Remote Sensing Improved Forages

Preview Results

November 5, 2021

Abstract

Key words:
JEL Classification:

Contents

List of Figures

List of Tables

1 Land Use Classification

1.1 Descriptive Statistics

- There are 8 Kebeles (subdivisions)
- In these Kebeles there are XX improved foraged plots which is XXX of the total polygons and XXXX of the area
- We kept in the data set polygons that are classified either as: Improved Forage, Crop, Grazing, and Tree. In the survey of the area some polygons were classified as Tree/Crop, Bare, but only in the Dil-betegel subdivision, and is less than 2% of the area. To maintain consistency I also drop those polygons classified as other, since it is missing for some of the plots.[1]. Table **??** shows land use by Kebele and percentage area. Improved forage accounts for 4.17%, whereas Crop 29.84%, Grazing 40.75%, and Tree 25.23% of the total area.

Table 1

kebele	Polygons	mean_area	Crop	Grazing	Improved.forage	Tree
Afesa	21	40,319.79	0.21	0.16	0.13	0.50
Bachema	36	117,633.60	0.32	0.36	0.08	0.25
Dil-betegel	38	119,057.20	0.45	0.25	0.04	0.26
Enashenefalen	58	298,654.80	0.22	0.04	0.02	0.72
Guiete	23	86,320.13	0.35	0.33	0.05	0.27
Gulet Abeshekan	26	79,150.17	0.69	0.10	0.09	0.12
Legaba	45	633,674.00	0.13	0.79	0.01	0.07
Wufeta Dati	16	141,751.40	0.84	0.02	0.03	0.11

1.2 Remote sensing

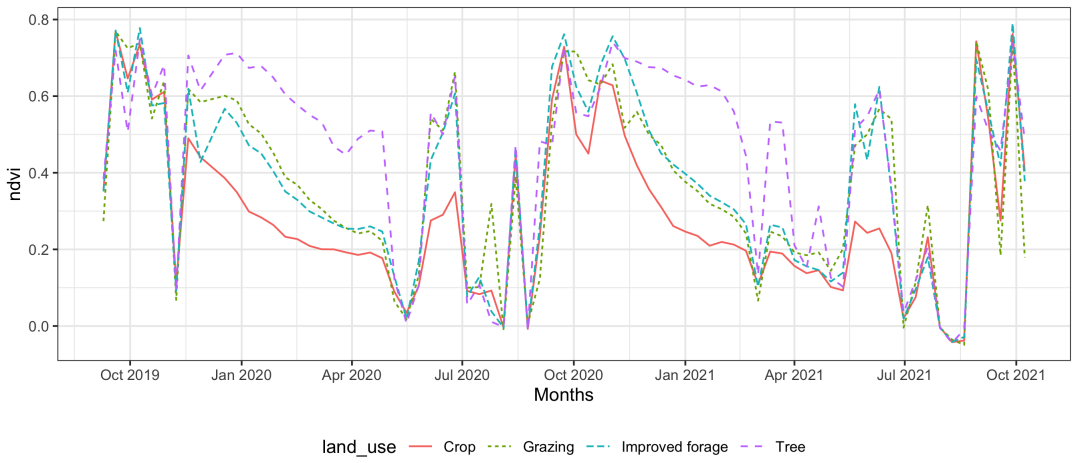
We use Sentinel 2 products

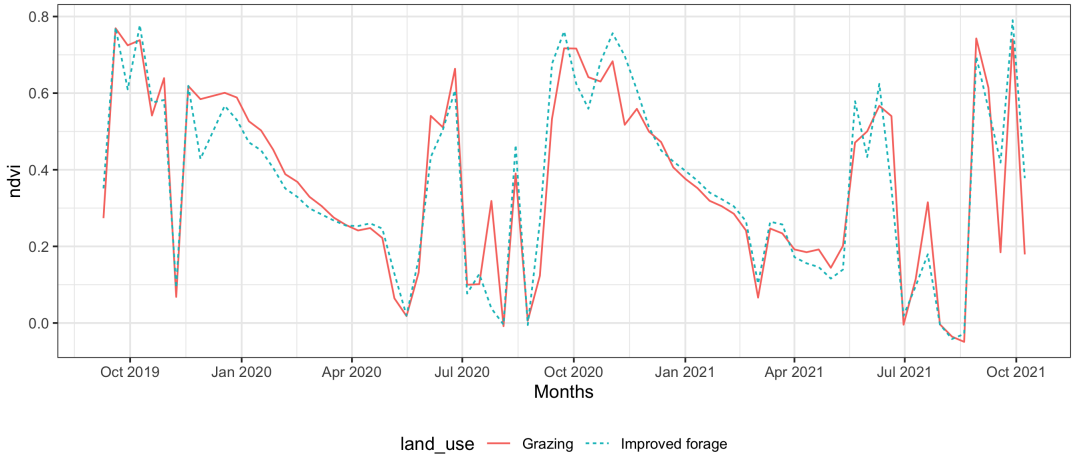
[1] we can potentially drop the Afesa Kebele that is missing the "Other" class

Bottom-Of-Atmosphere reflectances in cartographic geometry Systematic and on-user side (using Sentinel-2 Toolbox) (each $100km x 100km$) The Sentinel-2 Multispectral Instrument (MSI) comprises two satellites that observe the Earth at 10 m, 20 m, and 60 m spatial resolutions (Drusch et al. 2012). The 10 m spatial resolution is the highest amongst freely available satellite products. Another unique aspect of the Sentinel-2 data is the presence of three red edge bands, which are able to capture the strong reflectance of vegetation in the near infrared portion of the electromagnetic spectrum (EMS). The criteria for satellite imagery selection was that the scenes must contain little or no clouds and haze. The imagery must also be from different seasons to capture different plant phenological stages. As such, four Sentinel-2 scenes from 2017 and 2018 from tile 33VXG were included in the analysis. Three of the scenes were in 2017: May 04, July 06, and November 13, and one in 2018: January 27 (Figure 2).

Table 2. Pixels by Land Use and Subdivision

kebele	Crop	Grazing	Improved.forage	Tree
Afesa	100	65	34	222
Bachema	395	437	73	285
Dil-betegel	556	310	43	305
Enashenefalen	653	118	49	2,115
Guiete	314	302	27	233
Gulet Abeshekan	552	95	49	99
Legaba	825	4,985	56	440
Wufeta Dati	1,201	29	32	153
All	4,596	6,341	363	3,852

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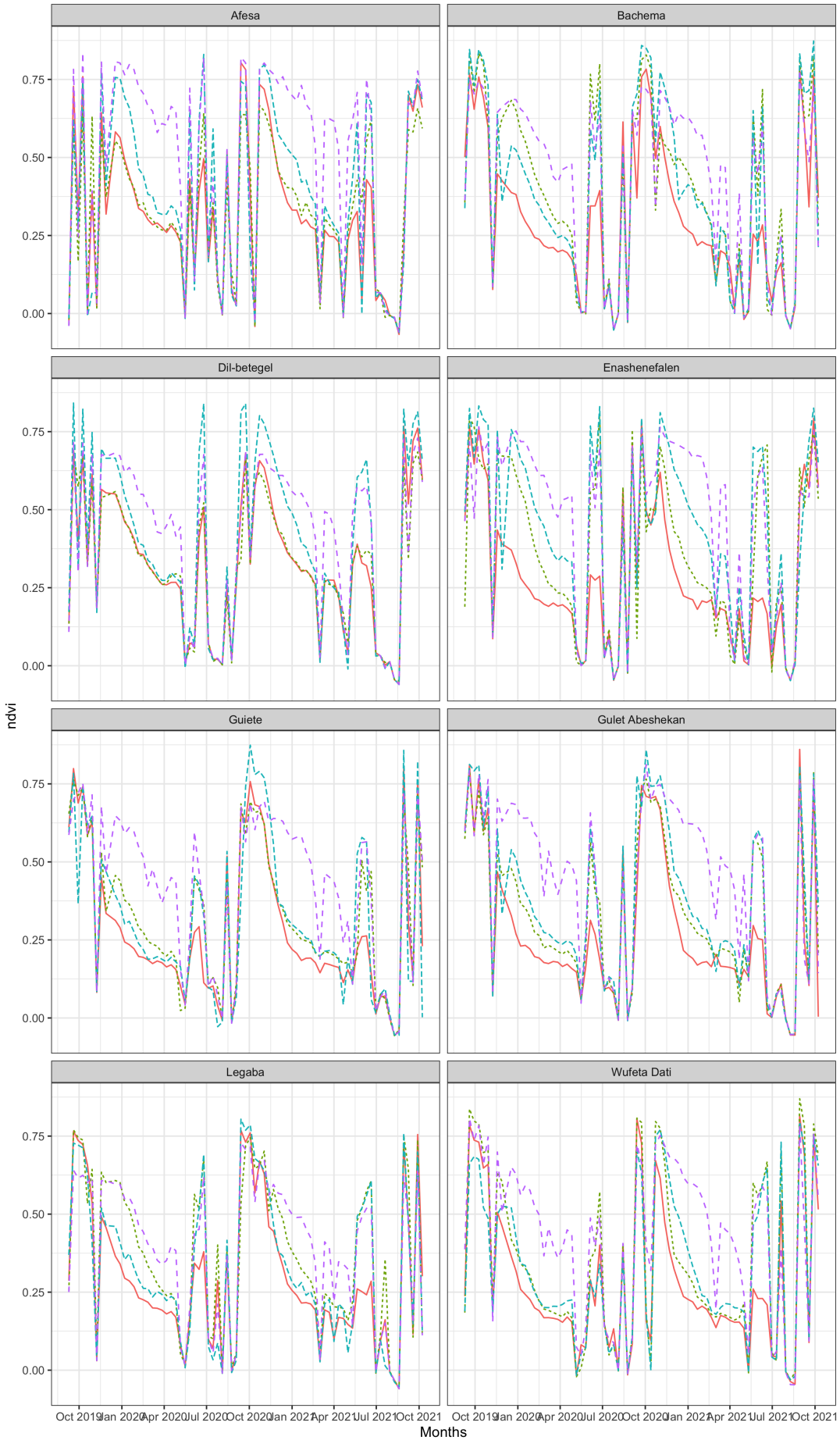
0.6
0.4
0.2
0.0
ndvi
Oct 2019
Jan 2020
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021
Jul 2021
Oct 2021
Months
land_use
Grazing
Improved forage


Afesa
Bachema
Dil-betegel
Enashenefalen
Guiete
Gulet Abeshekan
Legaba
Wufeta Dati
ndvi
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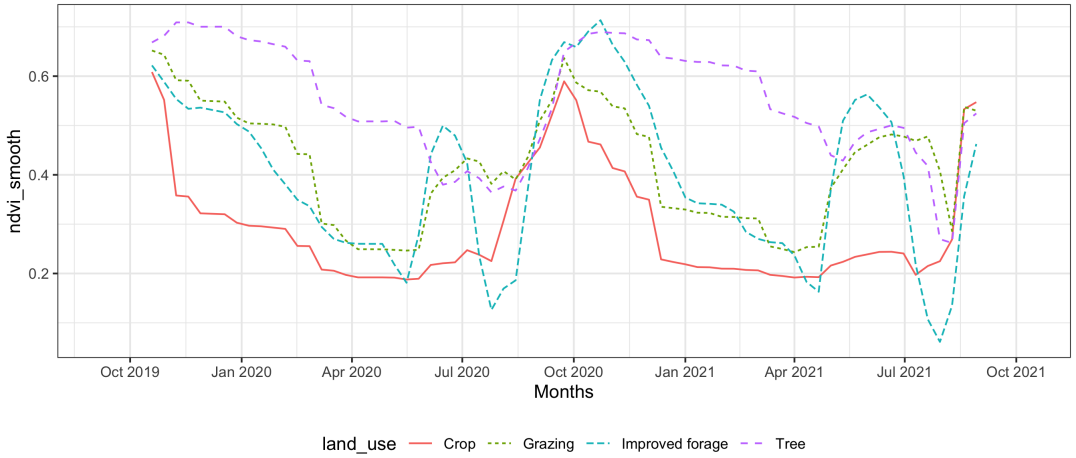
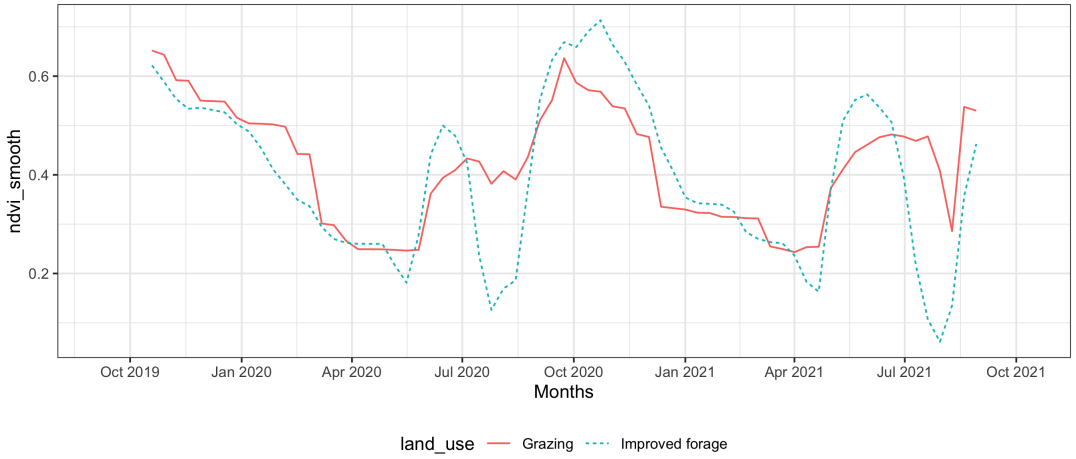
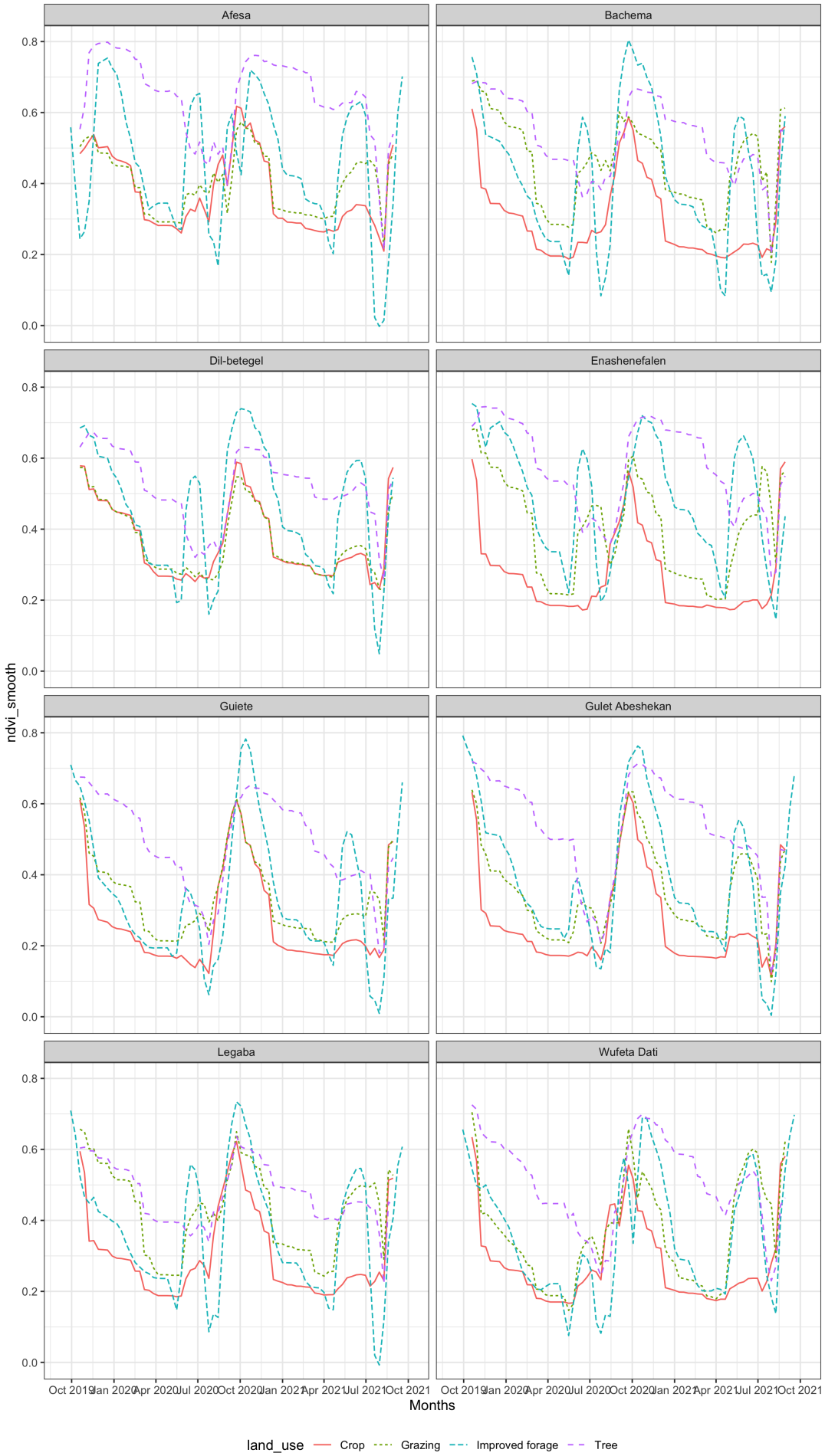
0.50
0.75
Oct 2019
Jan 2020
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021
Jul 2021
Oct 2021
Months
land_use
Crop
Grazing
Improved forage
Tree

I smoothed out the series with a 90 day moving average weighted by cloud coverage. (Some preliminary robustness for 30,40,50,60,70) 90 works best






Afesa
Bachema
Dil-betegel
Enashenefalen
Guiete
Gulet Abeshekan
Legaba
Wufeta Dati
ndvi_smooth
0.0
0.2
0.4
0.6
0.8
Oct 2019
Jan 2020
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021
Jul 2021
Oct 2021
Months
land_use
Crop
Grazing
Improved forage
Tree

1.3 Model

I used a k-shapes clustering algorithm introduced by Paparrizos and Grabvano (2015). This is a clustering algorithm that proposes as a distance measure, a normalized version of the cross-correlation measure to consider the shapes of time series while comparing them. The idea is that, given the set of time series search for a "centroid" and assign the series to the closest centroid.

I only use NDVI and a smoothed version of NDVI (which is the one that performs the best), and an undersampling approach. (Still working on bootstraps for robustness) and a full version (takes a really long time to do 15k series)

1.3.1 Other unsuccessful approaches

I modeled land use as a function of the 3 bands and the NDVI:

$$LandUse_{ij} = f(Blue, Green, Red, NDVI) + u_{ij} \tag{1}$$

where $LandUse_{ij}$ is the land use in pixel i of polygon j. f is the ML function that we use to predict land use. We explore 3 classes of models:

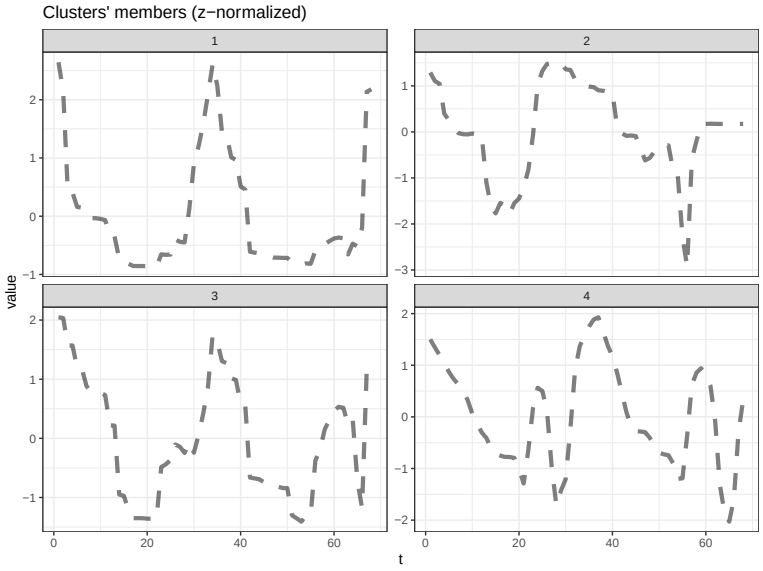
- Binary classifications: In this case $LandUse_{ij} = I(LandUse_{ij} == ImprovedForage)$ and 0 are the other classes
- Multiclass classification where $LandUse_{ij}$ takes 4 classes: Improved Forage, Crop, Grazing, and Tree

The challenge was incorporating the time dimension, one approach was collapse to a single crossection and in different variables consider multiple moments of the distribution of predictors: mean, sd, iqr, max, min. I did these for within pixel and between pixels of the same polygon for the entire time series, and quarterly (approximating the seasons, although there are no seasons in Ethiopia, but the idea was trying to capture the cycles seen in the time series). None of these were successfull so far

1.4 k-shapes

1.4.1 Smoothed

	1	2	3	4
Crop	287	9	35	29
Grazing	55	8	256	41
Improved forage	0	4	45	311
Tree	11	256	57	36



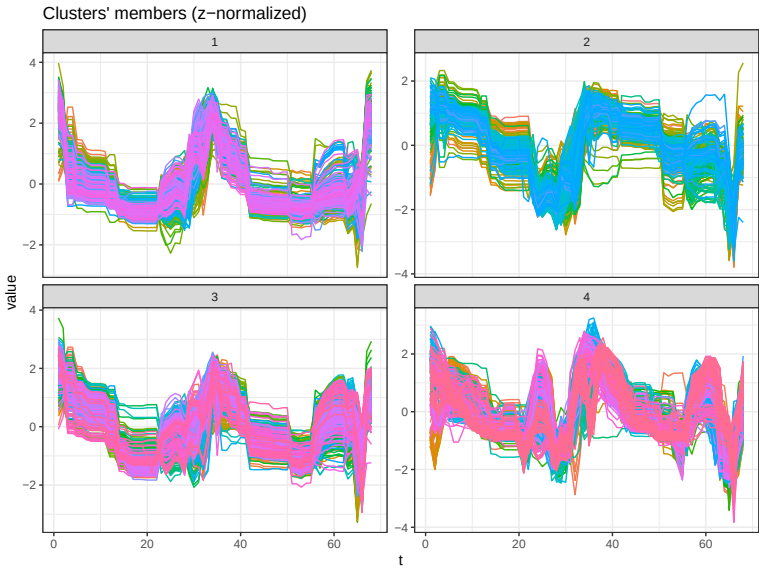


Table 3

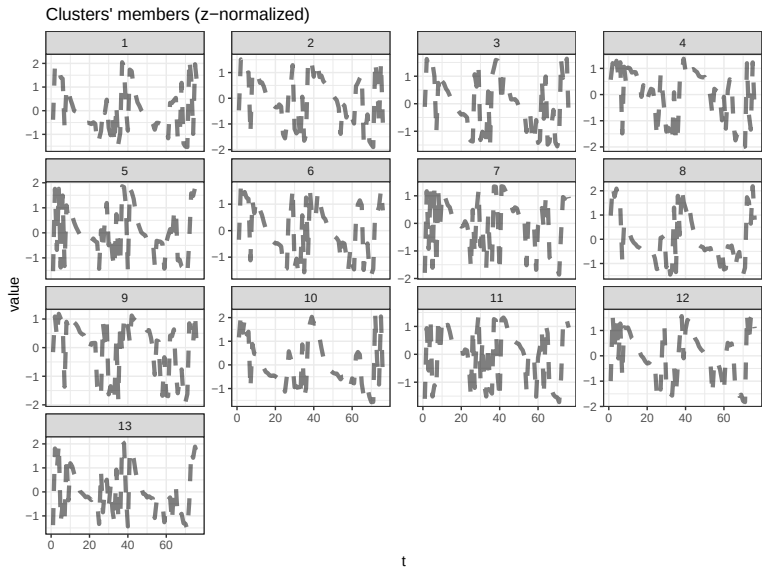
regions	k_2	k_3	k_4	k_5	k_6	k_7	k_8	k_9	k_10	k_11	k_12	k_13	k_14	k_15	k_16
Afesa	0.46	0.64	0.61	0.49	0.52	0.51	0.46	0.47	0.42	0.52	0.48	0.42	0.46	0.40	0.42
Bachema	0.29	0.40	0.53	0.58	0.50	0.51	0.47	0.54	0.52	0.55	0.52	0.53	0.55	0.40	0.54
Dil-betegel	0.35	0.47	0.39	0.39	0.41	0.41	0.38	0.35	0.38	0.34	0.33	0.37	0.30	0.35	0.30
Enashenefalen	0.43	0.53	0.67	0.68	0.60	0.46	0.57	0.53	0.46	0.39	0.49	0.42	0.36	0.34	0.35
Guiete	0.47	0.63	0.57	0.55	0.50	0.38	0.43	0.52	0.40	0.45	0.38	0.40	0.46	0.48	0.52
Gulet Abeshekan	0.53	0.57	0.57	0.56	0.50	0.58	0.47	0.52	0.35	0.40	0.53	0.43	0.47	0.40	0.42
Legaba	0.43	0.42	0.58	0.51	0.48	0.51	0.49	0.43	0.39	0.36	0.29	0.33	0.36	0.38	0.38
Wufeta Dati	0.41	0.61	0.66	0.60	0.59	0.59	0.49	0.52	0.47	0.42	0.44	0.36	0.47	0.44	0.42
Results_all	0.31	0.38	0.40	0.37	0.32	0.31	0.33	0.32	0.32	0.29	0.23	0.29	0.24	0.27	0.32

Table 4

regions	clusters	sil	max	ind
Afesa	k_3	0.64	0.64	1
Bachema	k_5	0.58	0.58	1
Dil-betegel	k_3	0.47	0.47	1
Enashenefalen	k_5	0.68	0.68	1
Guiete	k_3	0.63	0.63	1
Gulet Abeshekan	k_7	0.58	0.58	1
Legaba	k_4	0.58	0.58	1
Wufeta Dati	k_4	0.66	0.66	1
Results_all	k_4	0.40	0.40	1

1.4.2 NDVI

	1	2	3	4	5	6	7	8	9	10	11	12	13
Crop	55	9	9	0	13	6	6	102	5	97	1	43	14
Grazing	29	55	65	1	15	54	19	0	3	76	0	43	0
Improved forage	29	45	56	8	0	48	0	0	18	79	34	43	0
Tree	14	73	17	70	0	1	13	0	104	4	21	43	0



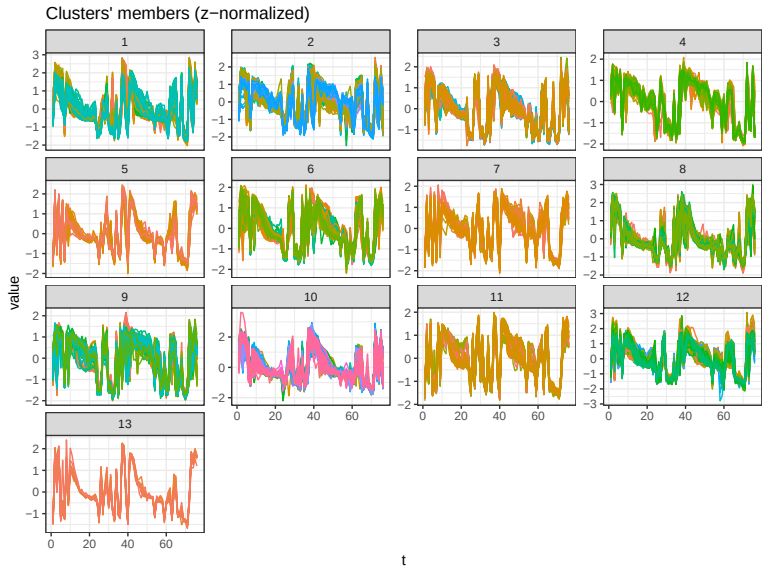


Table 5

regions	k_2	k_3	k_4	k_5	k_6	k_7	k_8	k_9	k_10	k_11	k_12	k_13	k_14	k_15	k_16
Afesa	0.40	0.45	0.42	0.43	0.36	0.45	0.42	0.35	0.38	0.44	0.34	0.35	0.42	0.38	0.45
Bachema	0.41	0.38	0.39	0.43	0.44	0.45	0.52	0.48	0.42	0.47	0.50	0.45	0.41	0.40	0.51
Dil-betegel	0.40	0.44	0.40	0.39	0.40	0.32	0.28	0.37	0.38	0.35	0.27	0.35	0.35	0.24	0.40
Enashenefalen	0.41	0.30	0.47	0.44	0.42	0.30	0.45	0.40	0.37	0.39	0.39	0.40	0.42	0.38	0.39
Guiete	0.58	0.61	0.58	0.63	0.41	0.46	0.31	0.43	0.46	0.29	0.40	0.35	0.34	0.36	0.25
Gulet Abeshekan	0.52	0.47	0.57	0.51	0.59	0.40	0.45	0.53	0.48	0.49	0.52	0.43	0.41	0.41	0.40
Legaba	0.30	0.31	0.36	0.35	0.40	0.45	0.38	0.45	0.46	0.44	0.42	0.44	0.46	0.42	0.45
Wufeta Dati	0.51	0.59	0.43	0.53	0.55	0.45	0.45	0.50	0.42	0.47	0.34	0.42	0.45	0.45	0.32
Results_all	0.26	0.31	0.32	0.34	0.32	0.37	0.34	0.33	0.34	0.31	0.38	0.40	0.35	0.34	0.38

Table 6

regions	clusters	sil
Afesa	k_7	0.45
Bachema	k_8	0.52
Dil-betegel	k_3	0.44
Enashenefalen	k_4	0.47
Guiete	k_5	0.63
Gulet Abeshekan	k_6	0.59
Legaba	k_10	0.46
Wufeta Dati	k_3	0.59
Results_all	k_13	0.40

A Appendix: Tables and Figures

Characteristic	**Bare**, N = 1,140[1]	**Crop**, N = 353,172[1]	**Grazing**, N = 482,372[1]	**Improved forage**, N = 49,400[1]	**Other**, N = 52,516[1]
Blue	2,165 (3,237)	2,318 (3,252)	2,196 (3,255)	2,422 (3,380)	2,457 (3,130)
Geen	2,291 (2,917)	2,476 (2,900)	2,363 (2,900)	2,570 (3,025)	2,576 (2,786)
Red	2,468 (2,616)	2,569 (2,679)	2,349 (2,724)	2,553 (2,850)	2,602 (2,579)
NIR	3,187 (2,301)	3,714 (2,166)	3,776 (2,105)	4,085 (2,142)	3,596 (2,127)
NDVI	0.22 (0.14)	0.29 (0.24)	0.37 (0.26)	0.37 (0.28)	0.25 (0.19)
cloudcov	33 (35)	33 (35)	33 (35)	33 (35)	33 (35)

[1]Mean (SD)

kebele	Polygons	mean_area (m^2)	Crop	Grazing	Improved forage	Tree	Tree/Crop	Other	Bare	NA
Afesa	22	41804.45	0.21	0.15	0.13	0.48	0.04	NA	NA	NA
Bachema	44	126129.41	0.29	0.33	0.08	0.23	NA	0.07	NA	NA
Dil-betegel	40	121036.30	0.45	0.24	0.04	0.25	0.01	NA	0.01	NA
Enashenefalen	63	301719.35	0.22	0.04	0.02	0.72	NA	0.01	NA	NA
Guiete	29	93043.98	0.32	0.31	0.04	0.25	NA	0.07	NA	NA
Gulet Abeshekan	32	121280.96	0.45	0.06	0.06	0.08	NA	0.35	NA	NA
Legaba	46	633953.41	0.13	0.79	0.01	0.07	NA	0.00	NA	NA
Wufeta Dati	19	145149.11	0.82	0.02	0.03	0.11	NA	0.02	NA	NA
NA	4	5742.78	NA	NA	NA	NA	NA	NA	NA	5742.78

A.0.1 Figures: Land Use and NDVI by Kebele

Figure A.1. NDVI: Average time series (smoothed)

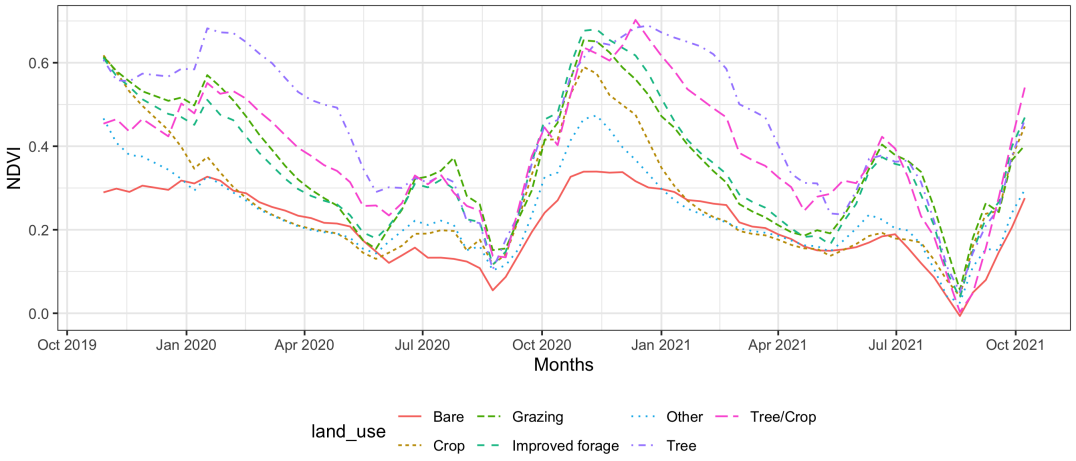


Figure A.2. NDVI: Average time series

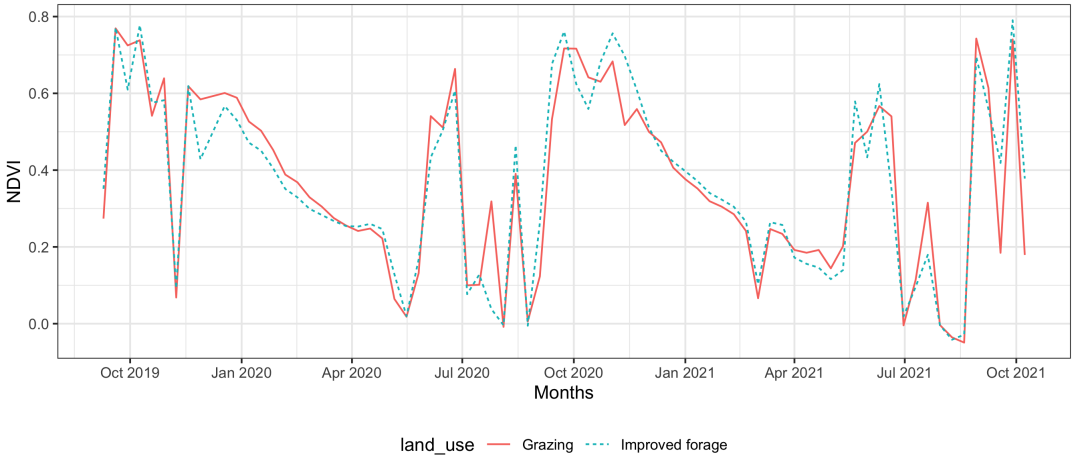
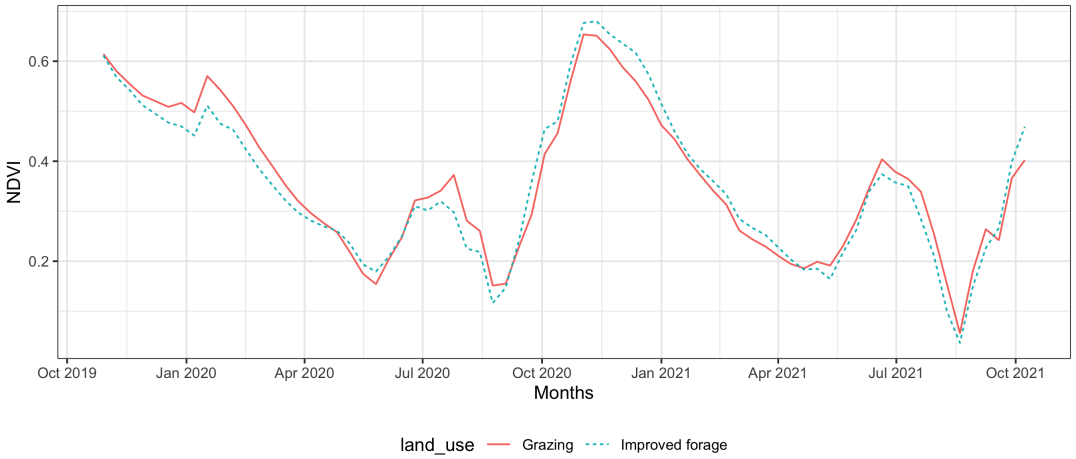


Figure A.3. NDVI: Average time series (smoothed)



B By Kebeles

B.1 Afesa

Figure A.4. NDVI: Average time series

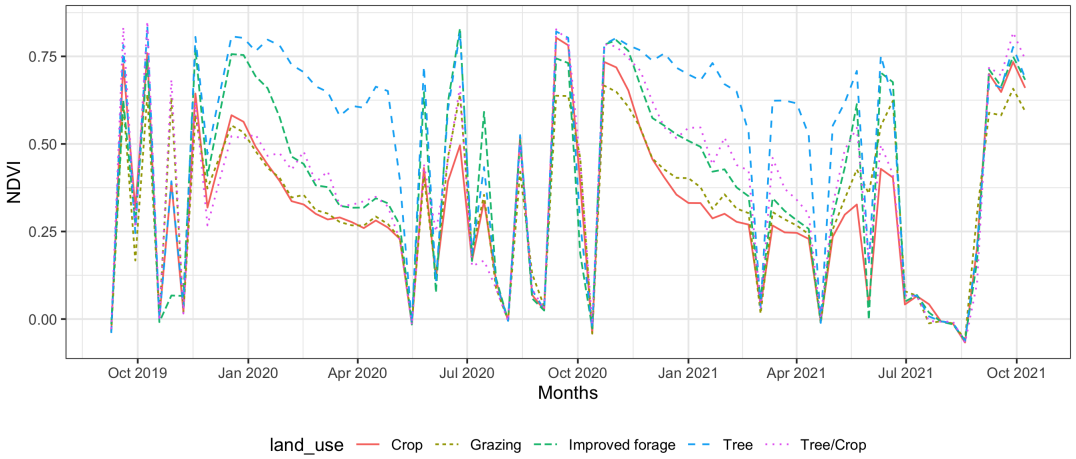
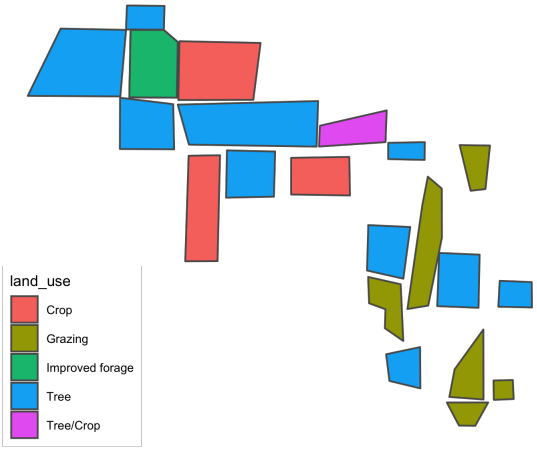


Figure A.5. Land Use



B.2 Bachema

Figure A.6. NDVI: Average time series

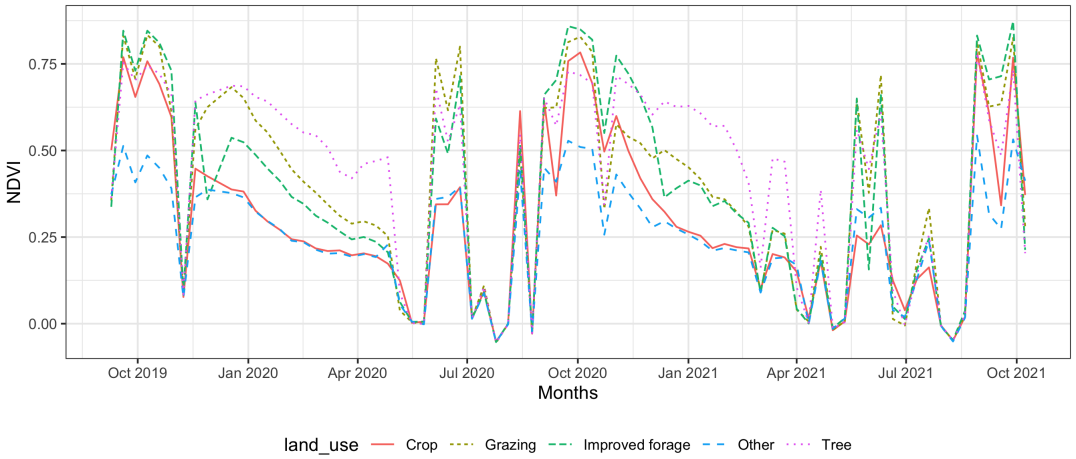
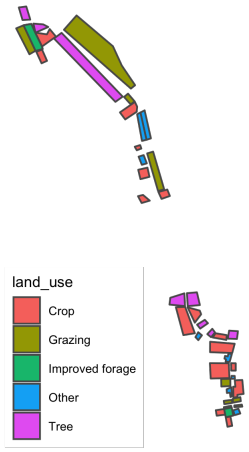


Figure A.7. Land Use



B.3 Dil-betegel

Figure A.8. NDVI: Average time series

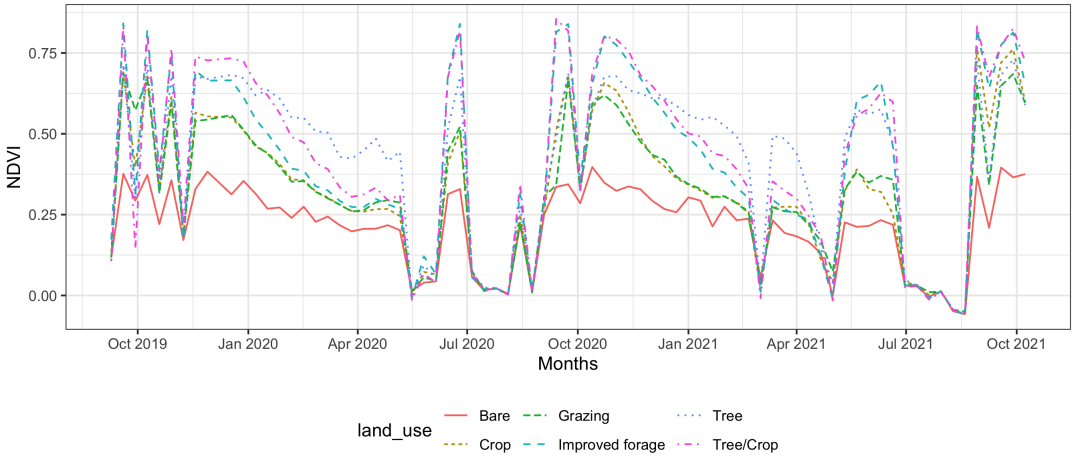
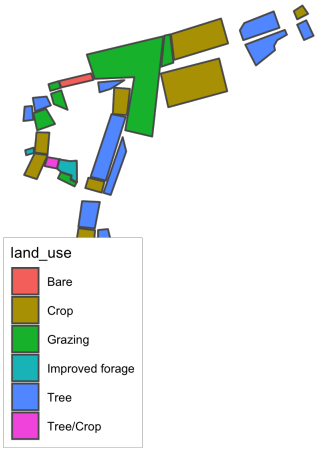


Figure A.9. Land Use



B.4 Enashenefalen

Figure A.10. NDVI: Average time series

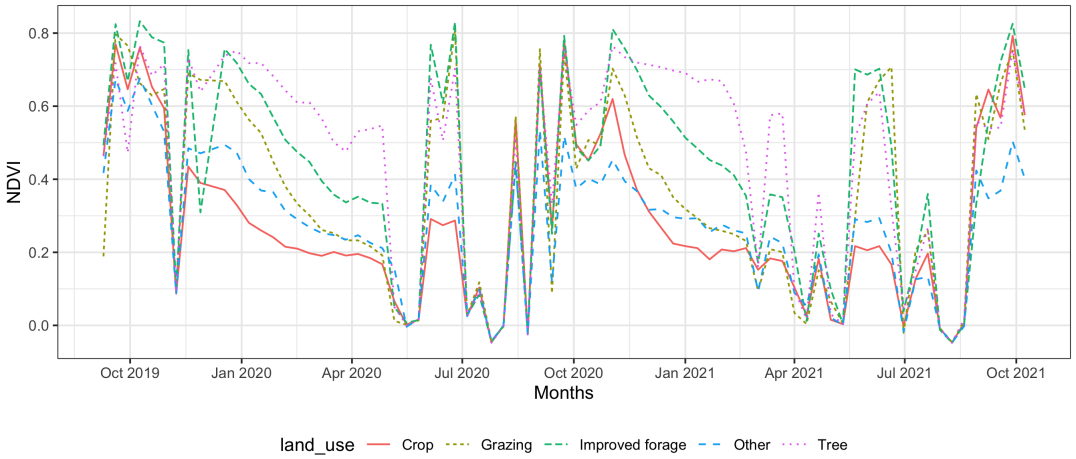
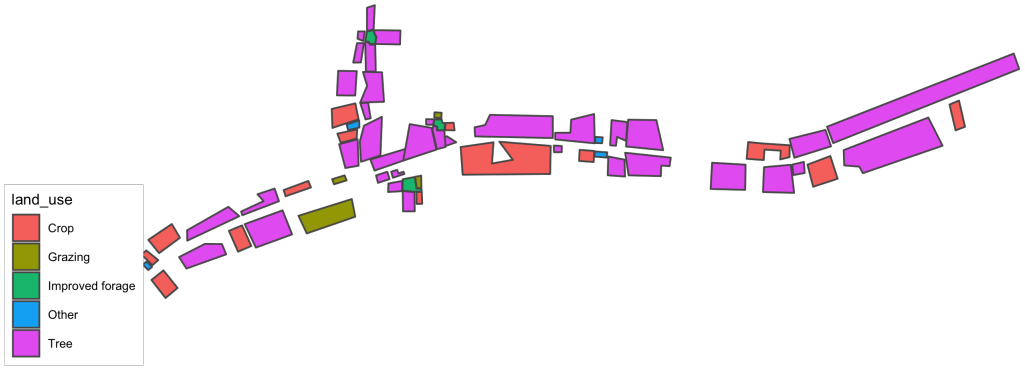


Figure A.11. Land Use



B.5 Guiete

Figure A.12. NDVI: Average time series

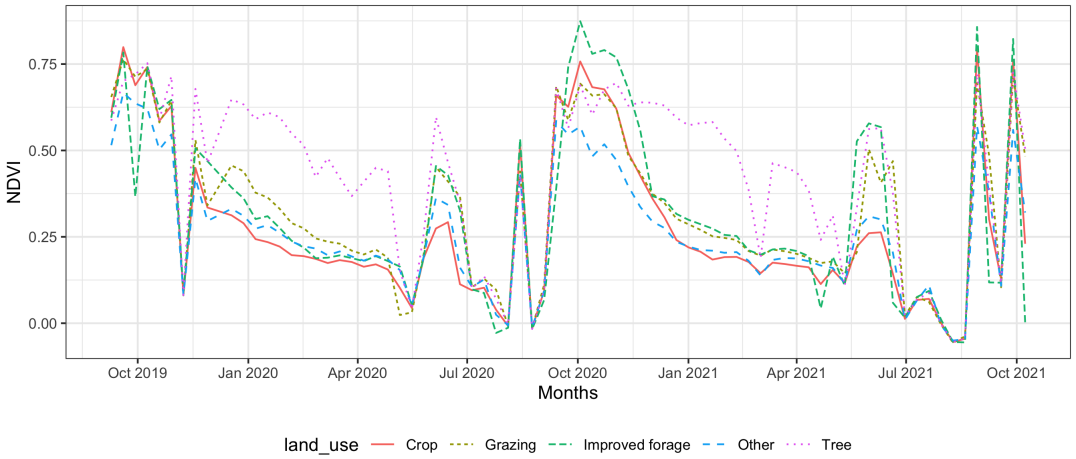


Figure A.13. Land Use

B.6 Gulet Abeshekan

Figure A.14. NDVI: Average time series

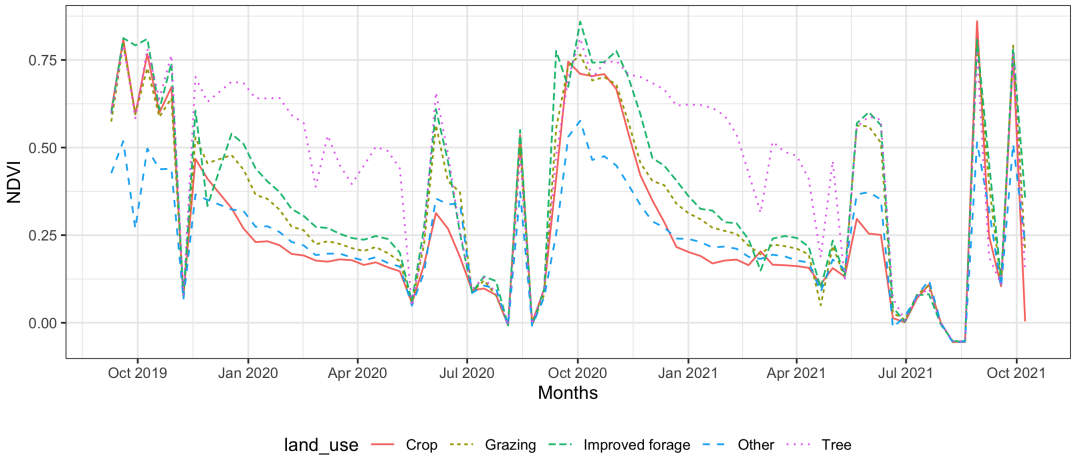
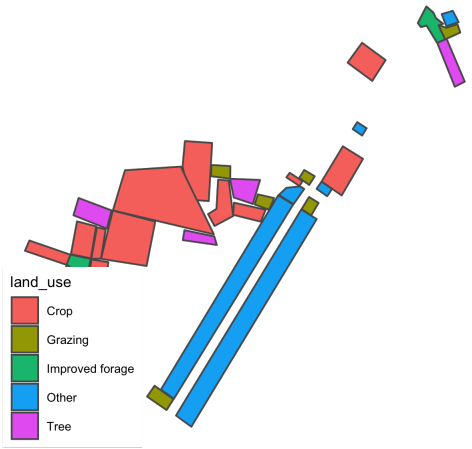


Figure A.15. Land Use



B.7 Legaba

Figure A.16. NDVI: Average time series

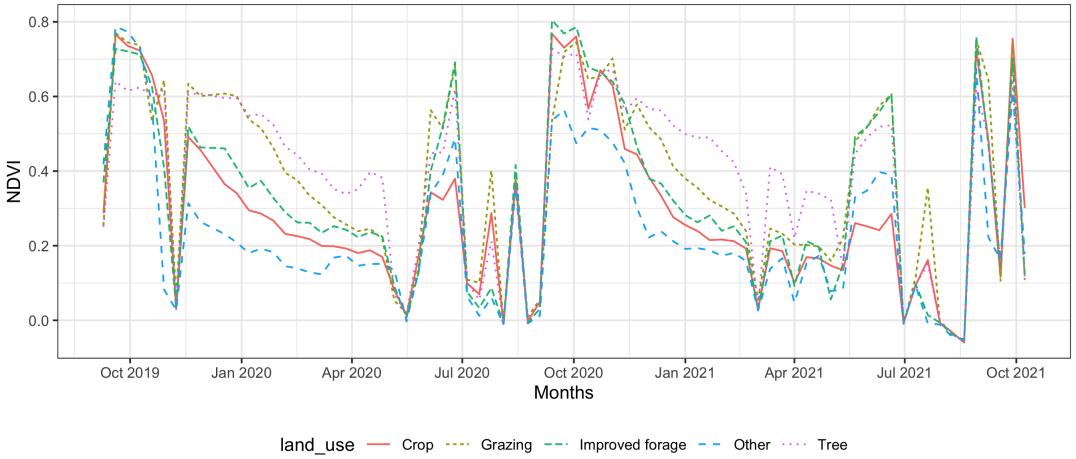
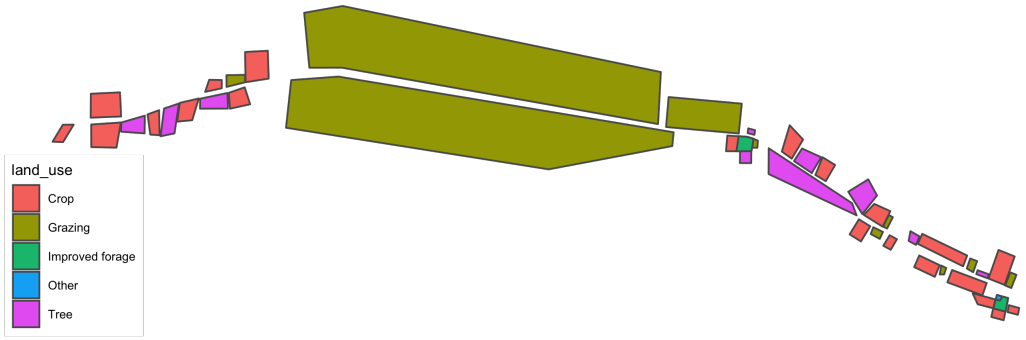


Figure A.17. Land Use



B.8 Wufeta Dati

Figure A.18. NDVI: Average time series

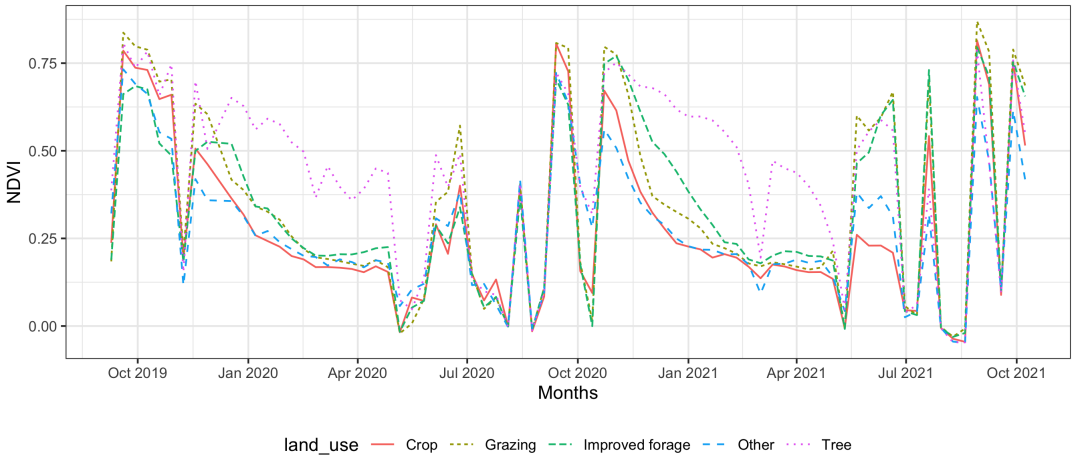


Figure A.19. Land Use