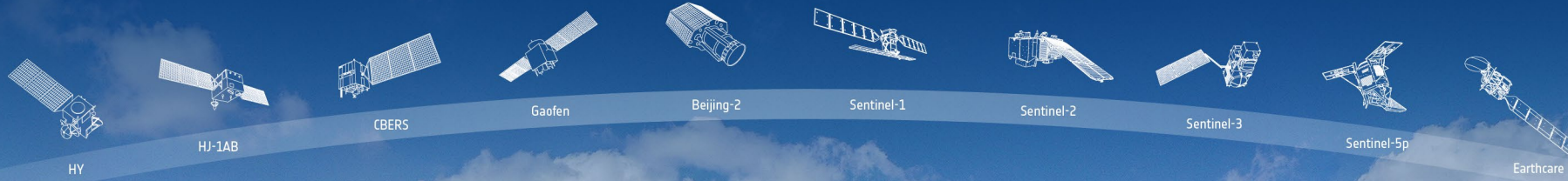




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2025 DRAGON 6 SYMPOSIUM

14-18 JULY 2025

[PROJECT ID. 95392]

[Essential Grassland Degradation Variables Mapping Based on Multiple Remote Sensing Datasets]





<16/JULY>

ID. 95392

PROJECT TITLE: ESSENTIAL GRASSLAND DEGRADATION VARIABLES MAPPING BASED ON MULTIPLE REMOTE SENSING DATASETS

PRINCIPAL INVESTIGATORS: [XIAOSONG LI, AEROSPACE INFORMATION RESEARCH INSTITUTE (AIR), CHINESE ACADEMY OF SCIENCES (CAS), CHINA] [ANNE GRAINGER, UNIVERSITY OF LEEDS, UK]

CO-AUTHORS: [CHAOCHAO CHEN, AEROSPACE INFORMATION RESEARCH INSTITUTE (AIR), CHINESE ACADEMY OF SCIENCES (CAS), CHINA] [MILENA CUDAK, UNIVERSITY OF LEEDS, UK] [FRANCESCO FUSTINONI, UNIVERSITY OF LEEDS, UK]

PRESENTED BY: [CHAOCHAO CHEN]

Objectives

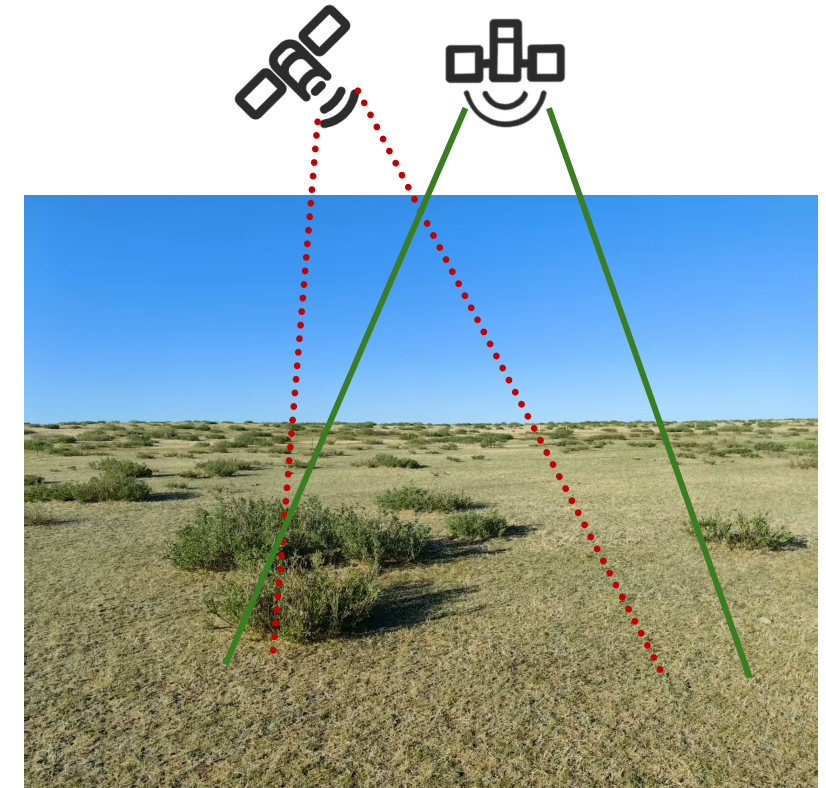


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- Establish connections between ground observations and satellite remote sensing, using multi-source and multi-scale remote sensing data to conduct **mapping and analysis of key grassland degradation variables**.
- Integrate multi-source remote sensing data and **propose novel remote sensing indices** to overcome sensor resolution limitations, providing technical solutions for large-scale grassland degradation monitoring challenges especially for shrub encroachment.



Dragon 6 EO Data Delivery



Data access (list all missions and issues if any). NB. in the tables please insert cumulative figures (since June 2024) for no. of scenes of high bit rate data (e.g. S1 100 scenes). If data delivery is low bit rate by ftp, insert “ftp”

ESA /Copernicus Missions	No. Scenes	ESA Third Party Missions	No. Scenes	Chinese EO data	No. Scenes
1.		1.Sentinel-2	64	1.	
2.		2.Sentinel-1	40	2.	
3.		3.		3.	
4.		4.		4.	
5.		5.		5.	
6.		6.		6.	
Total:		Total:	104	Total:	
Issues:		Issues: All the data from GEE.		Issues:	

Chinese Young Scientists contributions in Dragon 6



Name	Institution	Poster title	Contribution including period of research
Chaochao Chen	Aerospace Information Research Institute (AIR), Chinese Academy of Sciences (CAS), China	A Novel Remote Sensing Index for Monitoring Shrub Encroachment	Data analysis Field work Investigation Writing

European Young Scientists contributions in Dragon 6



Name	Institution	Poster title	Contribution including period of research
Milena Cudak	University of Leeds, UK	The Potential for Using Image Fusion to Monitor Grassland Degradation	Methodology Field work Data analysis Investigation Writing
Francesco Fustinoni	University of Leeds, UK	Assessment of Grassland Degradation and its Mechanisms using VHR Imagery	Methodology Field work Data analysis Investigation Writing

Main achievements

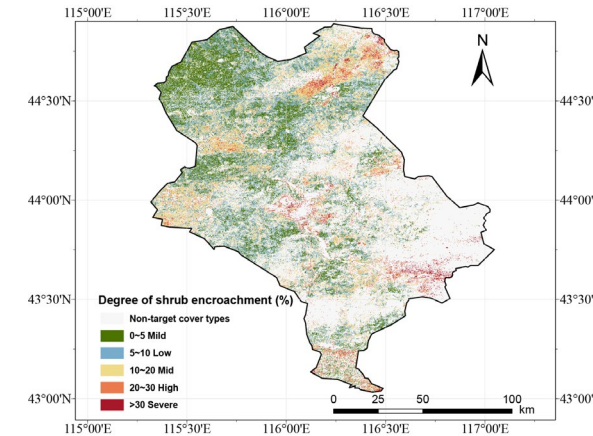


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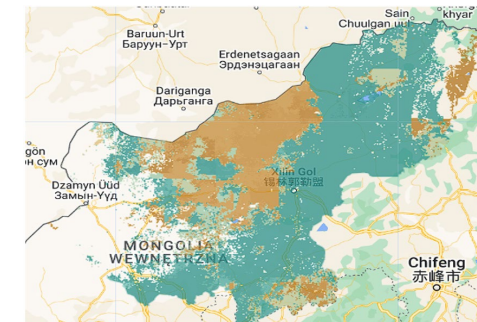


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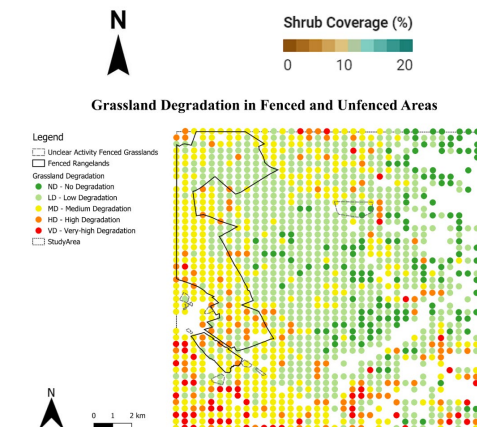
- 1. Training & Exchange:** Co-supervised 2 China-European graduate researchers, including successful thesis completion for one European MSc candidate.
- 2. Publication:** 1 SCI paper. Chinese postgraduate researcher Chaochao Chen developed a novel shrub encroachment index demonstrating strong applicability in Xilinhote typical steppe with scalable potential. (Manuscript submitted)
- 3. Scientific Innovations**
 - European researcher Milena Cudak conceptualized SARcal-NDVI for shrub encroachment monitoring, enabling large-scale mapping in Xilingol League.
 - European researcher Francesco Fustinoni pioneered a VHR-based degradation assessment method with mechanism analysis, advancing research in Hexigten Banner.



Novel Remote sensing index for grassland shrub encroachment monitoring
By Chaochao Chen



Large scale mapping for fraction of shrub coverage in Xilingol League based on SARcal-NDVI
By Milena Cudak



Assessment and mechanisms of degraded grassland in Hexigten
By Francesco Fustinoni

1 Study Area — Xilinhot City

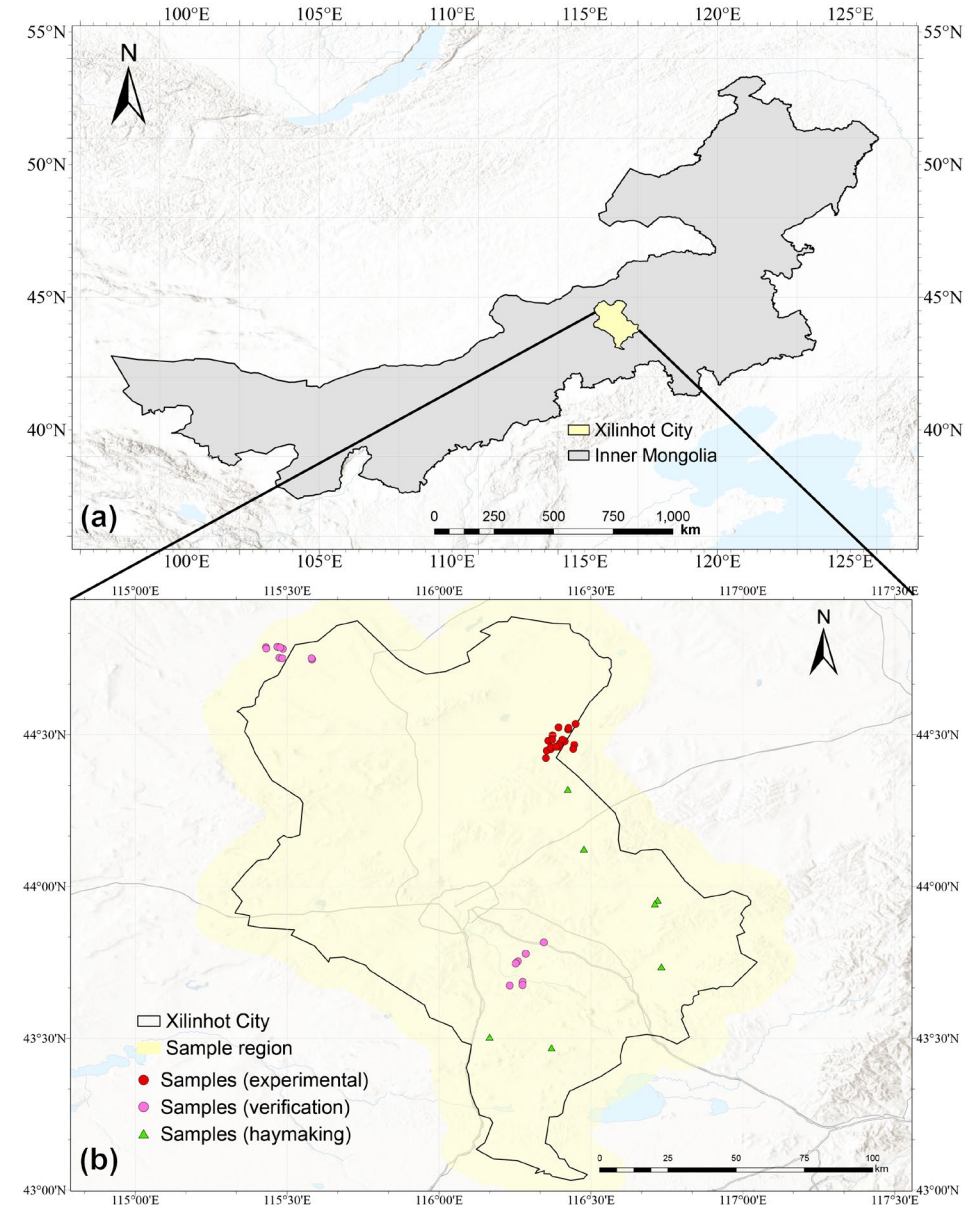


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- An area of typical steppe in China , covers a total area of 14,785 km²
- Vegetation: 13,966 km² of typical steppe, accounting for over 90% of the total area.
- Climate: a typical temperate continental semi-arid climate, the annual precipitation is 309 mm
- Degradation: drought and overgrazing leads to the obviously degradation, also it belongs to the Beijing-Tianjin sand source region, large scale conservation is underway.



2 In-situ data measurements



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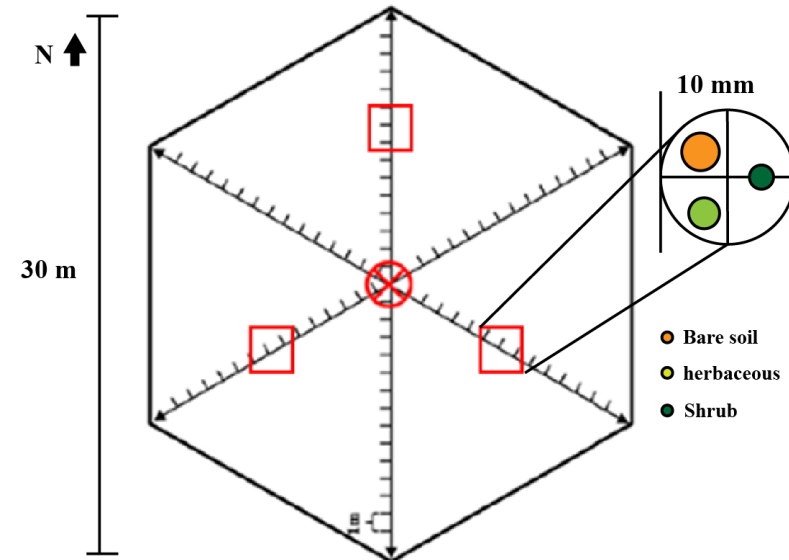


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Collect time: 2019-2024

Sample size: 30m*30m

**Fraction of vegetation cover
(shrub and herbaceous respectively)**



3 A Novel Remote Sensing Index for Monitoring Shrub Encroachment

Chaochao Chen



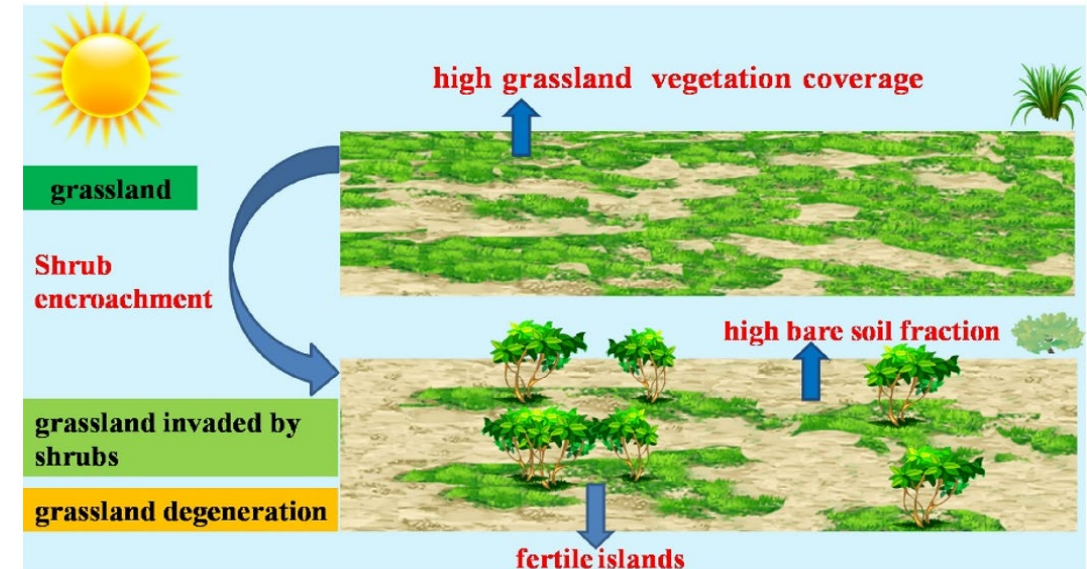
3.1 Background

■ Grassland Shrub encroachment

Shrubs gradually dominates the plant community, leading to increased coverage, density, and biomass, as well as expanded distribution (Chen et al., 2015). 10%–20% area of grassland in arid and semi-arid are affected by shrub encroachment (Van Auken, 2000)

■ Challenges for large scale remote sensing

- Shrubs mix with grass and have a strong heterogeneity both in temporal and spatial
- Low stature of shrubs, showing weak signal in coarse-resolution sensors
- Lack of remote sensing indices sensitive to shrub cover, which is a key factor for data-driven models



(Shen et al., 2022)

A remote sensing index sensitive to shrub coverage needs to be developed.

3 A Novel Remote Sensing Index for Monitoring Shrub Encroachment

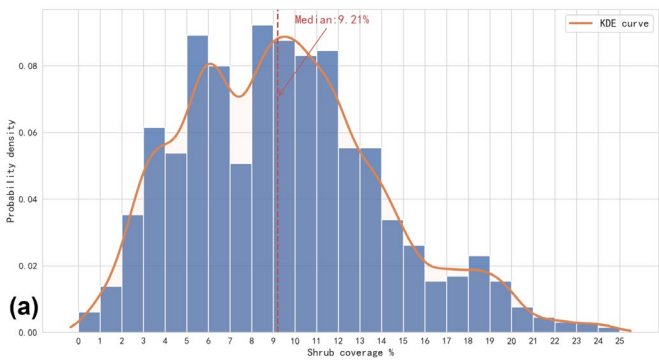


3.2 Samples processing

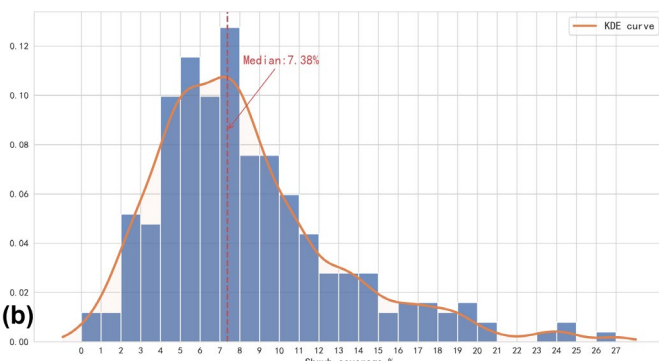
Samples from VHR imagery

[Experimental] 13 high-resolution image samples averaging 0.2 km²

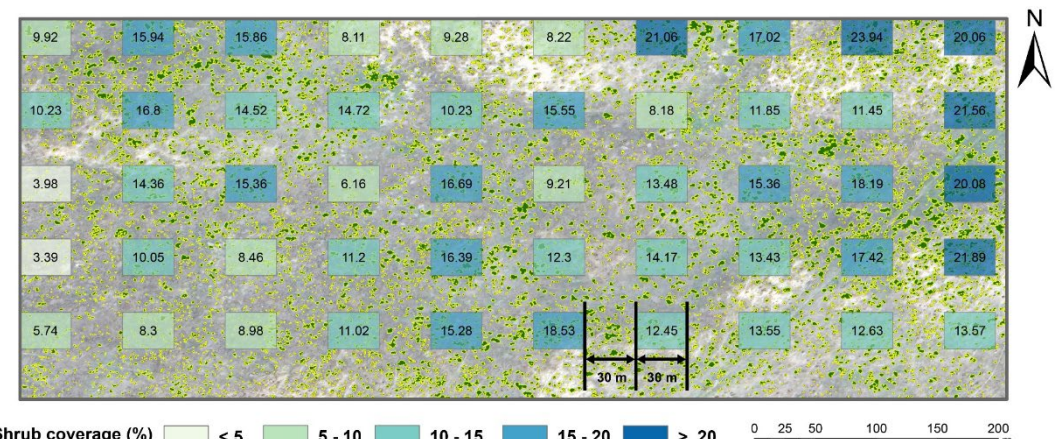
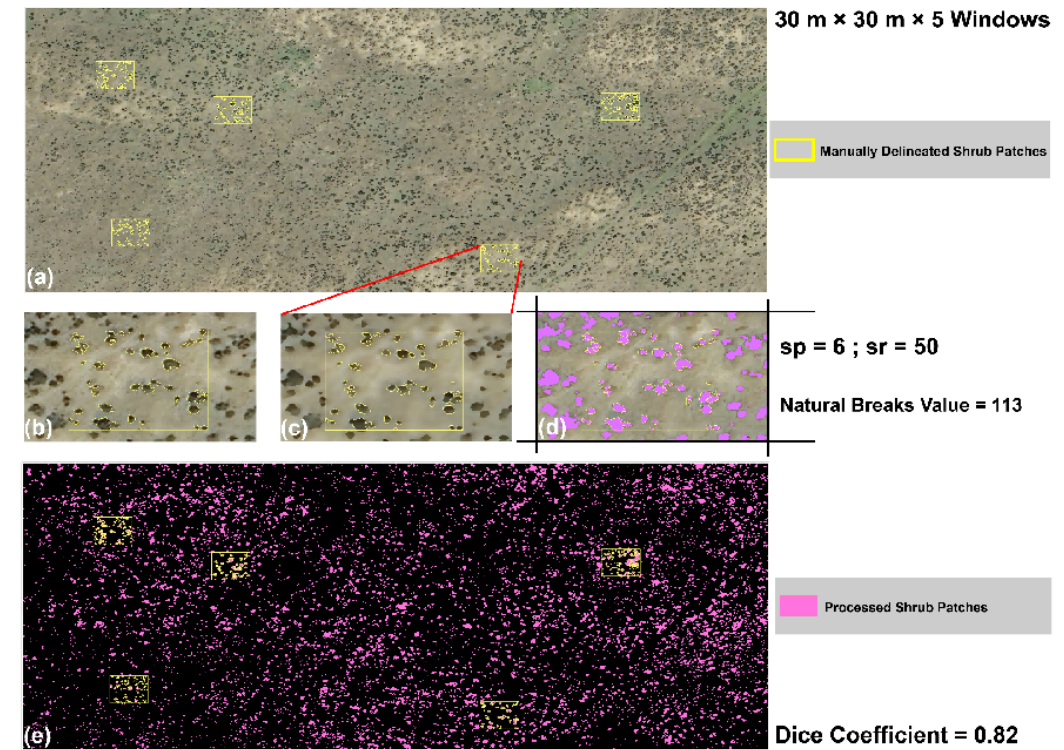
[Validation] Additional 14 samples averaging 0.07 km²



Experimental
n=650



Validation
n=252



3 A Novel Remote Sensing Index for Monitoring Shrub Encroachment



3.3 Extract remote sensing variables

3.3.1 EO data

- Sentinel-1 IW GRD
 - Data: VV, VH 10m, 32°~38° incident angles
 - Filter: 5.26 to 10.29, 2024, every 12 days, ascending
 - Processing: refined Lee filter, radiometric terrain normalization
- Sentinel-2 L2A SR
 - Data: 10 Bands (visible to infrared), 10m or 20m
 - Filter: ±6 days of each Sentinel-1 acquisition date
 - Processing: Cloud masking with QA60

3.3.2 Remote sensing features

Feature Type	Name
Band reflectance	B2-B8, B8A, B11, B12
Optical vegetation indices	NDVI, GNDVI, MNDVI, EVI, MSAVI, NDWI, REVDVI, NDRE, CIRE, SAVI, ARVI, STVI1, STVI2.....

Feature Type	Name
Bascatter coefficient	VV, VH
Simple indices	Span=VV+VH, Ratio=VH/VV
Radar vegetation indices	RVI, NDPI, DpRVlc.....

3 A Novel Remote Sensing Index for Monitoring Shrub Encroachment

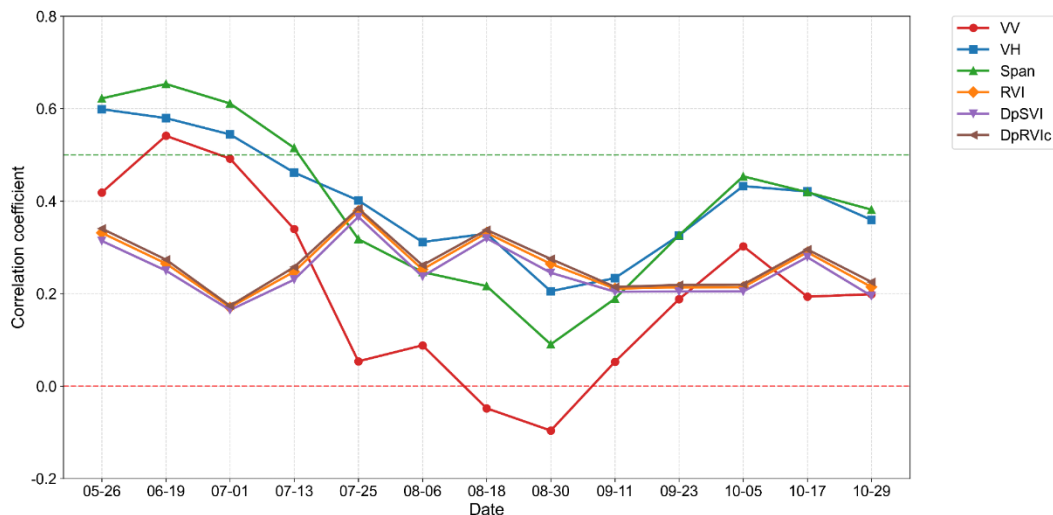
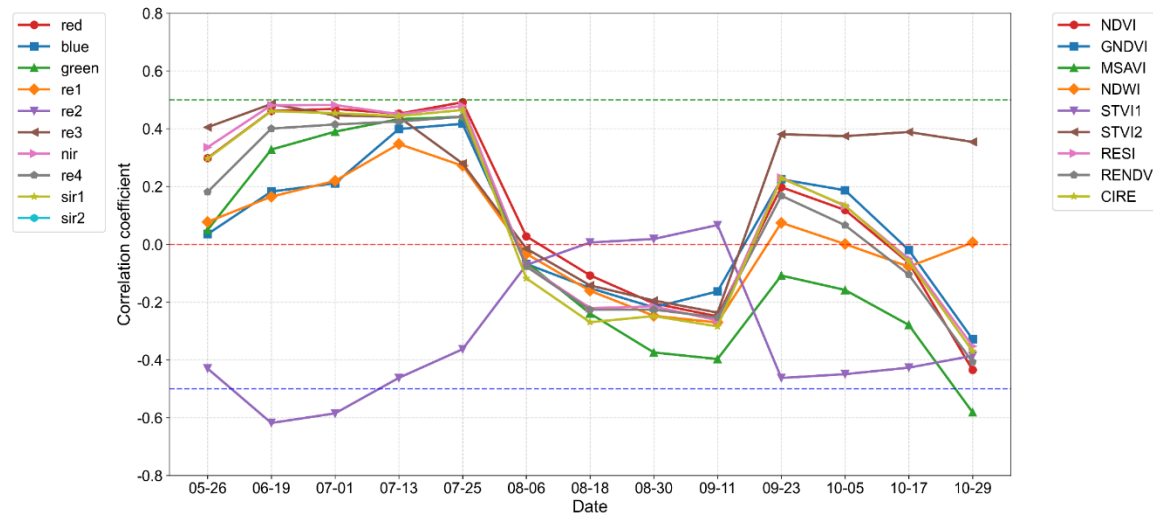
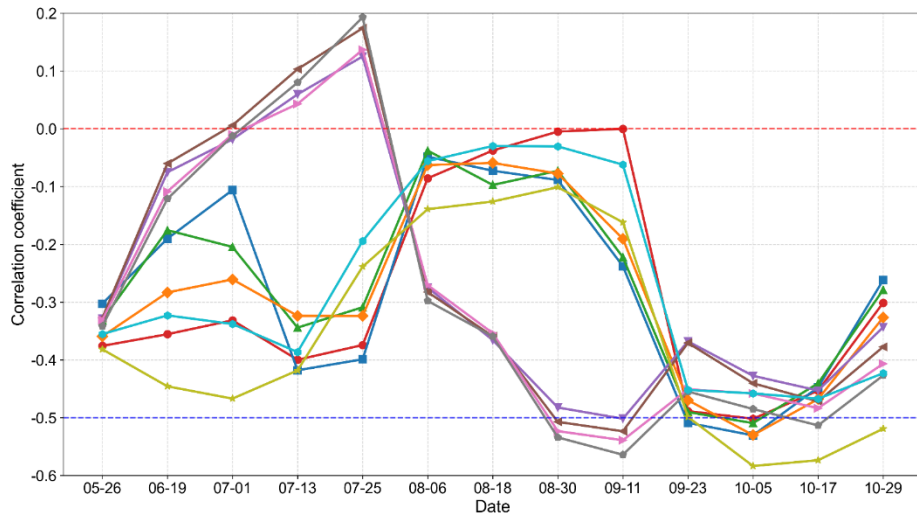


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3.4 Analysis between remote sensing features and shrub coverage



3.4.1 Correlation time series

- STVI1, VV, VH show relatively higher correlation coefficients with shrub coverage
- June is the optimal time spot for monitoring
- The SAR RVIs based on ratio of cross- and co-polarization underperform in grassland shrubs

3 A Novel Remote Sensing Index for Monitoring Shrub Encroachment



3.4 Analysis between remote sensing features and shrub coverage



3.4.2 LOWESS curve and local slope

- STVI1: small slope magnitudes (low sensitivity) at low shrub coverage (0–5%) but significantly increased slope magnitudes at coverage >10%
- VV and VH: larger slopes (high sensitivity) at low coverage but reduced slopes at high coverage (especially 15–20%)
- SAR data showed strong associations with shrubs in low-coverage areas—consistent with prior findings—while optical data gained importance as increasing shrub dominance enhanced spectral signals

3 A Novel Remote Sensing Index for Monitoring Shrub Encroachment



3.5 Development of SSEI

3.5.1 Registration of different remote sensing data

$$\sigma_{xy}^0_{norm} = \frac{1}{-\sigma_{xy}^0_{dB}/10} = \frac{1}{-\log_{10} \sigma_{xy}^0}$$

Remote sensing variables	Max	Min	Mean	Std	(Max-Min)/Mean	Cv
VV_{liner}	0.049	0.004	0.016	0.006	2.867	0.362
VH_{liner}	0.010	0.000	0.002	0.001	4.110	0.581
VV_{dB}	-13.137	-23.950	-18.360	1.550	-0.589	-0.084
VH_{dB}	-19.994	-36.737	-26.976	2.671	-0.621	-0.099
VV_{norm}	0.761	0.418	0.549	0.047	0.626	0.085
VH_{norm}	0.500	0.272	0.374	0.036	0.609	0.097
STVI1	0.407	0.235	0.319	0.026	0.539	0.083

3.5.2 Build Steppe shrub encroachment index (SSEI)

$$SSEI = \frac{A * VH + VV}{STVI1}, \quad A = 1.5$$

Part1: $STVI1 = \frac{RED \times SWIR}{NIR}$

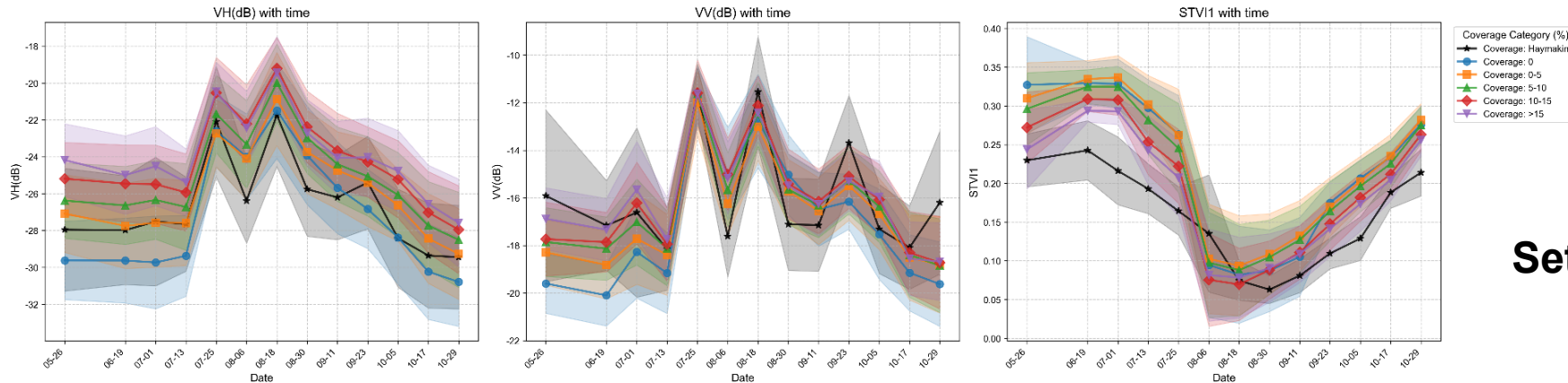
Part2: $1.5 * VH + VV = 1.5 * \frac{1}{-\sigma_{VH_{dB}}^0/10} + \frac{1}{-\sigma_{VV_{dB}}^0/10}$

3 A Novel Remote Sensing Index for Monitoring Shrub Encroachment



3.5 Development of SSEI

3.5.3 Index for discriminating shrubs from haymaking fields vegetation

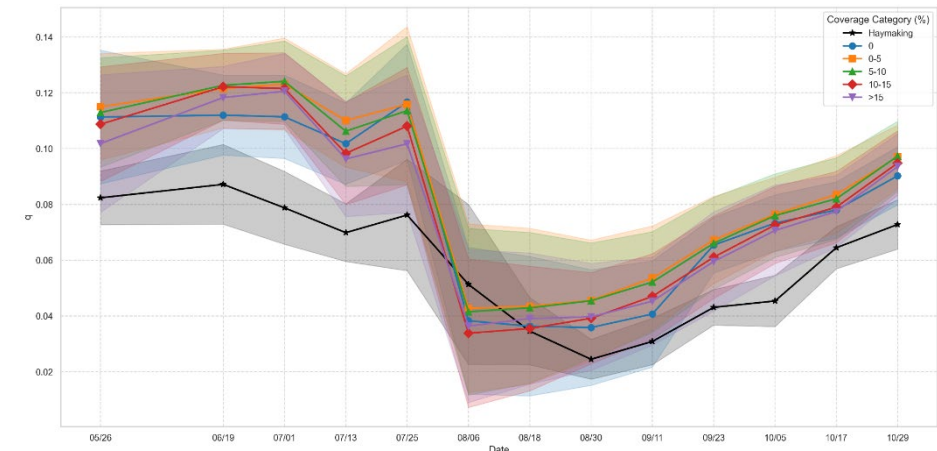


$$q = \frac{VV * STV11}{1 - \log_{10} \sigma_{VH}^0} * \frac{RED * SWIR1}{NIR}$$

Set $q=0.1$ in Xilinhote in 19, June



- Under similar vegetative conditions, herbaceous vegetation lacks the distinct vertical canopy structure characteristic of shrubs, resulting in diminished volumetric scattering responses captured by VH
- **Construct the relative volumetric scattering (q-factor) to represent this structural disparity**

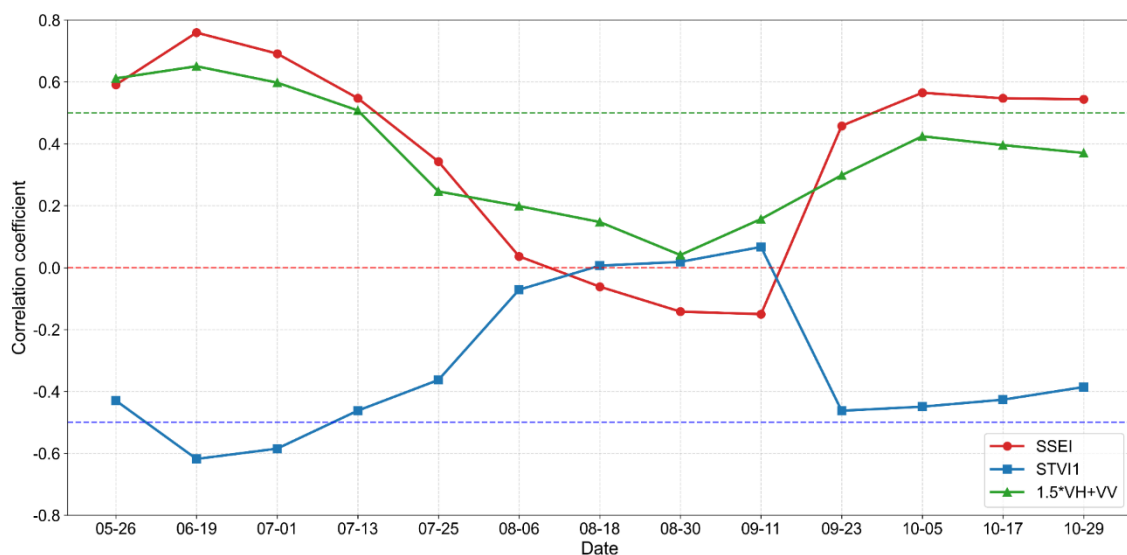


3 A Novel Remote Sensing Index for Monitoring Shrub Encroachment

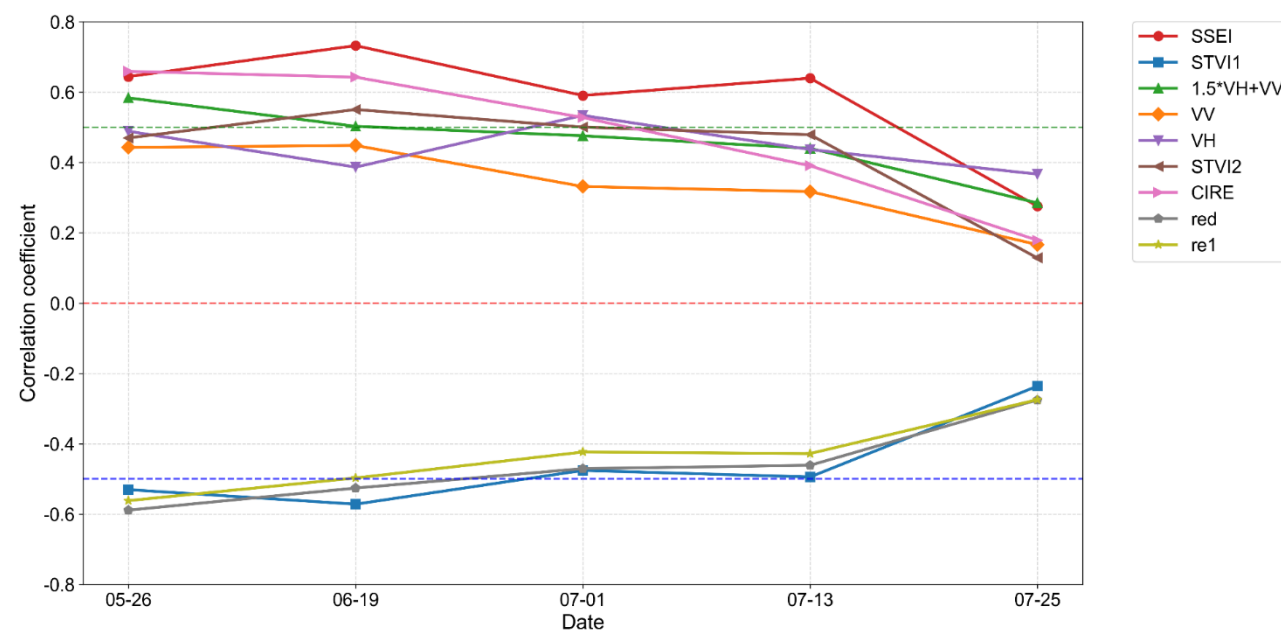


3.6 Analysis of SSEI performance

3.6.1 Higher correlation both in experimental and validation samples



Features with the highest correlation
in experimental samples
SSEI R=0.76



Features with the highest correlation
in validation samples
SSEI R=0.73

3 A Novel Remote Sensing Index for Monitoring Shrub Encroachment



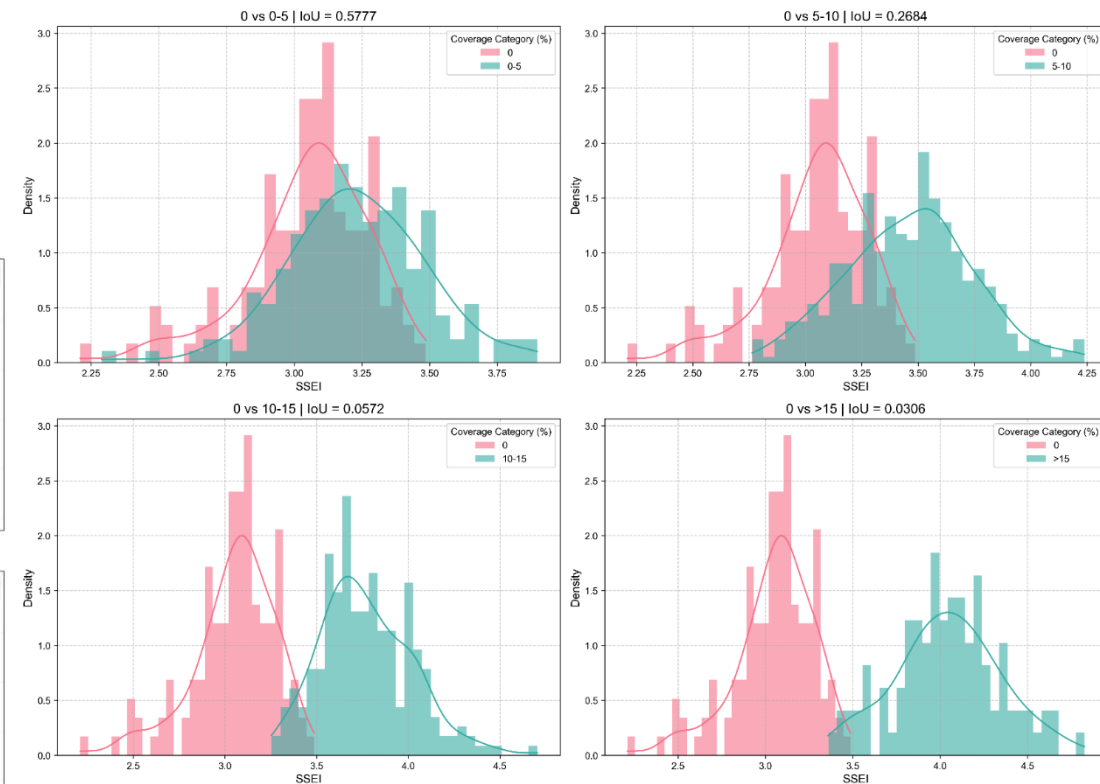
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3.6 Analysis of SSEI performance

3.6.2 Higher sensitivity to shrub coverage



Threshold identification of shrub coverage by SSEI is
10% with only 5% IoU
between grass and SE grassland

3 A Novel Remote Sensing Index for Monitoring Shrub Encroachment

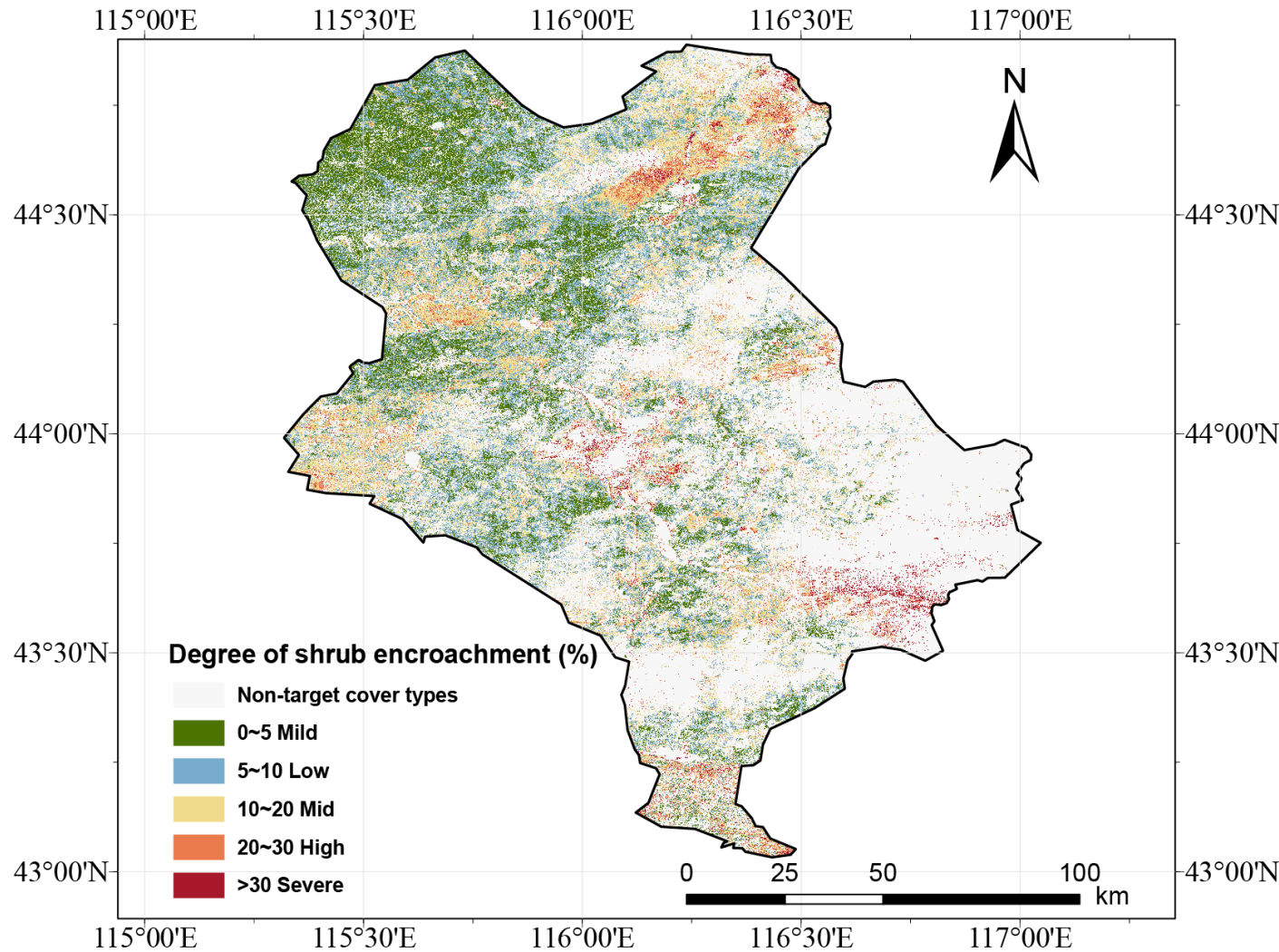


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3.7 Mapping of grassland shrub encroachment in Xilinhot City



- **June 19, 2024**
- A simple linear regression model ($R^2=0.533$)
- Filter $q < 0.1$ & slope $> 5^\circ$
- Use ESA World Cover 2021 to acquire grassland cover type
- ◆ Northeastern, western, southeastern, and southern - adjacent to shrub-dominated dunes indicating desertification trends.
- ◆ Northern Xilinhot (primary grazing zones) showed significant encroachment requiring ecological restoration attention

4 The Potential for Using Image Fusion to Monitor Grassland Degradation

Milena Cudak



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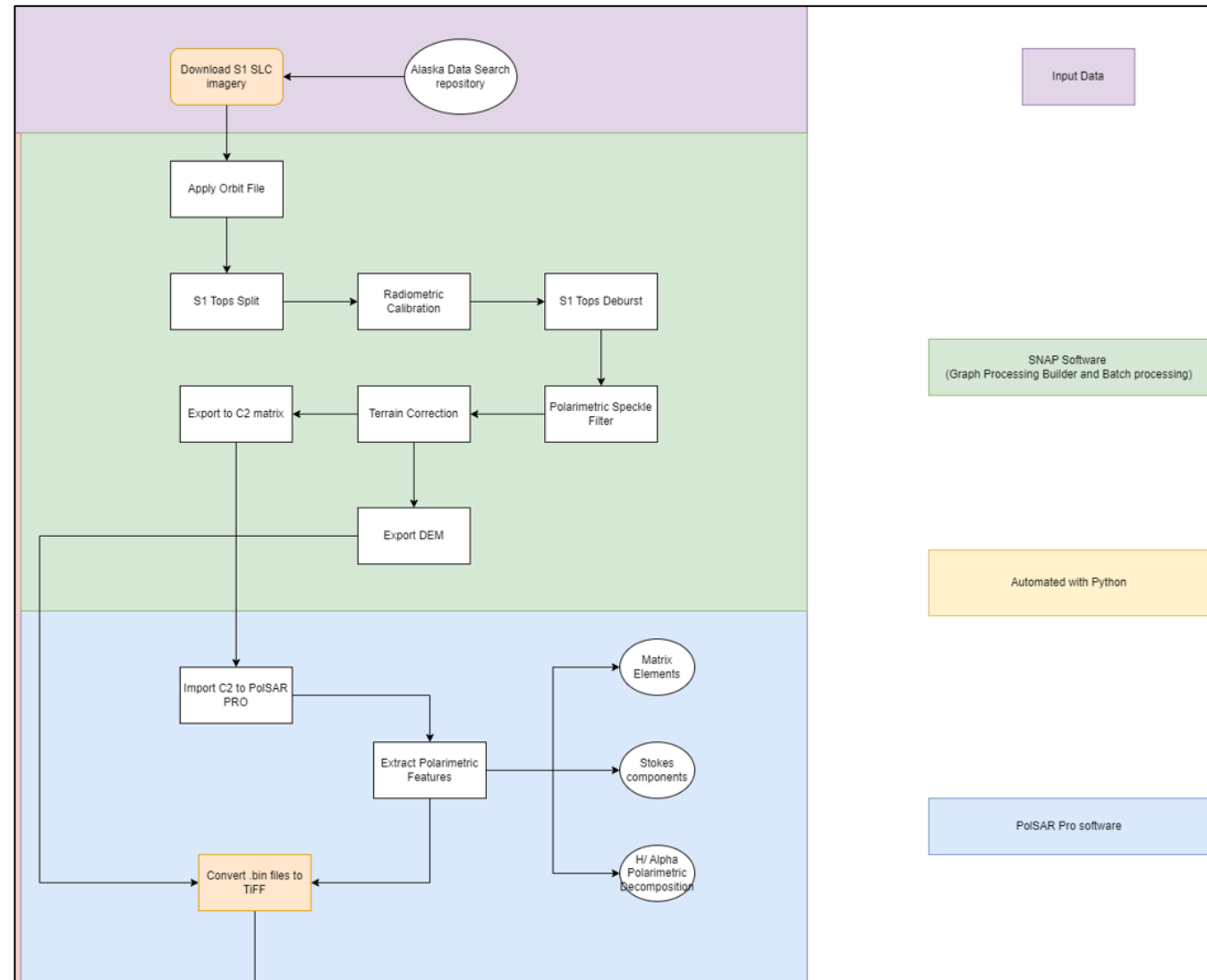
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4.1 Data Sources And Preprocessing

Data Sources:

- Sentinel-1 dual-pol (VV, VH) Single Look Complex (SLC)
- Sentinel 2 Level-2A orthorectified atmospherically corrected surface reflectance

- Pre-processing: Conducted in SNAP and automated using GPT and batch processing.
- C2 Matrix Upload: Imported into PolSAR Pro, processed and saved as .bin files.
- Export: Converted and exported to GeoTIFF format.



4 The Potential for Using Image Fusion to Monitor Grassland Degradation



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4.2 Processing Steps in GEE

01

Collocating Sentinel 2 and Sentinel 1 images (SAR-optical pairs with +/- 4 days between acquisitions)

02

Segmentation of NDVI images.

03

Feature extraction and calculation of mean values per segment.

04

Fitting the RF model.

05

Calibrating NDVI with SAR features.

06

Shrub biomass and coverage predictions

07

Change detection maps

4 The Potential for Using Image Fusion to Monitor Grassland Degradation

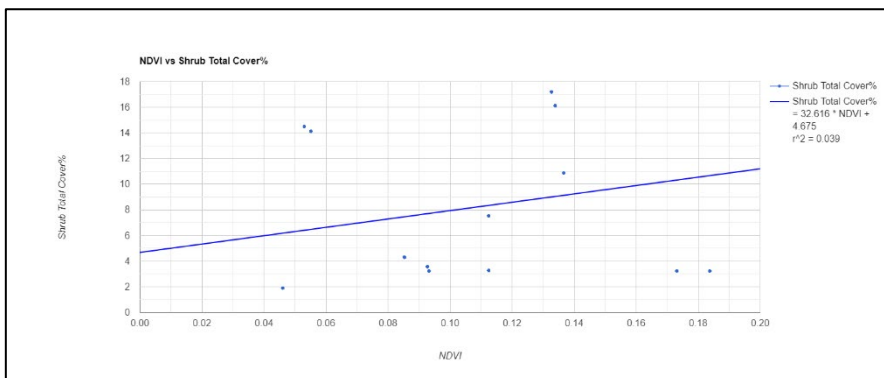


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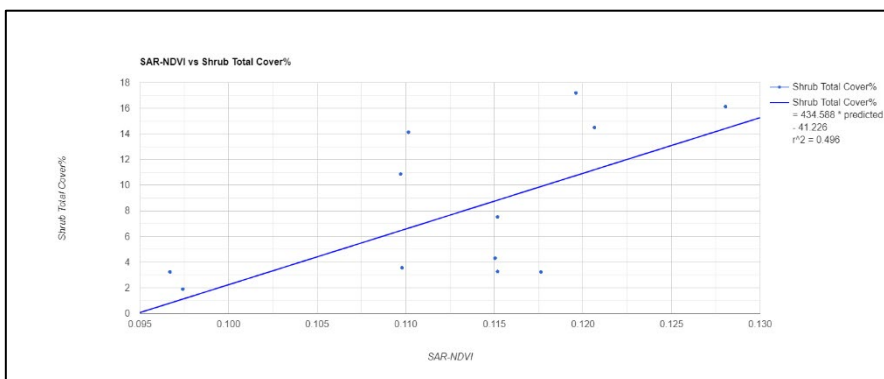
4.3 Validation with Field Observation (Shrub Cover)



Pearson correlation matrix (NDVI and Shrub Total Cover%):

correlation:
0.197814458031869
p-value:
0.000660975276757069

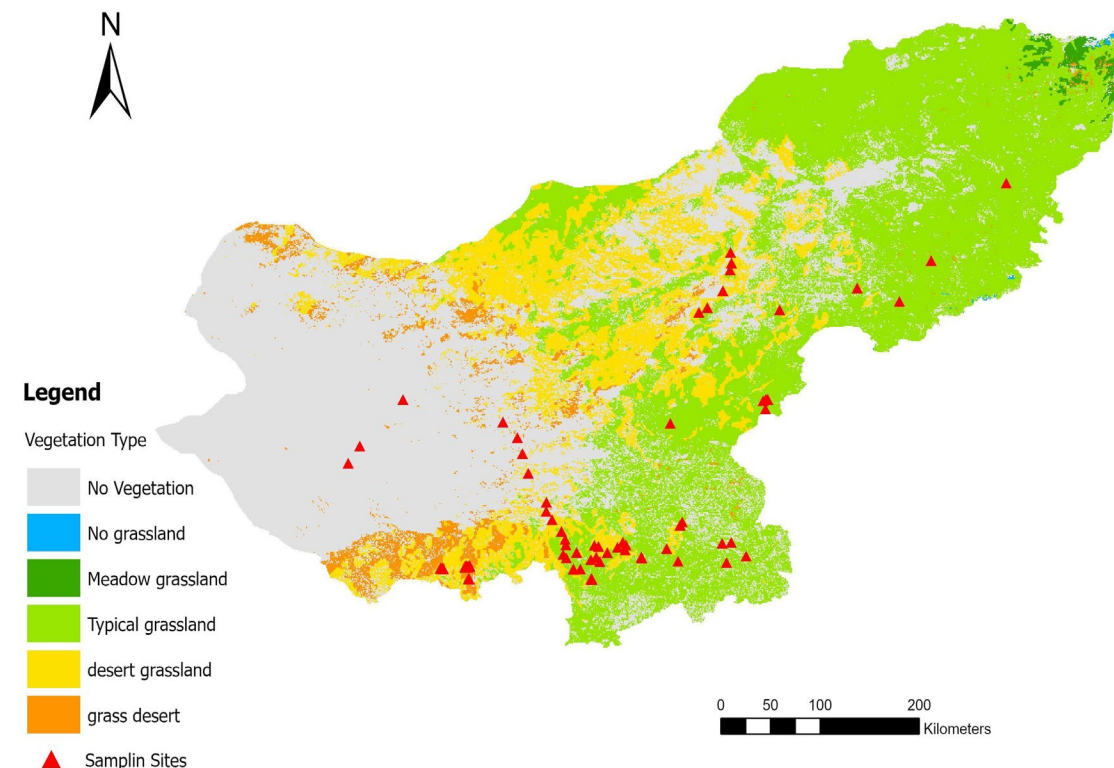
- Correlation between shrub coverage and classic NDVI



Pearson correlation matrix (SAR-NDVI and Shrub Total Cover%):

correlation:
0.7042393872950754
p-value:
3.387876613523755e-45

- Correlation between shrub coverage and SAR-NDVI



4 The Potential for Using Image Fusion to Monitor Grassland Degradation



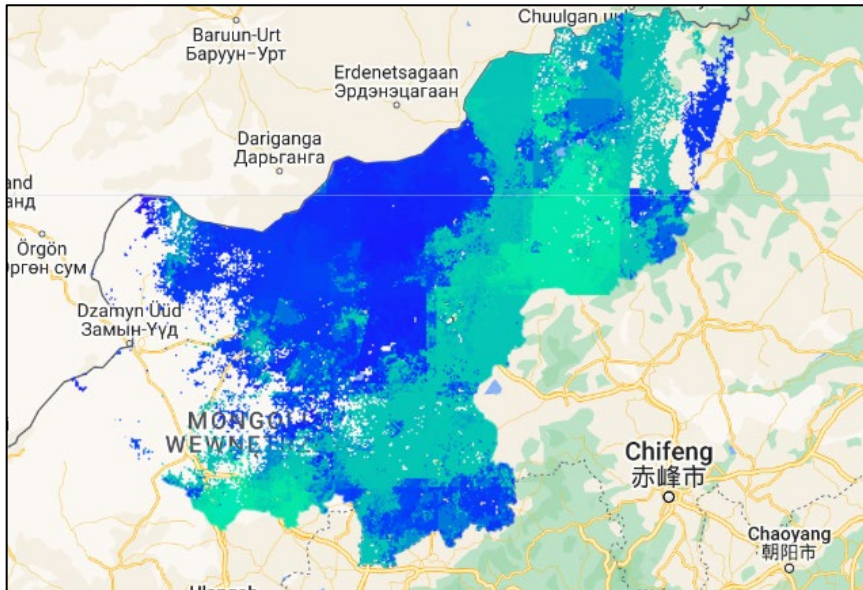
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4.4 Validation with Field Observation (Shrub Cover)

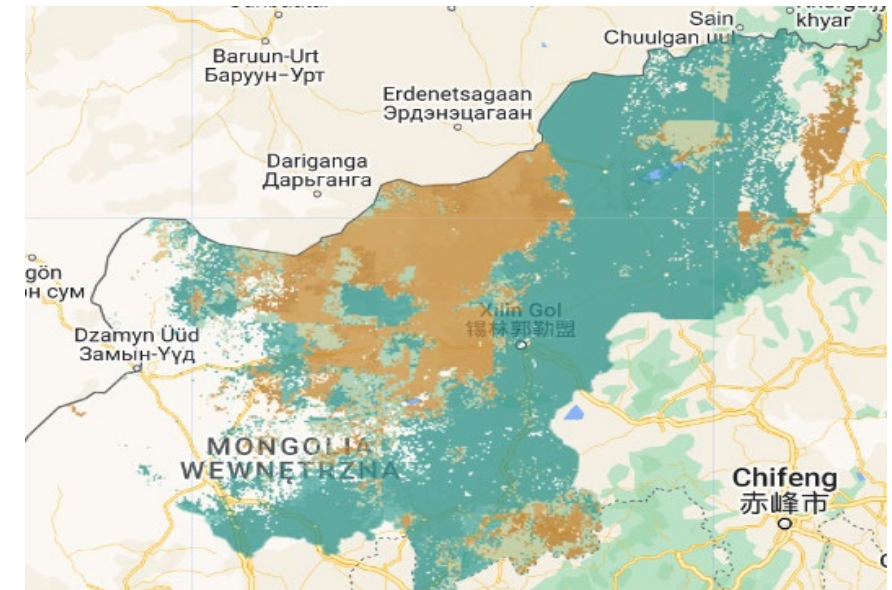
SAR-NDVI Map (July 2021)



SAR-NDVI



Shrub Coverage Map (July 2021)



Shrub Coverage (%)



5.1 Background & Objectives

■ Key Issue

Severe grassland degradation in Inner Mongolia, driven by overgrazing, land use change, and policy shifts.

■ Limitations of Current Methods

Low/medium-resolution remote sensing hinders detailed assessment of vegetation and soil degradation.

■ Study Objectives

- Explore VHR imagery (e.g., Google Earth) for comprehensive grassland degradation monitoring.
- Explain degradation patterns using a cross-scalar framework linking ecological, policy, social, and economic factors.



Figure 1.2: Vegetation degradation in the study area, Hexigten Banner, Inner Mongolia, China (Image by author)



Figure 1.3: Soil degradation in the study area, Hexigten Banner, Inner Mongolia, China (Image by author)

5 Assessment of Grassland Degradation and its Mechanisms using VHR Imagery



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5.2 Methodology

■ Study Area

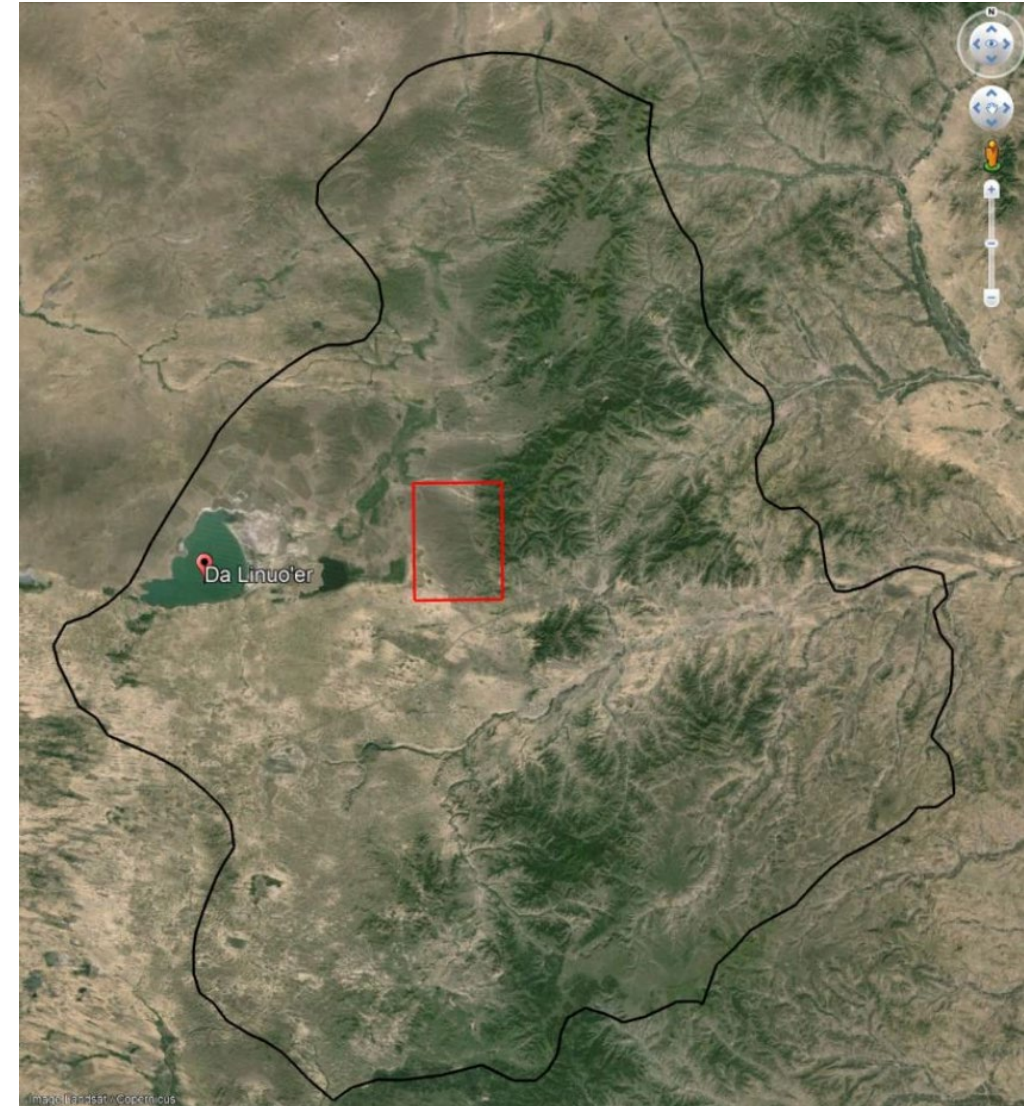
Hexigten Banner, Inner Mongolia (16×21 km), a critical agro-pastoral ecotone with fenced and unfenced grasslands.

■ Data & Tools

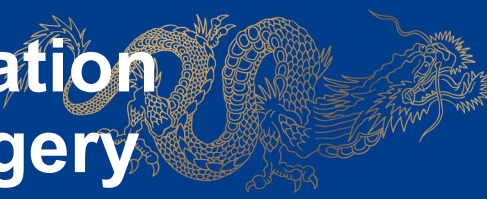
- Open-access VHR imagery (Google Earth, 2020).
- Software: QGIS, Collect Earth (for visual interpretation).

■ Analysis Approach

- Visual Interpretation: Classify desertification attributes (vegetation density, soil erosion, compaction, salinization).
- Grassland Degradation: Assessed as a combination of vegetation degradation (VDI index) and soil degradation (extent + severity).
- Sample Plots: 1692 plots (0.5 ha each) to quantify degradation patterns.



5 Assessment of Grassland Degradation and its Mechanisms using VHR Imagery



5.3 Key Results

■ Degradation Extent

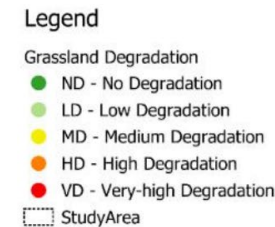
89% of grasslands show degradation; 47% low, 30% medium, 13% high/very high.

■ Spatial Patterns

- Higher degradation near settlements, croplands, and water points.
- Wind erosion (sand dunes) and water erosion (rills, gullies) concentrated in specific zones.

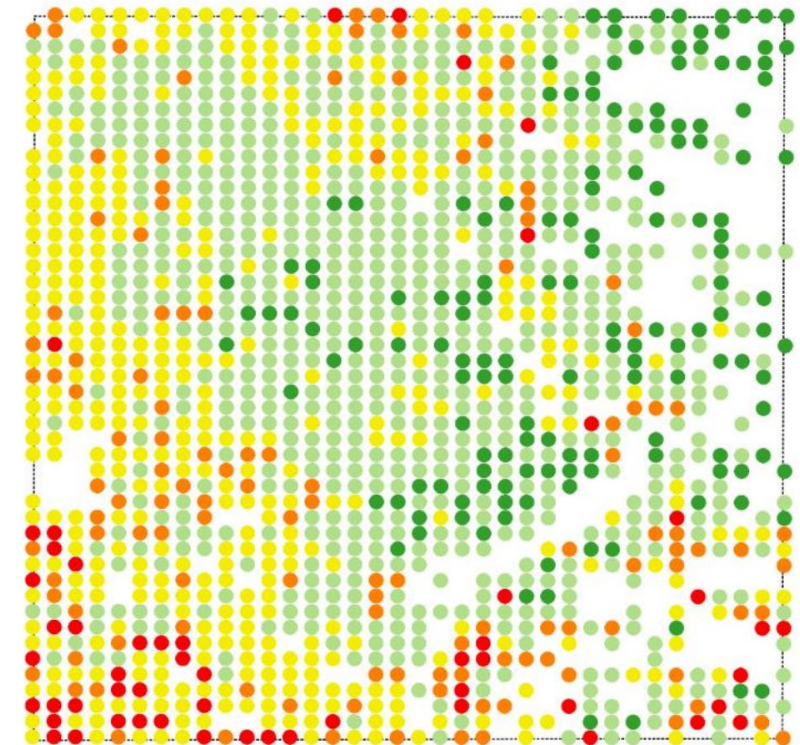
■ Fenced vs. Unfenced Areas

- Fenced grasslands: Uniform moderate degradation (likely from overgrazing in restricted spaces).
- Unfenced grasslands: More severe degradation (linked to unregulated use near resources).



0 1 2 km

Grassland Degradation



5 Assessment of Grassland Degradation and its Mechanisms using VHR Imagery



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5.4 Conclusions & Implications

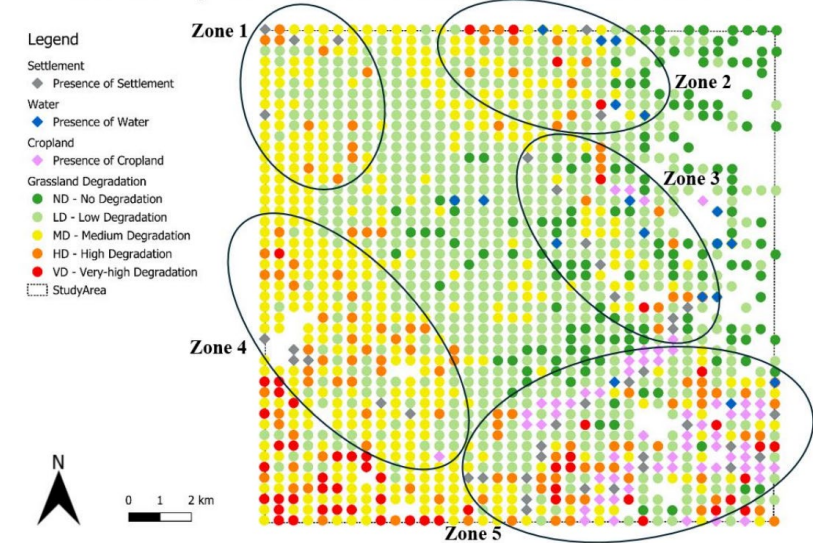
■ Key Findings

- VHR imagery effectively captures fine-scale vegetation and soil degradation, enabling comprehensive assessment.
- Degradation driven by:
 - Cropland/built-up expansion reducing rangelands.
 - Overexploitation near settlements/water sources.
 - Land fragmentation and socioeconomic imbalances (e.g., policy-induced privatization).

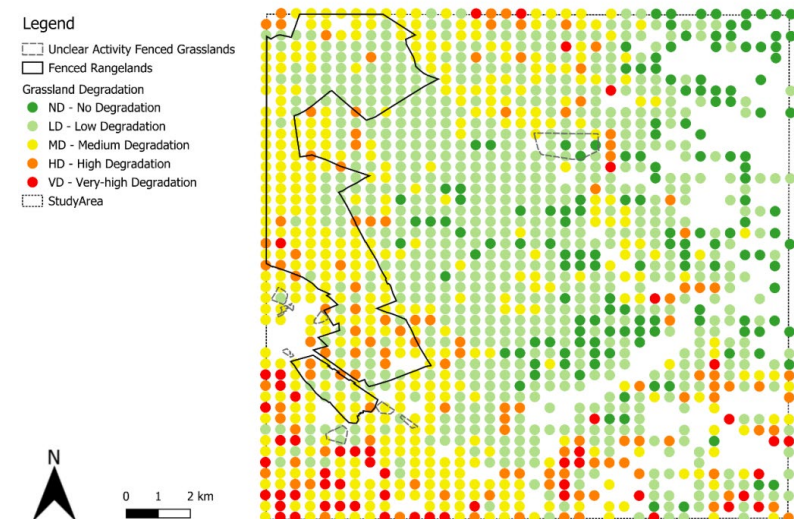
■ Implications

- VHR imagery and cross-scalar frameworks support targeted policy and sustainable land management.
- Further research needed to standardize methods and integrate long-term data.

Grassland Degradation and Settlement, Cropland, and Water Points



Grassland Degradation in Fenced and Unfenced Areas



6 Schedule and plan for the following year



1. Establish explicit linkages between multi-source remote sensing data and grassland degradation-related variables through additional ground experiments combined with bridging approaches (e.g., UAV observations), building robust connections between ground measurements and satellite remote sensing.
2. Extend existing work by collecting more representative field samples to develop standardized data products for large-scale grassland degradation variables (e.g., shrub encroachment distribution), enhancing monitoring capabilities for Land Degradation Neutrality (LDN) implementation.

7 Contribution of partners



1. Xiaosong Li, theoretical indicator framework of grassland degradation assessment driven by EO
2. Anne Grainger, facilitate education and training, and enable pooled sharing of data and information resources.
3. Chaochao Chen, steppe grassland shrub encroachment monitoring with developing a novel remote sensing index
4. Milena Cudak, large scale mapping of shrub coverage in Xilin Gol League by fusing Sentinel-1 and Sentinel-2 data
5. Francesco Fustinoni, assessing and clarifying mechanisms of grassland degradation by analyzing VHR images

8 Young scientist training



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- 1 young scientist attend the Dragon 6 technical training, offline or online;
- 2 European young scientists go to AIRCAS, China, to conduct joint study for 3 month.

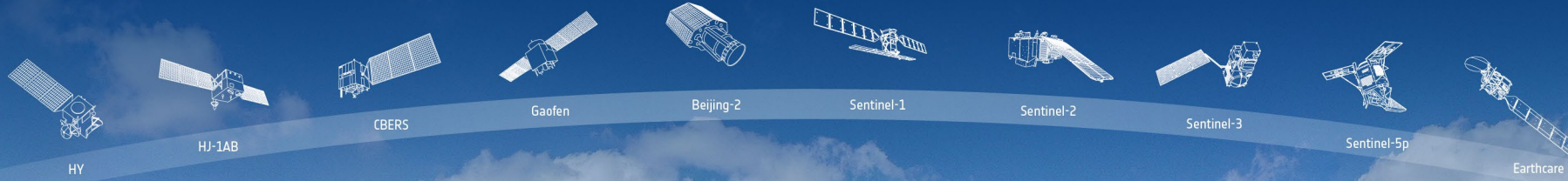




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THANKS FOR YOUR ATTENTION!

