Investigating the effect of vegetation cover management in a semi-arid experimental watershed

Masoud Eshghizadeh (m.eshgizadeh@gonabad.ac.ir)
University of Gonabad
Vahid Moosavi
Tarbiat Modares University

Research Article

Keywords: Grazing, NDVI, Remote Sensing, Vegetation cover, Watershed management

Posted Date: June 12th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-3010513/v1

Abstract

This research investigated the effect of long-term excluding livestock as a measure of vegetation cover management in the Kakhk experimental watershed in northeast Iran. For this purpose, the normalized difference in vegetation index was investigated in two grazed and ungrazed sub-catchments from 1991 to 1995 and 2015 to 2019. The results of statistical comparisons showed only in the ungrazed sub-catchment, the mean values of the NDVI in the second period are significantly higher than in the first period. Based on the results, the mean NDVI in the ungrazed sub-catchment has increased from 0.103 in the first period to 0.163 in the second period, whereas, in the grazed sub-catchment it has decreased from 0.152 in the first period to 0.139 in the second period. The survey of temperature data and NDVI showed the growth period of plants in the second period started faster due to higher temperatures in March and April. The results demonstrated the ability of remote sensing to investigate the effects of exclosure to rehabilitate and restore the vegetation cover in watershed management. Also, the results showed the possibility of long-term use of the rangeland without vegetation destruction if the grazing period is managed. Therefore, grazing in the long-term cannot decrease the vegetation cover by correct grazing management. Therefore, the long-term exclosure will not be significant without the application of vegetation restoration methods in watershed management. Also, remote sensing images are capable to investigate the effects of biological measures in watershed management projects.

Introduction

Iran has about 86 million ha of rangeland with more than 70% of them located in the arid and semi-arid regions. Land degradation and vegetation deterioration are the main problems that have a direct impact on rangeland stakeholders. Climate changes, human activities, and livestock overgrazing are the main factors to degrade the rangelands in Iran (Niknahad–Gharmakher et al., 2017). The most important signs of rangeland degradation are a decrease in canopy cover, biomass, and soil quality (Hoshino et al., 2009; Qasim et al., 2017).

There are many watershed management practices, but these practices under different ecological conditions are not yet fully understood (Zarekia et al., 2018). These practices are aimed at controlling and decreasing soil erosion, land degradation, and vegetation deterioration, and obtaining maximum production (Huss, 1996). One of the main biological watershed management practices is grazing management. Unmanaged grazing affects vegetation characteristics. Therefore, their management is very important and difficult (Ahmad et al., 2012). The grazing system is a grazing management practice that determines the periods of grazing and non-grazing of vegetation cover in a watershed. The correct stocking rate, duration of grazing, and distribution of livestock are the issues in grazing management (Zarekia et al., 2018). Different factors are affected by a grazing system. The common principle in all these systems is avoiding defoliation during the early stages of plant growth as the most vulnerable stage of growth (Huss, 1996).

The main grazing systems are yearlong grazing, seasonal grazing, decision deferment, systematic grazing, and grazing exclosures (Huss, 1996; Qasim et al., 2017). In a yearlong grazing system, the vegetation cover is grazed all year round. In a seasonal grazing system, the vegetation cover is grazed only in some seasons for various reasons such as topography, temperature, snow, flooding, seasonal growth patterns, and others. The grazing of vegetation cover in the Region's mountainous areas is an example of seasonal grazing. A Decision deferment can be involved in a seasonal grazing system or deferred-rotation grazing system. Also, this type of grazing system is an effective method to utilize and improve yearlong vegetation cover and is a kind of systematic grazing system. In a systematic grazing system, the watershed is divided into different units and each unit is grazed on a fixed schedule or specified calendar dates. This type of grazing system is named by various names such as rotation, deferred grazing, deferred-rotation, rest-rotation, high intensity-low frequency, short-duration grazing, and cell grazing (Huss, 1996). A grazing exclosures system is often used for the rehabilitation of degraded vegetation cover in arid and semi-arid regions. This system prevented livestock grazing for a specified period (Aerts et al., 2009; Verdoodt et al., 2010). The main objective of a grazing exclosures system is to allow native vegetation to regenerate as a means of providing fodder and woody biomass, reducing soil erosion, and increasing infiltration (Aerts et al., 2009).

Grazing can be slowly affected the vegetation cover in arid and semi-arid environments (Dianati Tilaki et al., 2010). The most direct effects of grazing include consumption of the vegetation cover and soil trampling which can have long-term negative effects on the vegetation cover, soil fertility, and water resources (Dianati Tilaki et al., 2010; Zarekia et al., 2018). Many studies have been done on the effects of grazing systems on vegetation cover. The previous results were shown that continuous grazing can be decreased vegetation composition and production of the rangeland (Zarekia et al., 2018). The study of Magnano et al. (2017) showed the effect of cattle grazing on a forage species of Gramineae in Argentina. Based on their results, grazing decreased biomass, density, survival, and lifespan of the species under study. Qasim et al. (2017) evaluate the impact of 16 years of grazing exclosure in arid rangeland in the Balochistan province of Pakistan on aboveground vegetation biomass, soil organic matter, soil aggregation, soil moisture contents, and nitrogen mineralization. Their results showed a significant difference between the grazing sites and the exclosure site. Dianati Tilaki et al. (2010) compared several attributes of range plant diversity in grazed and long-term ungrazed sites in the North Khorasan Province of Iran. They showed that exclosures will increase species richness. Also, a study of the composition changes in a 19-year exclosure of Zanjan Rangeland showed that the vegetation composition has significantly changed and increased (Aghajanloo & Mousavi, 2007).

Ordinary field methods to assess vegetation cover require extensive field sampling of the plant communities. Also, due to the large area of the watershed, the generalization of these points to the whole area usually increases the error in estimates (Imani et al., 2018). Also, given the importance of time in watershed management and its high sensitivity to applying the management measures, is essential to access up-to-date data from the vegetation cover. This requires the development of a quick, economical, and accessible method for vegetation cover assessment (Hangs et al., 2011).

The use of remotely sensed data and images from satellites are the possible and available methods for data collection, monitoring, and analysis of the vegetation cover. The remotely sensed data from the satellites can be widely used in vegetation cover studies due to its extensive coverage, specific repetition time, ability to update, and easy access.

Spectral change detection methods are the numerical indicators, which use the visible and near-infrared electromagnetic spectrum of an image for the analysis of remotely sensed satellite images on an area to assess the presence or absence of green live vegetation. The ratio is differenced by the division of the digital number of one band by the corresponding digital number of another band of an image. Analysis and monitoring of changes in the spectral reflection data of plants can be recorded by satellites at different times and place scales. The basis of these studies is to establish an experimental relationship between the desired parameters and plant indices, which are calculated by combining different bands of a satellite (Olexa & Lawrence, 2014). These indicators are radiometric ratios between different radiometric bands that are affected by temporal and spatial patterns of plant photosynthetic activity (Amiri et al., 2010). Various vegetation indices have been proposed for the study of rangeland vegetation. In vegetation studies, a vegetation index should be considered that is sensitive to vegetation and is insensitive to bare soil and has the least impact on atmospheric factors (Jackson et al. 1983). The most important of these indicators used for vegetation studies in previous studies are the Normalized Difference Vegetation Index and Soil-Adjusted Vegetation Index (Soleymani et al., 2007; Yeganeh et al., 2008; Long et al., 2010; Xiaoping et al., 2011; Zarineh et al., 2012; Wagle et al., 2014; Imani et al., 2018; Eshghizadeh & Esmaeilian, 2020). Renormalized Difference Vegetation Index, Difference Vegetation Index, Ratio Vegetation Index, Transformed Normalized Difference Vegetation Index, and Green Normalized Difference Vegetation Index (Zarineh et al., 2012; Xiaoping et al., 2011; Yeganeh et al., 2008), Enhanced Vegetation Index, and Land Surface Water Index, TVI and NIR (Soleymani et al., 2007; Wagle et al., 2014).

In the mountain and especially in arid and semi-arid regions, one of the main grazing systems is seasonal grazing. Also, excluding livestock is a management solution to rehabilitate vegetation cover in biological measures of watershed management. However, no information is available on the impact of that on vegetation cover especially long-term excluding livestock in a semi-arid watershed. This research, are studied the interrelationships between grazing and ungrazing systems on vegetation cover in a semi-arid watershed. Therefore, this research has investigated the effect of seasonal grazing systems and long-term excluding livestock on the vegetation cover by remote sensing data. For this purpose, investigated the changes in vegetation cover for a period of 29 years (1991–2019) in a grazed and ungrazed sub-catchment of the kakhk experimental watershed in northeastern Iran by normalized difference vegetation index (NDVI).

Material and methods

Study Area

The study was done in the Kakhk experimental watershed in Gonabad County of the Razavi Khorasan Province, Iran (Fig. 1), a national project of the Forests, Ranges, and Watershed Management Organization of the Ministry of Agriculture Jihad. This watershed includes Sample and Control sub-catchments with an area of 106.5 and 110.6 ha, respectively. The sub-catchments were almost similar in physiography, climate, geology, geomorphology, soil, and vegetation cover. The Sample sub-catchments involve excluding livestock under the Kakhk experimental watershed project since 1999 and are called ungrazed sub-catchment, while The Control sub-catchment has a seasonal grazing system and is called grazed sub-catchment. The dominant geological formation is Shemshak Js, Jsvb and the soils are loam and sandy loam. The dominant plants in the vegetation are *Lactoca orientalis* Boiss, *Poa bulbosa* L, *Serratula orientalis* Poir, *Ferula ovina* Boiss, *Gundelia tournefortii* L, *Acanthophyllum heratense* Schiman-Czeika, *Thymus transcaspicus* Klokov, *Artemesia sp*, *Astragalus sp*. The climate in the studied area is the semi-arid Mediterranean with annual average precipitation and temperature of 243 mm and 14.2°C, respectively. The vegetation types in the Control and Sample sub-catchments are shrubs and herbs which are regularly monitored since 1999 and the vegetation types map for the sub-catchments provided in the Kakhk experimental watershed project (Fig. 2). The sheep and goats are the main livestock in the study area (Eshghizadeh, 2012). Table 1 shows the main characteristics of the study area.

Figure 1. Location of the Kakhk experimental watershed in Eastern Iran

Table 1
Monthly rainfall, temperature, and stocking intensity in the Control (grazed) and Sample (ungrazed) sub-catchments in two time periods: 1991–1995 and 2015–2019

	Characteristic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
First period (1991–1995)	Average monthly precipitation (mm)	41.7	64.4	82.1	41.2	21.8	0	0	0	0	1.4	11.5	45.7	309.8
	Average monthly temperature (°C)	1.9	3.4	7.0	14.1	18.9	25.2	26.8	24.9	20.4	15.2	10.2	4.4	14.4
	Average Stocking Intensity in the Sample sub-catchment (AU/ha)	0	0	0	0	0	2.9	2.9	2.9	2.9	2.9	0	0	2.9
	Average Stocking Intensity in the Control sub-catchment (AU/ha)	0	0	0	0	0	2.9	2.9	2.9	0	0	0	0	2.9
Second period (2015–2019)	Average monthly precipitation (mm)	39.4	75.9	59.1	37.4	14.9	0	0.5	1.3	0.2	6.5	10.2	12.1	257.5
	Average monthly temperature (°C)	4.0	5.3	9.5	14.6	20.4	24.7	25.0	22.8	21.0	15.3	7.6	5.2	14.6
	Average Stocking Intensity in the Sample sub-catchment (AU/ha)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Average Stocking in the Control sub-catchment (AU/ha)	0	0	0	0	0	1.2	1.2	1.2	0	0	0	0	1.2

Figure 2. Vegetation types map of the Control (grazed) and Sample (ungrazed) sub-catchments in the Kakhk experimental watershed. Type I: *Poa bulbosa-Lactoca orientalis*, Type II: *Gundelia tournefortii-Ferula ovina*, Type III: *Serratula orientalis-Ferula ovina*, Type IV: *Acanthophyllum heratense-Thymus transcaspicus*, Type V: Cultivated lands

Satellite images acquisition and analysis

Landsat 8 and 5 satellite images for each month of the spring and summer seasons were downloaded from US Geological Survey (U.S. Geological Survey, 2020) to use as row data sets for the rangeland cover change detection (Table 2). In the next stage, pre-processing operations (Geometric, Atmospheric, and Radiometric correction) were performed on the downloaded Landsat images in ENVI 5.3. For this purpose, selected cloud-free remotely sensed satellite imageries (Landsat 5 TM of 1991 to 1995 and Landsat 8 OLI of 2015 to 2019 imagery) with 30 m by 30 m spatial resolution for the study area.

To compare the seasonal grazing and excluding livestock on vegetation cover were used the NDVI index. The NDVI is calculated from reflectance measurements in the red (RED) and near-infrared (NIR) portions of the electromagnetic spectrum (Rouse et al., 1974).
NDVI = $(NIR - RED) \,/\, (NIR + RED)$ (1)

The NDVI ranges between − 1 and + 1. Negative values indicate low vegetation cover whereas positive values indicate high vegetation cover. The green healthy or high amounts of vegetation cover have a positive portion of NDVI values.

For this study, NDVI analysis was computed using ENVI 5.3 software for satellite images of the study area. In the next stage, the maximum, minimum, and mean values of the index were calculated.

Table 2
Satellite images used for the study area

	Date					Data type
Landsat 8	12.4.2015	21.4.2016	17.4.2017	11.4.2018	7.4.2019	Oll/TIRS
	21.5.2015	16.5.2016	19.5.2017	13.5.2018	16.5.2019	(30 m × 30 m)
	15.6.2015	17.6.2016	20.6.2017	14.6.2018	10.6.2019	
	17.7.2015	19.7.2016	22.7.2017	9.7.2018	12.7.2019	
	18.8.2015	20.8.2016	7.8.2017	10.8.2018	13.8.2019	
	19.9.2015	21.9.2016	8.9.2017	11.9.2018	14.9.2019	
Landsat 5	17.4.1991	12.4.1992	22.4.1993	9.4.1994	28.4.1995	TM
	19.5.1991	14.5.1992	8.5.1993	20.5.1994	7.5.1995	(30 m × 30 m)
	20.6.1991	15.6.1992	9.6.1993	5.6.1994	8.6.1995	
	15.7.1991	16.7.1992	11.7.1993	7.7.1994	10.7.1995	
	7.8.1991	18.8.1992	12.8.1993	8.8.1994	11.8.1995	
	17.9.1991	10.9.1992	13.9.1993	9.9.1994	12.9.1995	

Statistical analysis

To compare changes in vegetation cover over time were analyzed the changes of NDVI values between year, month, and vegetation types in each period for each sub-catchment. Then, these values were compared in the two sub-catchments.

At first, the mean NDVI in each period was calculated for each sub-catchment and a statistical comparison of it was done between two periods in each sub-catchment. In the next step, the periodic, annual, and monthly mean NDVI of each vegetation type was calculated for each sub-catchment. A Mann-Whitney test of annual and monthly mean NDVI was done between two time periods in each sub-catchment. Also, a Mann-Whitney test of annual and monthly mean NDVI of each vegetation type was done between the first and second periods in each sub-catchment. The changes in the monthly mean NDVI were calculated in each vegetation type among the two time periods for sub-catchments. A Spearman correlation test was done between average monthly temperature and precipitation with monthly mean NDVI of each vegetation type in each sub-catchment and period time. Also, the correlation coefficients were used to reflect the sequence of climatic variability and NDVI degree of correlation. For this purpose, monthly NDVI values were correlated with monthly average temperature and precipitation. The range of correlation coefficient varies from − 1 to 1 and the graphical representation shows the relation between temperature and precipitation with NDVI value.

Results

The general results of statistical comparisons showed that the mean values of the NDVI in the second period (2015–2019) are significantly higher than in the first period (1991–1995) in the ungrazed sub-catchment ($P < 0.001$), but in the grazed sub-catchment this difference is not significant ($P = 0.485$). Based on the results, the mean NDVI in the ungrazed sub-catchment has increased from 0.103 in the first period to 0.163 in the second period whereas, in the grazed sub-catchment it has decreased from 0.152 in the first period to 0.139 in the second period (Table 3).

Table 3
Annual mean NDVI in both sub-catchments in two studied periods

First period (1991–1995)			**Second period (2015–2019)**		
Year	Ungrazed sub-catchment	Grazed sub-catchment	Year	Ungrazed sub-catchment	Grazed sub-catchment
1991	0.098	0.143	2015	0.156	0.135
1992	0.111	0.160	2016	0.169	0.130
1993	0.082	0.143	2017	0.146	0.127
1994	0.109	0.165	2018	0.175	0.153
1995	0.115	0.149	2019	0.167	0.149
Mean	0.103	0.152	Mean	0.163	0.139

The results of the Mann-Whitney test showed that in the ungrazed sub-catchment, the monthly mean NDVI of vegetation types of the years between the two time periods had a significant difference at the 0.01 level ($P < 0.001$), but in the grazed sub-catchment, there was no difference between the two time periods ($P = 0.096$).

In the ungrazed sub-catchment, the highest increase of the mean NDVI of each vegetation type in the second period compared to the first period was observed in the *P.bulbosa-L.orientalis* type with a value of 0.093 (Fig. 3). In the grazed sub-catchment, instead of increasing the mean NDVI of each vegetation type, we faced a decrease in the second period compared to the first period. The highest decrease was 0.027 (Fig. 3).

Figure 3. Mean NDVI of vegetation types in both sub-catchments in two studied periods

The statistical comparisons of the monthly mean NDVI for each vegetation type in the two time periods showed that all types had a significant difference at the 0.01 level in the ungrazed sub-catchment, but in the grazed sub-catchment the *S.orientalis-F.ovina* and *A.heratense-T.transcaspicus* types had a significant difference at the 0.05 level (Table 4).

Table 4
Mann-Whitney Test of the monthly mean NDVI for each vegetation type in the two periods for each sub-catchment

Sub-catchment		**Type 1** (***P.bulbosa-L.orientalis***)	**Type 2** (***G.tournefortii-F.ovina***)	**Type 3** (***S.orientalis-F.ovina***)	**Type 4** (***A.heratense-T.transcaspicus***)
Ungrazed (Sample)	Mann-Whitney U	36.000	159.500	233.500	272.000
	Wilcoxon W	501.00	624.500	698.500	737.000
	Z	-6.123	-4.296	-3.201	-2.632
	Asymp. P-value (2-tailed)	0.000**	0.000**	0.001**	0.008**
Grazed (Control)	Mann-Whitney U	408.000	442.500	305.500	313.500
	Wilcoxon W	873.000	907.500	770.500	778.500
	Z	-0.621	-0.111	-2.136	-2.018
	Asymp. P-value (2-tailed)	0.534	0.912	0.033	0.0436
* is a significant difference at 0.05					
** is a significant difference at 0.01					

The highest increase of the monthly mean NDVI among the plant types in the second period compared to the first period was in the *P.bulbosa-L.orientalis* type and April in the ungrazed sub-catchment with a value of 0.157. Also, the lowest changes it was observed in June and July in the *S.orientalis-F.ovina* type which decreased by 0.04 and 0.01, respectively (Fig. 4, a and b). In other types and months, the monthly mean NDVI in each vegetation type in the second period has increased compared to the first period.

In the grazed sub-catchment, the monthly mean NDVI in each vegetation type in the second period compared to the first period was increased only in the *P.bulbosa-L.orientalis* and *G.tournefortii-F.ovina* types in April with a value of 0.196 and 0.112, respectively. Also, a slight increase was observed in the *G.tournefortii-F.ovina* type in August and September in the *P.bulbosa-L.orientalis*, *G.tournefortii-F.ovina*, and *A.heratense-T.transcaspicus* types (Fig. 4, c and d). In other types and months, the monthly mean NDVI in each vegetation type in the second period has decreased or has not changed.

Figure 4. Monthly mean NDVI in each vegetation type in both sub-catchments in two studied periods. a) Ungrazed sub-catchment in the first period, b) Ungrazed sub-catchment in the second period, c) Grazed sub-catchment in the first period, d) Grazed sub-catchment in the second period

The results of the correlation between average monthly temperature and monthly mean NDVI in each vegetation type showed that in the first period, the correlation is significant at the level of 0.05 for the *P.bulbosa-L.orientalis* and *S.orientalis-F.ovina* types in the ungrazed sub-catchment and at the level of 0.01 for the *P.bulbosa-L.orientalis, S.orientalis-F.ovina*, and *A.heratense-T.transcaspicus* types in the grazed sub-catchment. In the second period, the correlation was significant at the level of 0.01 for the *P.bulbosa-L.orientalis*, *G.tournefortii-F.ovina*, and *S.orientalis-F.ovina* types in the ungrazed sub-catchment and at the level of 0.01 for the *P.bulbosa-L.orientalis* and *G.tournefortii-F.ovina* types and at the level of 0.05 for the *A.heratense-T.transcaspicus* type in the grazed sub-catchment (Table 5).

Table 5
Spearman correlation test between average monthly temperature and monthly precipitation with monthly mean NDVI of each vegetation type in sub-catchments and period time

			First period		Second period	
Sub-catchment	Vegetation type		Monthly precipitation	Average monthly temperature	Monthly precipitation	Average monthly temperature
Ungrazed (Sample)	*P.bulbosa-L.orientalis*	Correlation Coefficient	-0.057	-0.450*	-0.027	-0.479**
		P-value (2-tailed)	0.767	0.013	0.888	0.007
	G.tournefortii-F.ovina	Correlation Coefficient	-0.009	-0.3	0.003	-0.570**
		P-value (2-tailed)	0.964	0.108	0.989	0.001
	S.orientalis-F.ovina	Correlation Coefficient	-0.276	0.016	-0.368*	-0.578**
		P-value (2-tailed)	0.140	0.933	0.045	0.001
	A.heratense-T.transcaspicus	Correlation Coefficient	0.038	0.420*	-0.046	0.254
		P-value (2-tailed)	0.840	0.021	0.809	0.175
Grazed (Control)	*P.bulbosa-L.orientalis*	Correlation Coefficient	0.243	0.545**	0.458	-0.498**
		P-value (2-tailed)	0.195	0.002	0.405	0.000
	G.tournefortii-F.ovina	Correlation Coefficient	-0.009	0.239	0.156	-0.765**
		P-value (2-tailed)	0.96	0.203	0.409	0.000
	S.orientalis-F.ovina	Correlation Coefficient	0.131	0.612**	0.012	-0.082
		P-value (2-tailed)	0.490	0.000	0.950	0.668
	A.heratense-T.transcaspicus	Correlation Coefficient	0.184	0.751**	0.357	0.392*
		P-value (2-tailed)	0.331	0.000	0.053	0.032
* is a significant difference at 0.05						
** is a significant difference at 0.01						

In the ungrazed sub-catchment, the results of the Mann-Whitney test showed that the monthly mean NDVI between the years of the two time periods had a significant difference at the 0.01 level ($P < 0.001$), but in the grazed sub-catchment, there was no difference between the two time periods ($P = 0.133$).

The monthly mean NDVI in each period time showed that in the ungrazed sub-catchment in all 6 months of the growing season, this value has increased significantly at the 0.01 level ($P < 0.001$) in the second period compared to the first period. The highest increase was in April with a value of 0. 105 (Fig. 5).

In the grazed sub-catchment, the monthly mean NDVI increased only in April and September in the second period. The highest increase of that was in April with a value of 0. 077 and in other months have decreased (Fig. 5). The results of the statistical comparisons showed that there was no significant difference in the monthly mean NDVI between the two time periods at the 0.05 level in the grazed sub-catchment (P = 0.398).

Figure 5. Monthly mean NDVI in both sub-catchments in two studied periods

The results of statistical comparisons for annual mean NDVI of vegetation types in the ungrazed sub-catchment showed that there was a significant difference for the *P.bulbosa-L.orientalis* and *G.tournefortii-F.ovina* types at the 0.01 level (P = 0.008) and *S.orientalis-F.ovina* type at the 0.05 level (P = 0.016) between the two time periods, but in the *A.heratense-T.transcaspicus* type, there was no difference (P = 0.056). Also, the annual mean NDVI in the two time periods had a significant difference at the 0.01 level (P = 0.008). In the grazed sub-catchment, there was no significant difference between the annual mean NDVI of vegetation types and the annual mean NDVI of two time periods.

In both sub-catchments, the results of the Spearman correlation test did not show a significant difference between monthly precipitation and monthly mean NDVI in both studied periods time. For the average monthly temperature, there was no significant difference in the first period, but in the second period, the difference was significant at the 0.01 level and showed an inverse correlation in the ungrazed sub-catchment, while in the grazed sub-catchment, was a significant difference at the 0.01 level in both studied periods (Table 6).

Table 6
Spearman correlation test between average monthly temperature and monthly precipitation with monthly mean NDVI in each sub-catchment and period time

		First period		**Second period**	
Sub-catchment	N = 30	Monthly precipitation	Average monthly temperature	Monthly precipitation	Average monthly temperature
Ungrazed (Sample)	Correlation Coefficient	-0.236	-0.118	-0.038	-0.682**
	P-value (2-tailed)	0.209	0.536	0.840	0.000
Grazed (Control)	Correlation Coefficient	-0.016	0.570**	0.123	-0.482**
	P-value (2-tailed)	0.934	0.001	0.518	0.007
* is a significant difference at 0.05					
** is a significant difference at 0.01					

Discussion

The general results showed the effect of grazing and ungrazing management on vegetation cover by mean values of the NDVI between two time periods. Based on the results, in the ungrazed period time (2015–2019) the mean values of the NDVI are significantly higher than in the grazed period time (1991–1995). The effects of livestock exclusion on the change of vegetation cover were determined by the NDVI index. A significant change has been shown between the inside and outside of a 19-year exclosure rangeland (Aghajanloo & Mousavi, 2007).

The ungrazed (Sample) and grazed (Control) sub-catchments are experimental basins in the field of natural resources and have similar physical and climatic characteristics. But they are different only in terms of exclusion. The Sample sub-catchment involves excluding livestock since 1999, while the Control sub-catchment has a seasonal grazing system. Therefore, a significant difference in mean NDVI in the Sample sub-catchment shows the effect of excluding livestock on the vegetation cover. It has also been confirmed in past studies that grazing is one of the main factors of vegetation cover degradation in arid and semiarid regions (Jeddi & Chaieb, 2010). The previous results are shown that exclosure can be increased the canopy cover in steppe slopes (Zarekia et al., 2018). Also, the exclosure can be enhanced the vegetation and soil characteristics and the NDVI index can be indicated these changes in the watershed. Therefore, remote sensing images are capable to investigate the effects of biological measures in watershed management projects (Assefa et al., 2021; Qasim et al., 2017).

Based on the previous data, before excluding livestock in the first period, the duration of the vegetation utilization in the Sample sub-catchment (ungrazed) has been done 2 months longer than in the Control sub-catchment (grazed). Low values of the mean NDVI in the first period confirmed this situation. With increasing the time of grazing, the livestock decides how frequently and intensely a particular plant will be grazed. Therefore, allows the animals to graze and forage more selectively. Moreover, it causes livestock grazes in favored local areas. Spatial patterns develop where some patches and plants are heavily grazed, while others remain ungrazed or only lightly grazed. This produces small-scale heterogeneity (Sandhage-Hofmann, 2016) and leads to the degradation of soil and deterioration of vegetation near the water (Kotzé et al., 2013). Missing resting times do not allow for recovery on heavily grazed patches (Teague et al., 2004). This situation can be observed in the Sample sub-catchment (ungrazed) in the first period that NDVI values confirm.

The results of the NDVI index showed that prolonged grazing of livestock in the first period in the Sample sub-catchment (ungrazed) has caused the severity of vegetation degradation to be such that after 20 years of excluding livestock, its vegetation cover is almost the same as the Control sub-catchment (grazed) which has been under grazing from the beginning (Fig. 3). Despite livestock grazing in the Control sub-catchment (grazed), the value of this index has been almost constant during the two periods. This showed that if vegetation cover is destroyed due to a lack of livestock grazing management, it will be very time-consuming to rehabilitate and return it to its original condition. Light grazing increases the above-ground biomass, canopy cover, and height of the species from a long-term perspective, moderate grazing can help balance the production of different species and livestock production (Huang et al., 2011). Grazing can be slowly affected the vegetation in arid environments (Dianati Tilaki et al., 2010). Some studies documented the improvements in vegetation, inside exclosures while others reported site-specific and minor differences between the protected and adjacent grazed areas (Haftay et al., 2013). The withdrawal of livestock grazing is often not sufficient to initiate the autogenic recovery of vegetation (Mureithi et al., 2014). However, the establishment of exclosure had positive significant effects on the vegetation cover (Niknahad–Gharmakher et al., 2017).

Based on the results in the second period, the monthly mean NDVI increased in April in both sub-catchments. The survey of temperature data showed that the average temperatures of March and April in the second period compared to the first period increased by 2.5 and 0.5 degrees Celsius, respectively. Also, the average cumulative rainfall in April in the second period compared to the first period decreased by only 17.7 mm. As a result of these climate changes, the growth period of plants in the second period has started faster, which has led to an increase in vegetation in April in the second period compared to the first period.

Based on the results, vegetation *P.bulbosa-L.orientalis* and *G.tournefortii-F.ovina* types have been more affected by grazing, and there was a significant difference in them after excluding livestock. The least effect of grazing was observed in the *A.heratense-T.transcaspicus* type. The predominant plants of this type are classified as non-*palatable* plants. Therefore, areas with non-palatable species excluding livestock will not cause significant changes in vegetation.

Conclusion

In this study, an attempt has been made to recognize the impact of long-term excluding livestock on vegetation cover by remote sensing. The NDVI can indicate the impact of seasonal grazing and excluding livestock on the vegetation cover over time. Overgrazing and exclosure have the main role in the degradation, rehabilitation, and restoration of the vegetation cover. The establishment of exclosures is a well-known management tool to increase vegetation cover. This increase can provide equal opportunities for both palatable and non-palatable species. Generally, it can be concluded that 1) the NDVI index can be used for monitoring and detecting the changes in vegetation cover over time and identifying the effect of corrective and managerial measures of watershed management. Therefore, remote sensing data has proven to be useful in data-poor regions where recent and reliable spatial information is lacking. 2) The effect of exclosure on increasing vegetation can be confirmed, but it cannot be considered the optimal use of vegetation. The complete long-term livestock exclusion is not normal protection of vegetation cover, which evolved with grazing animals, both wild and domestic. Because some undesirable changes may occur, such as excessive litter accumulation that will change the habitat enough to reduce or eliminate many native species in the area. 3) light and moderate grazing intensities can cause an increase in species diversity and plant production. Therefore, grazing in the long-term cannot decrease the canopy cover of vegetation in a correct grazing management program, and given the economic benefits, it should be preferred over exclosure.

Declarations

Author contribution Masoud Eshghizadeh: administration, data curation, conceptualization, visualization, methodology, software, formal analysis, validation, original draft, writing, review and editing. Vahid Moosavi: conceptualization, methodology, investigation, resources, validation, review and editing, supervision.

Funding The authors declare no funding.

Data availability The full datasets generated or analyzed during this study are available from the corresponding author on reasonable request.

Competing interests The authors declare no competing interests.

References

1. Aghajanloo, F., & Mousavi, A. (2007). An investigation on the effects of exclosure on quantitative and qualitative changes of rangeland vegetation cover. *Iranian Journal of Natural Resources Research,* 59, 981-986.
2. Aerts, R., Nyssen, J., & Haile, M. (2009) On the difference between exclosures and enclosures in ecology and the environment. *Journal of Arid Environment,* 73(8), 762–763. https://doi:10.1016/j.jaridenv.2009.01.006
3. Ahmad, S., Islam, M., & Mirza, S. N. (2012). Rangeland degradation and management approach in Balochistan. *Pakistan Journal of Botany,* 44, 127-136.
4. Amiri, F., Rashid, A., & Shariff, M. (2010). Using remote sensing data for vegetation cover assessment in a semi-arid rangeland of Center province of Iran. *World Applied Sciences Journal, 11*(12), 1537-1546.
5. Assefa, A., Tamiru Haile, A., Dhanya, C. T., Walker, D. W., Gowing, J., & Parkin, G. (2021). Impact of sustainable land management on vegetation cover using remote sensing in Magera micro Watershed, Omo Gibe Basin, Ethiopia, *International Journal of Applied Earth Observation and Geoinformation,* 103, 102495. https:// doi.org/10.1016/j.jag.2021.102495.
6. Dianati Tilaki, Gh. A., Naghipour Borj, A. A., Tavakoli, H., & Haidarian Aghakhani, M. (2017) The effects of exclosure on plants in the semi-arid rangeland of North Khorasan province, Iran. *Desert,* 15, 45-22.
7. Eshghizadeh, M. (2012). *Plan review of Kakhk paired catchment*. Forests, Range & Watershed Management Organization of Iran. Gonabad.
8. Eshghizadeh, M., & Esmaeilian, Y. (2020). Evaluation possibility of rangelands biomass estimation using Landsat 8 satellite data. *Iranian Journal of Range and Desert Research,* 27(1), 159-176. https://doi: 10.22092/ijrdr.2020.122161
9. Haftay, H., Yayneshet, T., Animut, G., & Treydte, A. C, (2013), Rangeland vegetation responses to traditional enclosure management in eastern Ethiopia. *Rangeland Journal,* 35, 29–36.
10. Hangs, R. D., Van Rees, J., Schoenau K. C. J., & Guo, X. (2011). A simple technique for estimating above-ground biomass in short-rotation willow plantations. *Biomass & Bioenergy,* 35, 2156-2162.
11. Hoshino, A., Tamura, K., Fujimaki, H., Asano, M., Ose, K., & Higashi, T. (2009) Effects of crop abandonment and grazing exclusion on available soil water and other soil properties in a semi-arid Mongolian grassland. *Soil and Tillage Research,* 105, 228–235.
12. Huang WHZ, Zhang Z., & Wu, G. (2011). Effects of grazing on the soil properties and C and N storage about biomass allocation in an alpine meadow. *Soil Science and Plant Nutrition, 11*, 27-39.
13. Huss, D. L. (1996). *The role of domestic livestock in desertification control*. FAO, Rome.
14. Imani, J., Ebrahimi, A., Gholinejad, B., & Tahmasebi, P. (2018). Comparison of NDVI and SAVI in three plant communities with different sampling intensities (Case study: Choghakhour Lake rangelands in Charmahal & Bakhtiri). *Iranian Journal of Range and Desert Research, 25*(1), 152-169.
15. Jackson, R. D, Slater, P. N., & Pinter, P. J. (1983). Discrimination of growth and turbid atmospheres. *Remote Sensing of Environment, 13*, 187-208.

16. Jeddi, K., & Chaieb, M. (2010). Changes in soil properties and vegetation following livestock grazing exclusion in degraded arid environments of South Tunisia. *Flora, 205*, 184–189.
17. Kotzé, M., Seedat, M., Suffla, S., & Kramer, S. (2013). Community conversations as community engagement: hosts' reflections. *South African Journal of Psychology, 43*(4), 494-505. doi.org/10.1177/0081246313508353.
18. Long, Y., Zhou, L., Liu, W., & Hua-Kun, Z. (2010). Using remote sensing and GIS technology to estimate grass yield and livestock carrying capacity of Alpine grasslands in Golog Prefecture China. *Pedosphere, 20*(3), 342-351.
19. Magnano, A. L., Nanni, A. S., Krug, p., Astrada, E., Vicari, R., & Quintana, R. D. (2018). Effects of livestock exclusion on density, survival and biomass of the perennial sagebrush grass Hymenachne pernambucense (Poaceae) from a temperate fluvial wetland. *Acta Oecologica,* 86, 72-78. doi.org/10.1016/j.actao.2017.12.006.
20. Mureithi, S. M., Verdoodt, A., Gachene, C. K., Njoka, J. T., Vivia, O. W., Neve, S. D., Meyerhoff, E., & Ranst, E. V. (2014). Enclosure management on soil properties and microbial biomass in a restored semi-arid rangeland, Kenya. Journal of Arid Environment, 6(5), 561–570.
21. Niknahad–Gharmakher, H., Sheidai-Karkaj, E., & Jafari, I. (2017). Effects of Exclosure on Soil Properties in Winter Rangelands in Golestan Province, Iran. *Journal of Rangeland Science,* 7(1), 55-66.
22. Olexa, E. M., & Lawrence, R. L. (2014). Performance and effects of land cover type on synthetic surface reflectance data and NDVI estimates for assessment and monitoring of semi-arid rangeland. *International Journal of Applied Earth Observation and Geoinformation,* 30, 30-31.
23. Qasim, S., Gul S., Hussain Shah, M., Hussain, F., Ahmad, S., Islam, M., Rehman G., Yaqoob, M., & Qasim Shah, S. (2017). Influence of grazing exclosure on vegetation biomass and soil quality, *International Soil and Water Conservation Research,* 5, 62-68.
24. Rouse J. W., Haas R. H., Schell J. A., & Deering D. W. (1974). Monitoring vegetation systems in the Great Plains with ERTS. *Abstracts of the 3rd Earth Resources Technology Satellite-1 Symposium*, Washington DC, 309-317.
25. Sandhage-Hofmann, A. (2016). *Rangeland Management, Reference Module in Earth Systems and Environmental Sciences*, Elsevier, Amsterdam. doi.org/10.1016/B978-0-12-409548-9.10455-5.
26. Soleymani, K., Tamartash, R., Alavi, F., & Lotfi, S. (2007). Utility of remote sensing data in the estimation of rangeland production. Case study: Sefidab Sub-basin of the Lar Dam. *Journal of Agricultural Science and Technology, 11*(40), 425-437.
27. Teague, W. R., Dowhower, SL., Waggoner, J. A. (2004). Drought and grazing patch dynamics under different grazing management, *Journal of Arid Environment,* 58, 97e117.
28. U.S. Geological Survey. (2020). *Earth Resources Observation and Science*. U.S. Geological Survey database, Earth Explorer, Download Satellite images, accessed 20 Jun 2020. http://earthexplorer.usgs.gov.
29. Verdoodt, A., Mureithi, S. M., & Van–Ranst, E. (2010) Impacts of management and enclosure age on recovery of the herbaceous rangeland vegetation in semi-arid Kenya. *Journal of Arid Environment,* 74, 1066-1073.
30. Wagle, P., Xiao, X. M., Torn, M. S., Cook, D. R., Matamala, R., Fischer, M. L, Jin, C., Dong, J., & Biradar, C, (2014), Sensitivity of vegetation indices and gross primary production of tallgrass prairie to severe drought. *Remote Sensing of Environment,* 152, 1-14.
31. Xiaoping, W., Kai, G. N., & Jing, W. (2011). Hyperspectral Remote Sensing estimation models of aboveground biomass in Gannan rangelands Procedia*. Journal of Environmental Sciences,* 10, 697-702.
32. Yeganeh, H., Khajeddin, S. J., & Soffianian, A. R. (2008). Evaluating the potentials of spectral indices of the MODIS in estimating the plant production in Semirom pastures. *Journal of Rangeland, 2*(1), 63-77. https://doi.org/10.1016/B978-0-12-409548-9.10455-5
33. Zarekia, S., Arzani, H., Jafari, M., Javadi, S. A., Ashraf Jafari, A., & Zandi Esfahan, E. (2018). Changes of vegetation structure and biomass in response to livestock grazing in steppe rangelands of Iran. *Journal of Animal and Plant Sciences, 23*(5), 1466-1472.
34. Zarineh, E., Asadi Brojeni, E., & Khorasgani, M. N. (2012). Estimation of range production using satellite data IRS LISS III (A case study of the Tang Sayyad, Chaharmahal, and Bakhtiari). *Journal of Iranian Remote Sensing and GIS, 3*(4), 63-80.

Figures

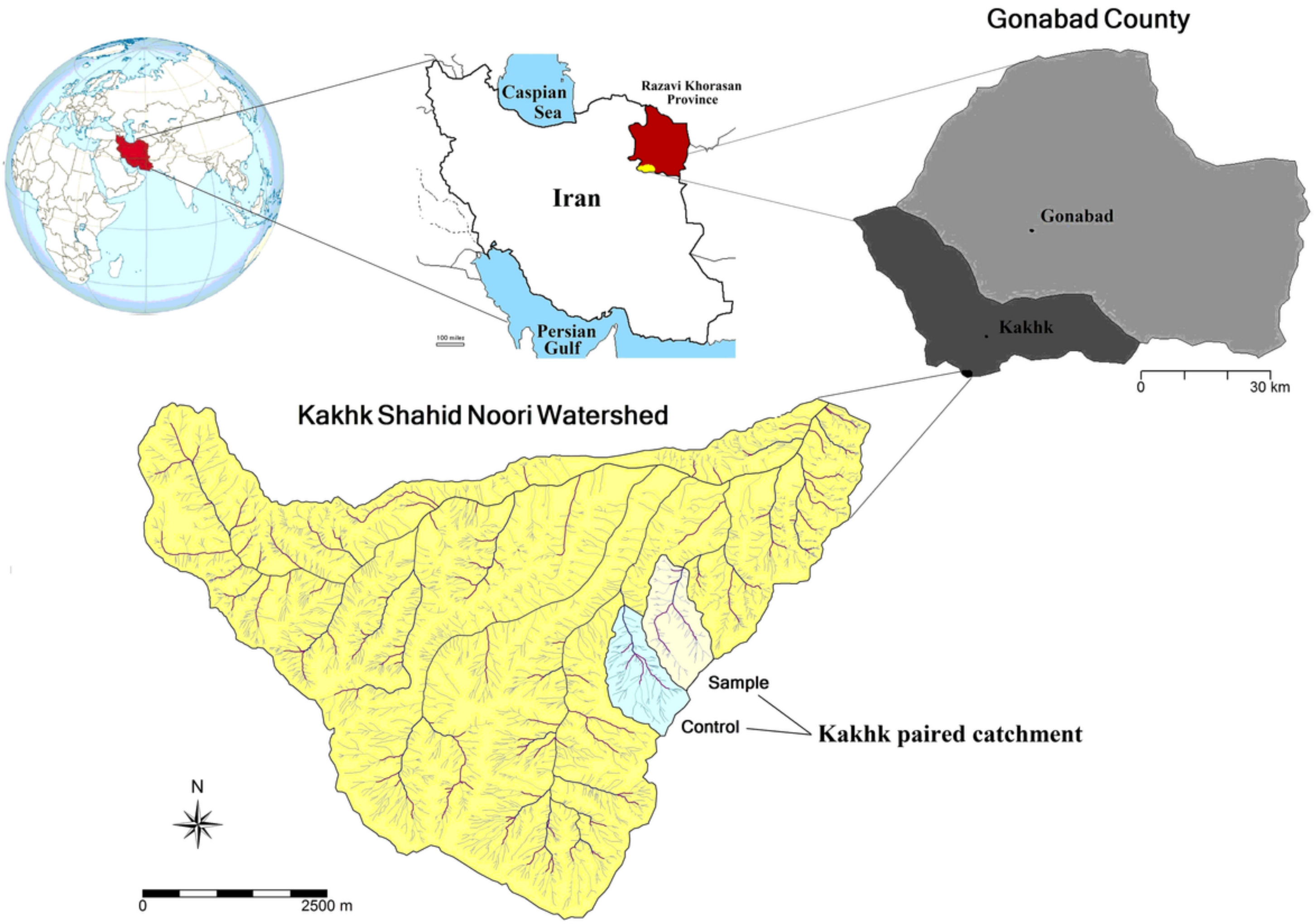

Figure 1

Location of the Kakhk experimental watershed in Eastern Iran

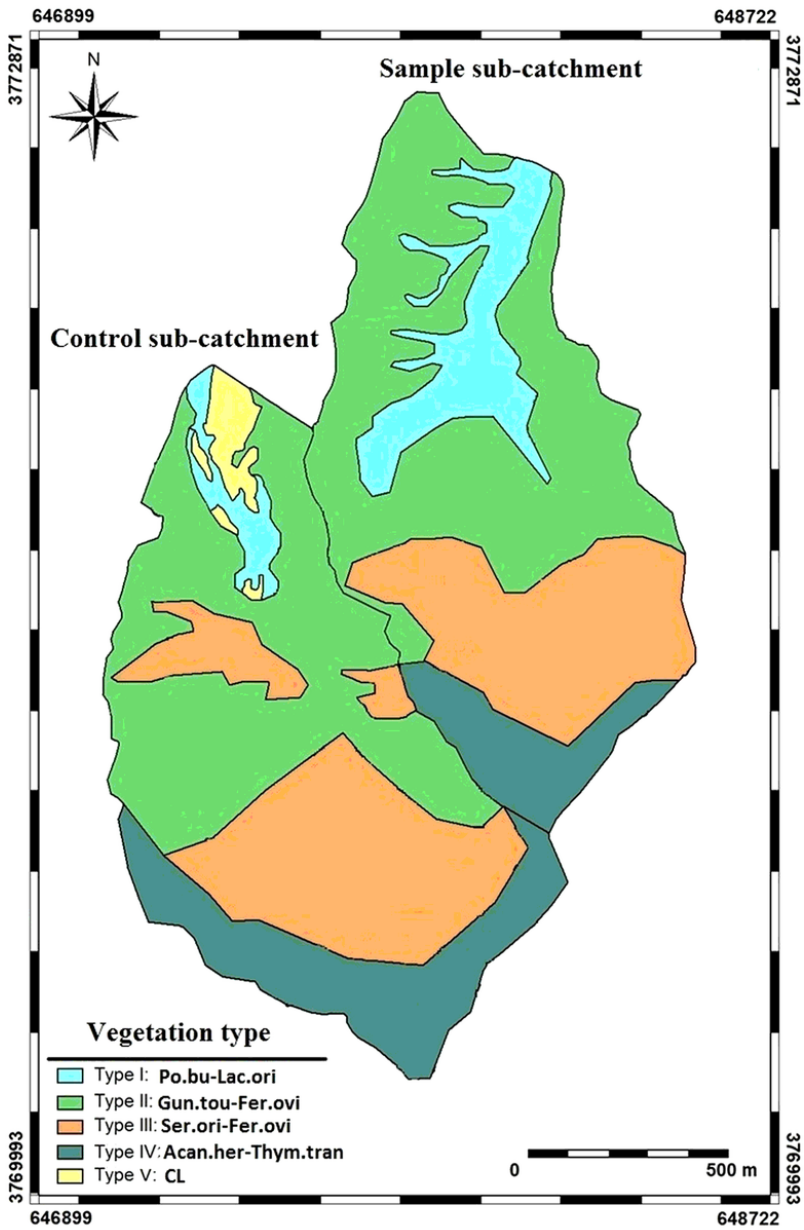

Figure 2

Vegetation types map of the Control (grazed) and Sample (ungrazed) sub-catchments in the Kakhk experimental watershed. Type I: *Poa bulbosa-Lactoca orientalis*, Type II: *Gundelia tournefortii-Ferula ovina*, Type III: *Serratula orientalis-Ferula ovina*, Type IV:*Acanthophyllum heratense-Thymus transcaspicus*, Type V: Cultivated lands

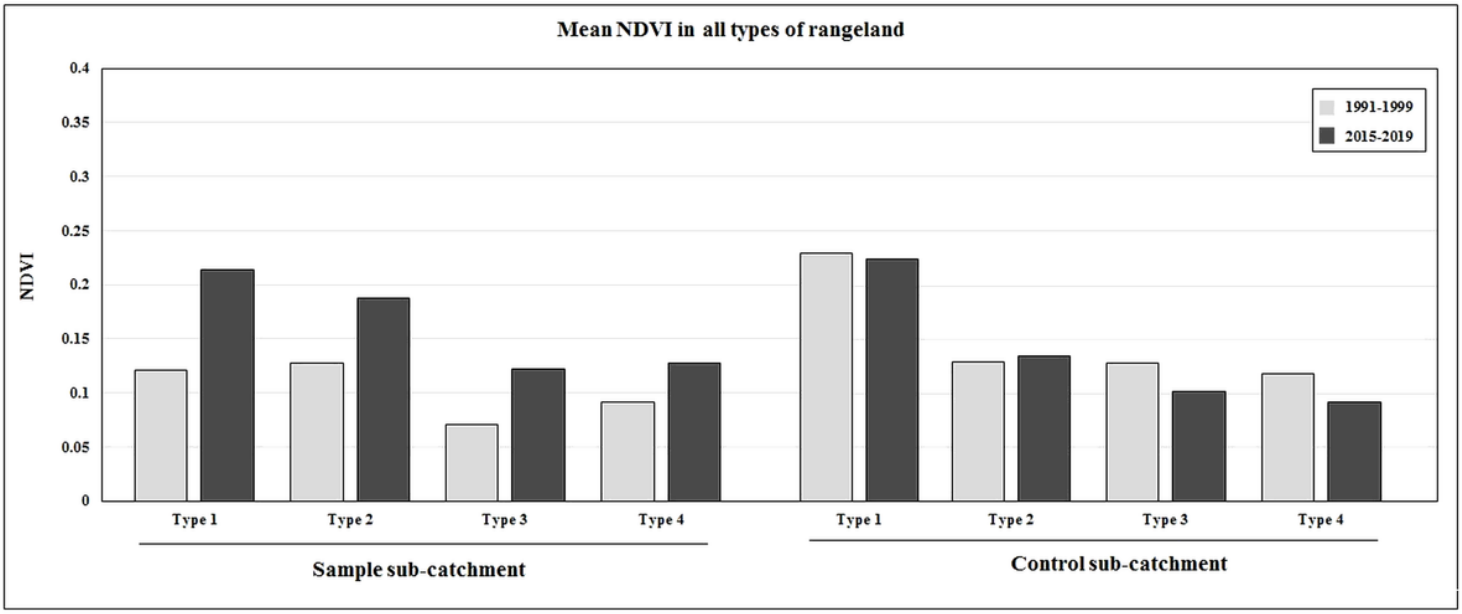

Figure 3

Mean NDVI of vegetation types in both sub-catchments in two studied periods

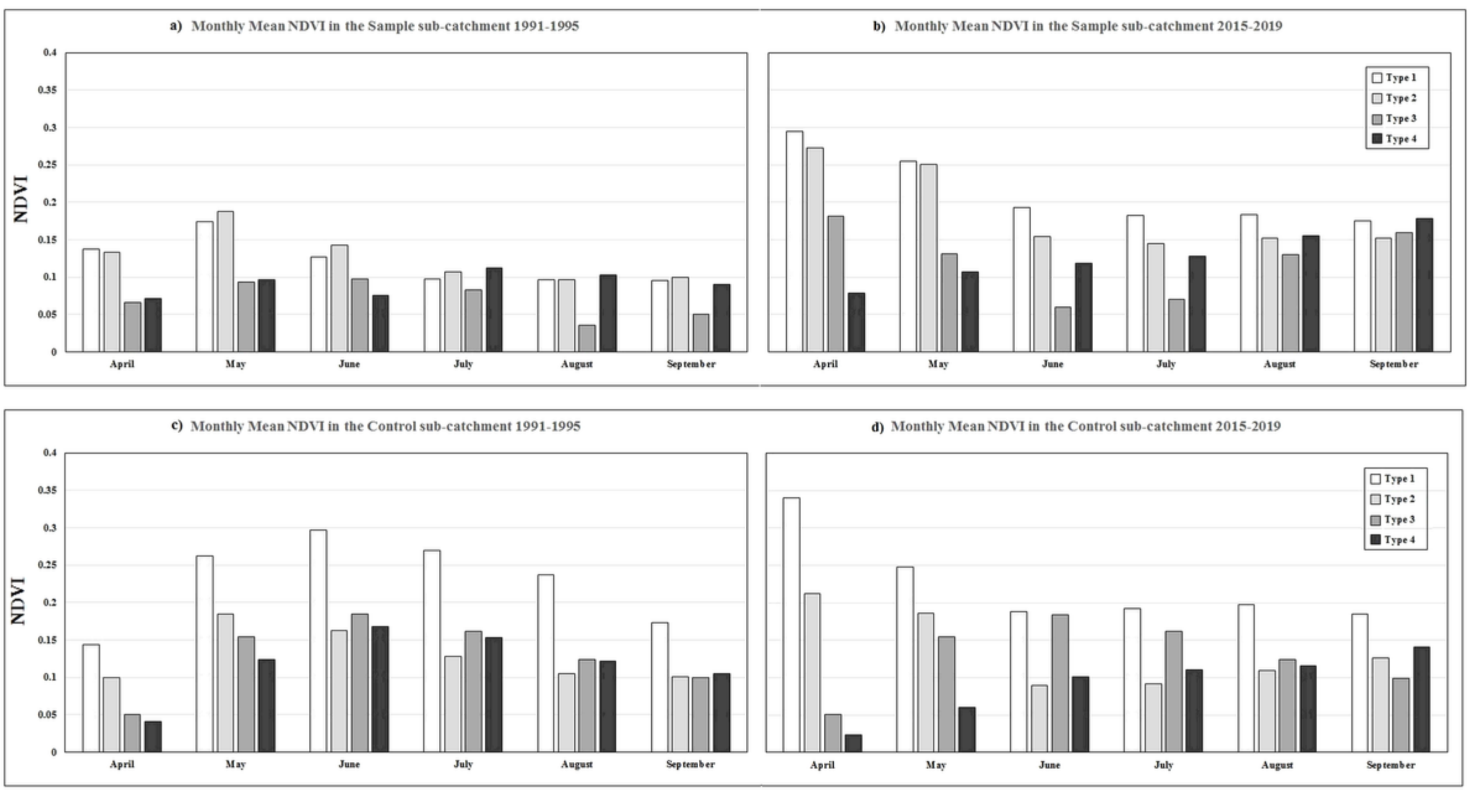

Figure 4

Monthly mean NDVI in each vegetation type in both sub-catchments in two studied periods. a) Ungrazed sub-catchment in the first period, b) Ungrazed sub-catchment in the second period, c) Grazed sub-catchment in the first period, d) Grazed sub-catchment in the second period

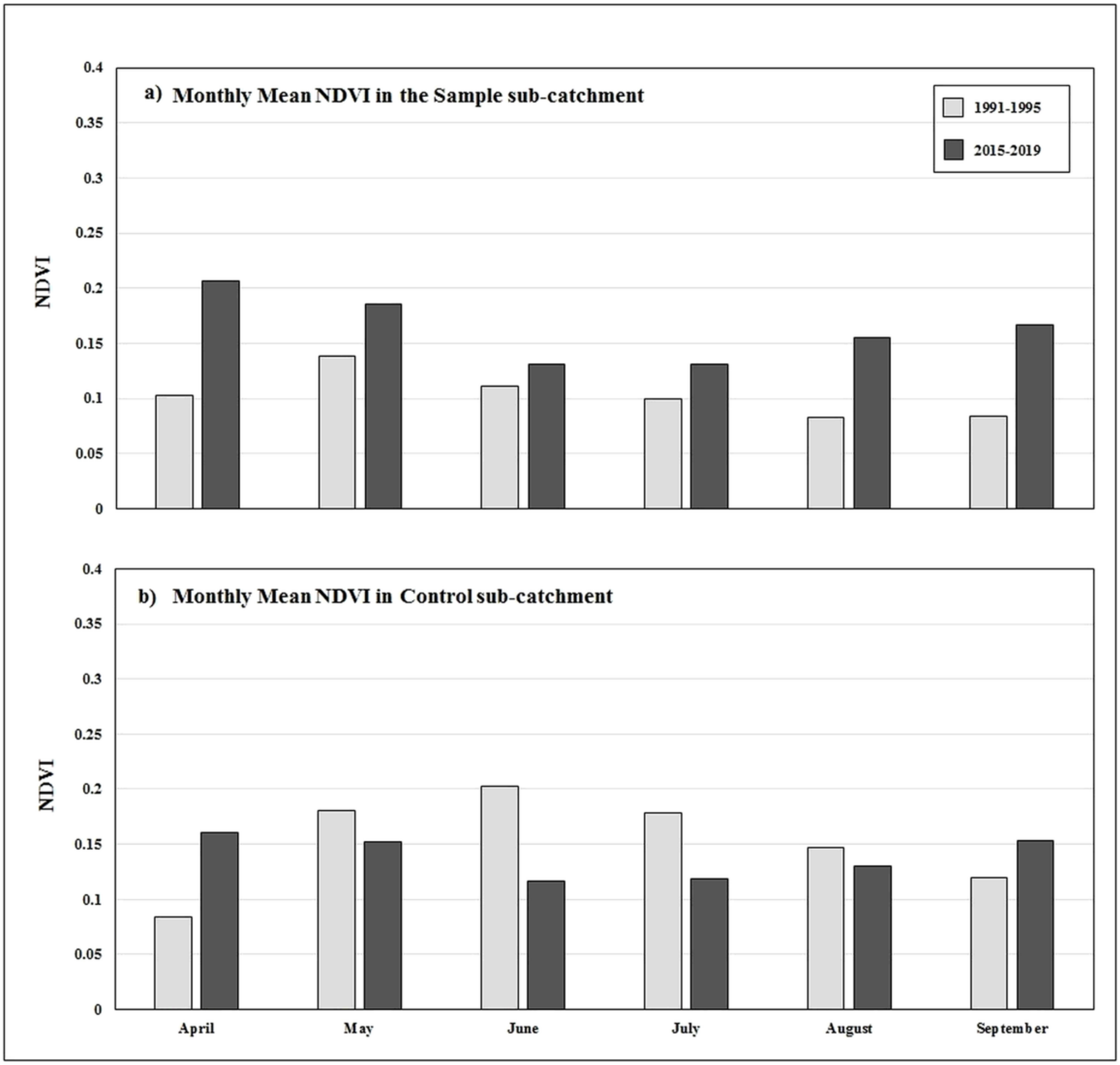

Figure 5

Monthly mean NDVI in both sub-catchments in two studied periods