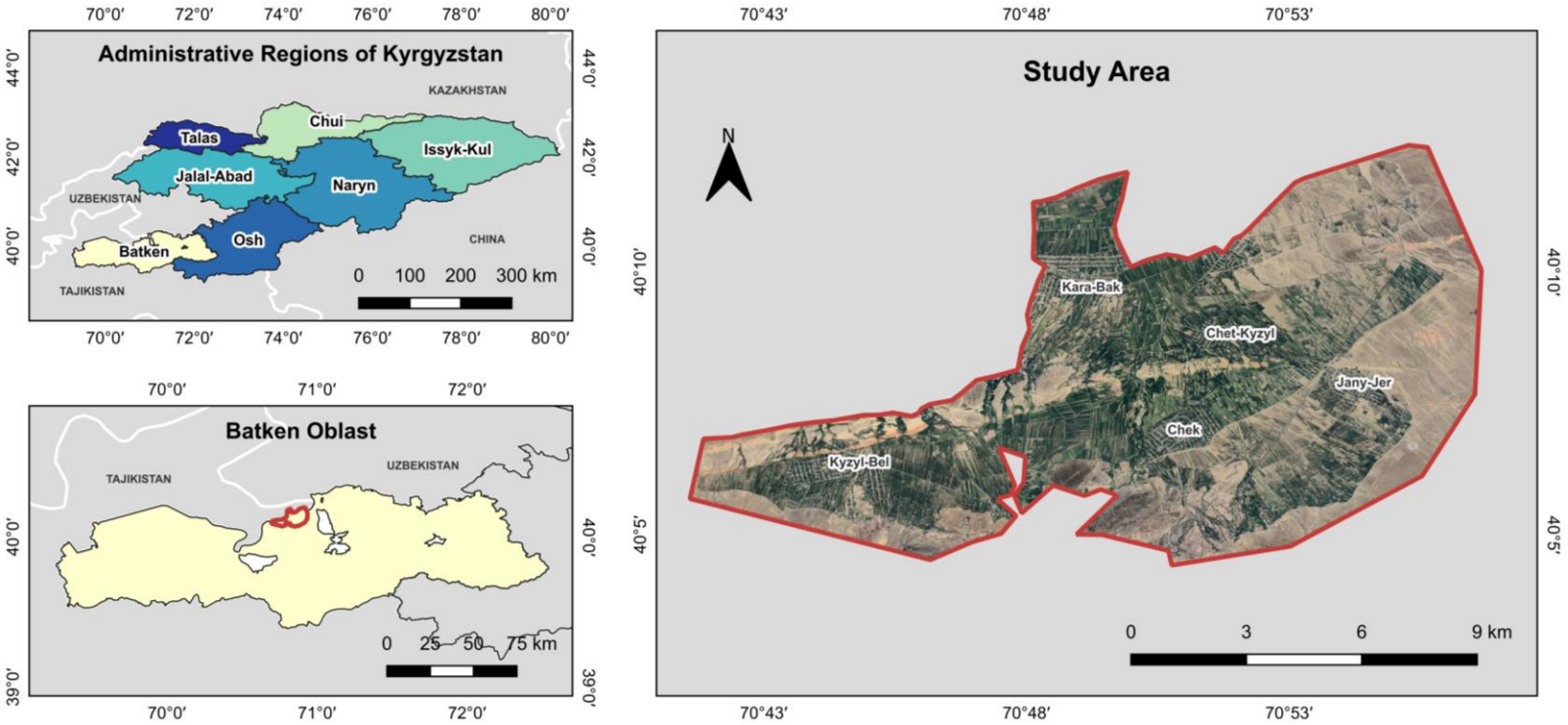
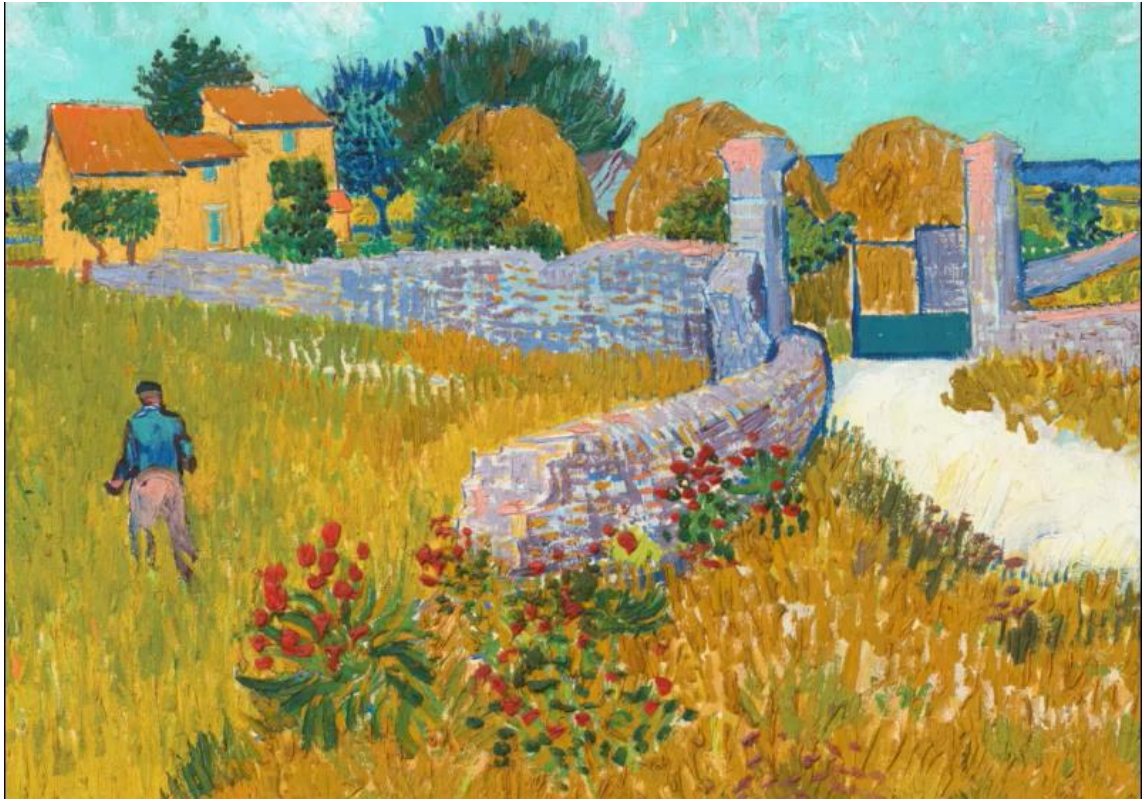


Fig. 6: Maps of Kyrgyzstan, Batken Oblast and the study area

Segmentation using Segment Anything Model (SAM)



- No available vector data of agricultural areas
- ➢ SAM as an efficient solution for automatic segmentation by Meta AI
- Segments new images and recognizes unseen objects without additional training data

(Wu & Osco 2023)

Fig. 7: Example of results using the model (Meta 2023)

Segmentation using Segment Anything Model (SAM)

Input Google Satellite

Segmentation Result

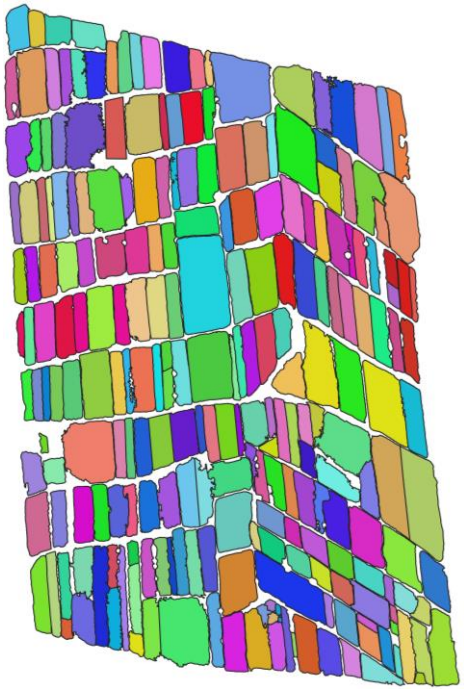


Fig. 8: Segmentation result using SAM for an example area

Segmentation Results

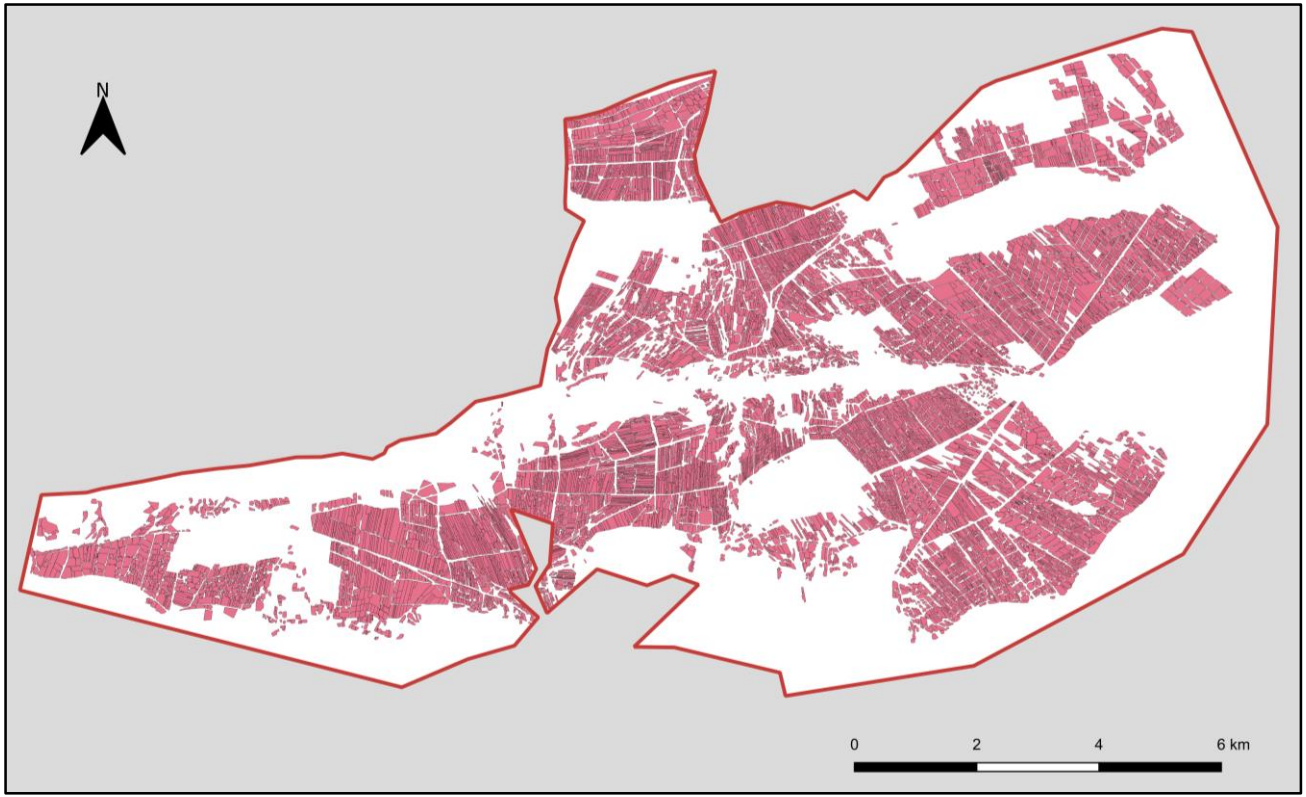


Fig. 9: Segmentation of all potential agricultural land in the study area

Excursus: Remote Sensing

- Satellites or aerial sensors gather data about the Earth's surface without physical contact
- Different materials reflect light uniquely
- Used to monitor vegetation, water, land use and environmental changes (USGS 2024)

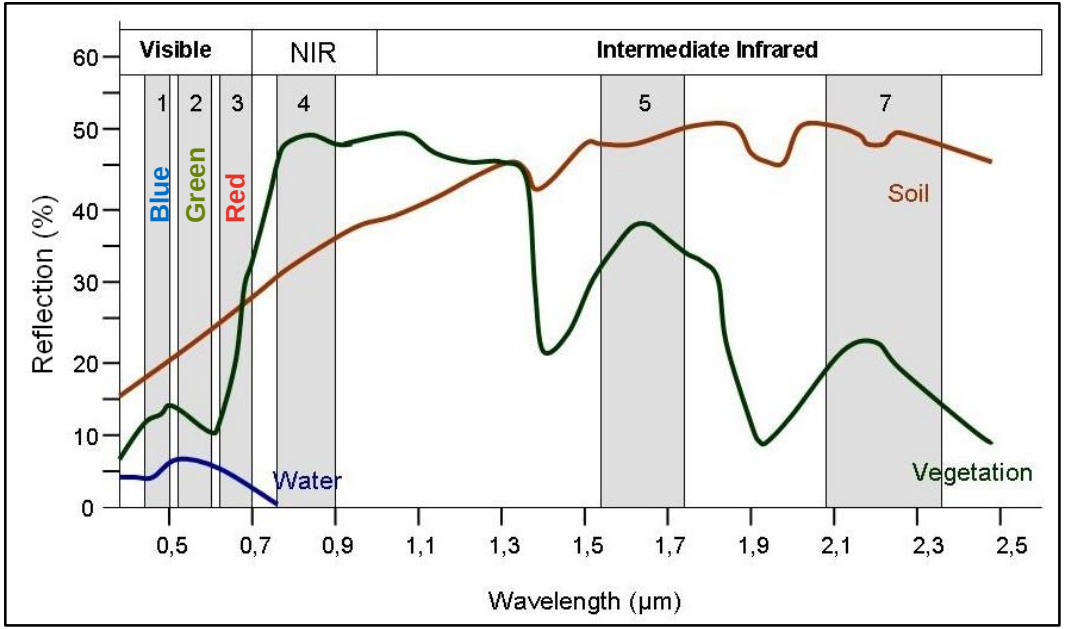


Fig. 10: Spectral signatures of soil, vegetation and water (Siegmund & Menz 2005)

Excursus: Remote Sensing Indices

- Spectral indices combine different bands to highlight specific surface features
- NDVI (Normalized Difference Vegetation Index) measures vegetation health by comparing red and near-infrared
- High values = dense, healthy vegetation
- Low values = bare soil or stressed plants

(Shurlaeva et al. 2021)

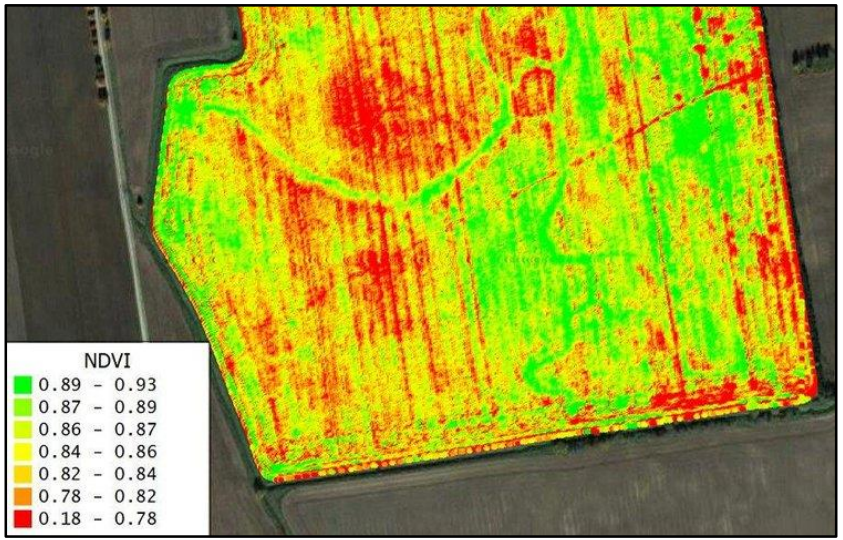


Fig. 11: An example of NDVI map visualization (Shurlaeva et al. 2021)

Model Training with Time Series of Spectral Indices

Data basis for model training

- 25 Sentinel-2 images (2024)
- 66 AFS, 88 apricot, 59 alfalfa plots

Spectral indices

- Normalized Difference Vegetation Index – **NDVI**
- Enhanced Vegetation Index – **EVI**
- Normalized Difference Water Index – **NDWI**
- Bare Soil Index – **BSI**

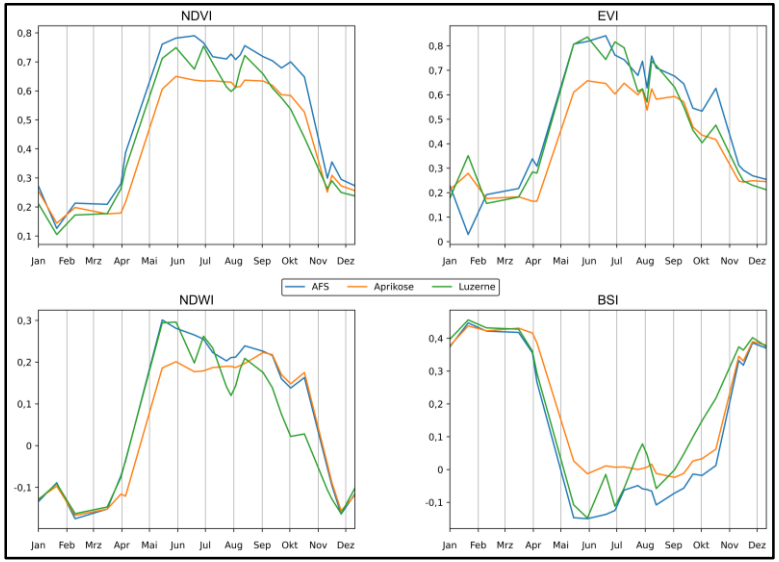


Fig. 12: Time series of average indices per category (2024)

Model accuracy of 80 % with Std Dev of 10.4 %

Model Results

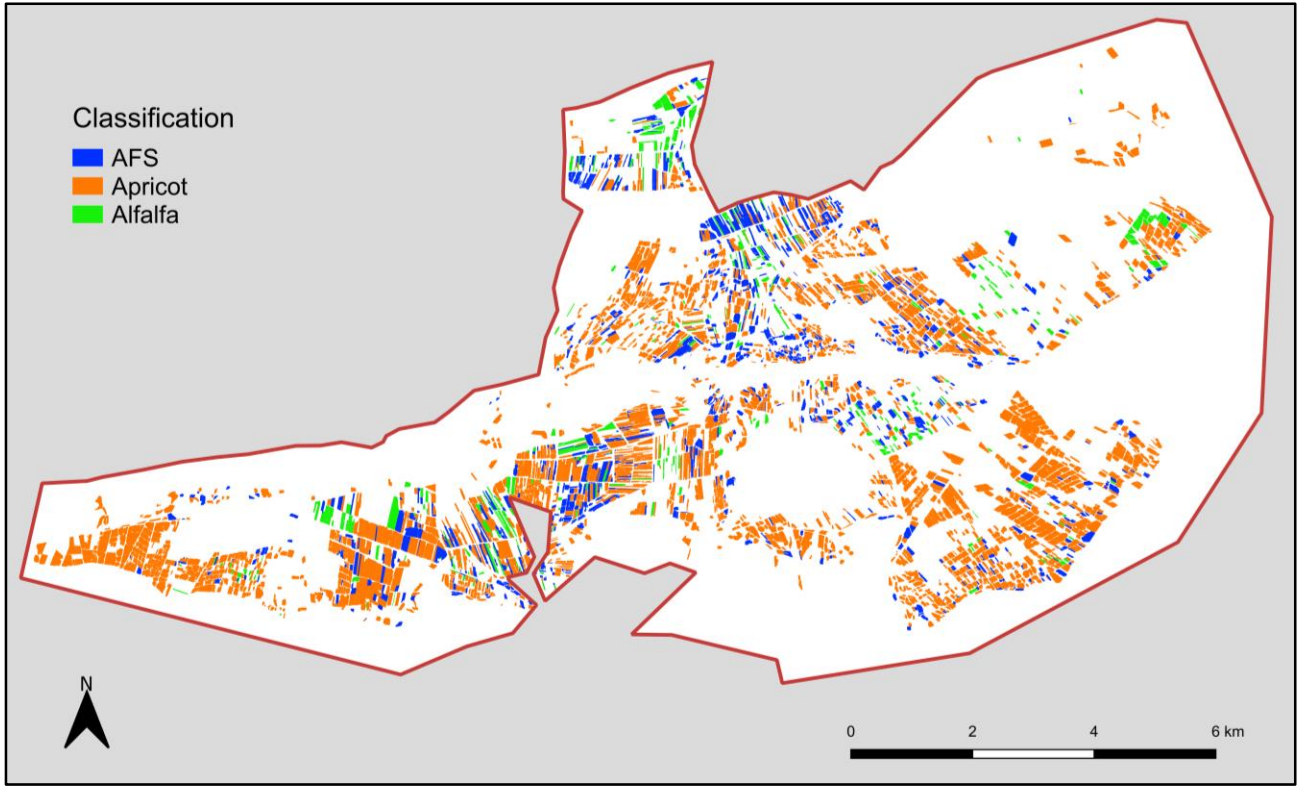


Fig. 13: Identified AFS, apricot orchards and alfalfa fields in the study area

Model Results

Tab. 1: Classification results for agricultural land

Category	Identified Plots	Ø Size per Plot	Total Size	Share
AFS	1234	0.43 ha	527.5 ha	9.3 %
Apricot	3417	0.58 ha	1984.4 ha	34.8 %
Alfalfa	547	0.43 ha	233.5 ha	4.1 %
Other Agricultural Land	6554	0.45 ha	2954.5 ha	51.8 %
Total	11752	0.49 ha	5699.9 ha	100 %

Conclusions

Overall model performance was highly satisfactory, with clear differentiation between AFS and monocultures. The results demonstrate the potential for using index-based classifications in the Batken region.

Outlook

- Analysis of water availability and drought stress across the different land use categories
- Validation of the classification results through field work
- Derivation of practical recommendations for agricultural practice and possible future applications of remote sensing techniques in similar regions

THANKS!

List of Figures

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Any Slides for Backup

Possible Advantages of Agroforestry Systems

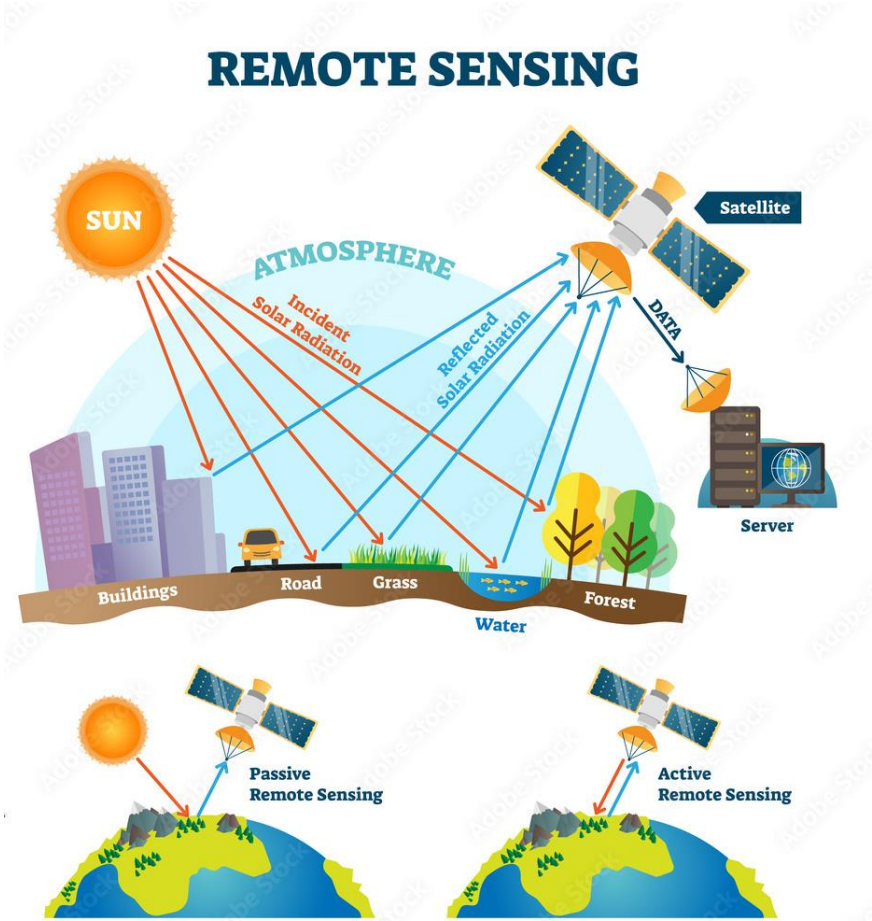
- Improvement of water management through:
  - Increased water infiltration → Root systems penetrate soils deeper → Water absorption
  - Less water loss through less surface runoff
  - Trees reduce soil temperature through shading effect → reduces evaporation
- Promotion of biodiversity through different microhabitats
- Improved soil health through organic material and nitrogen-fixing through trees
- Reduction of income risk through diversification of income

Apricot Cultivation in Batken

Fig. XX: Apricot monoculture (Schierning 2024)

Fig. XX: Apricot AFS (Oetker 2023)

Remote Sensing



Sentinel-2 Band Setting

Band	Spatial Resolution	Central Wavelength	Description
B2	10 m	490 nm	Blue
B3	10 m	560 nm	Green
B4	10 m	665 nm	Red
B8	10 m	842 nm	NIR
B11	20 m	1610 nm	SWIR1

Spectral Indices utilized in this Study

Index	Equation	Description	Reference
Normalized Difference Vegetation Index (NDVI)	$\frac{NIR - Red}{NIR + Red}$	Measures vegetation health and density	Rouse et al. 1974
Enhanced Vegetation Index (EVI)	$2{,}5 * \frac{NIR - Red}{NIR + 6 * Red - 7{,}5 * Blue + 1}$	Adaptation of the NDVI for dense vegetation by reducing atmospheric disturbances and ground reflection	Huete et al. 2002
Normalized Difference Water Index (NDWI)	$\frac{NIR - SWIR1}{NIR + SWIR1}$	Records the liquid water content in the vegetation	Gao 1996
Bare Soil Index (BSI)	$\frac{SWIR1 + Red - NIR + Blue}{SWIR1 + Red + NIR + Blue}$	Estimates the proportion of uncovered ground	Chen et al. 2004