On behalf of:

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

The GIZ regional project "Ecosystem-based Adaptation to Climate Change in High Mountainous Regions of Central Asia"

Report

Pasture degradation in Suusamyr Valley of Kyrgyzstan

November 2019

The regional project "Ecosystem-based Adaptation to Climate Change in High Mountainous Regions of Central Asia" is a part of the International Climate Initiative (IKI). The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag.

BACKGROUND INFORMATION

Pastures are an important land resource in many developing countries and provide the livelihood for majority of rural communities. Various natural and human-induced pressures on pastures in many parts of the world have resulted in transformation of large pastures areas into deserts, croplands or shrub lands, replacing grasses with cultivations or bare ground.

The territory of the Kyrgyz Republic, dominated by mountains, is ecologically fragile and vulnerable to various natural and anthropogenic hazards. About 50% of the agricultural land is exposed to various types of degradation. This pressure on land is aggravated by the increasing impacts of natural and climate disturbances, such as periods of low water in rivers, mudflows, heavy snows and others. Recently, water deficiency in 2012 and 2014 years decreased supply of the irrigation water to arable areas down to 30 – 40%, which correspondingly resulted in reduced crop harvests[1].

In Kyrgyzstan, pastures cover around 45% of the country’s territory (NSC 2018) and play a key role in ensuring the food security and wellbeing of rural inhabitants in the country. Despite their importance, about 70% of pastures are estimated to be moderately to severely affected by degradation. Unfortunately, research on the causes and specific extent of pasture degradation in the Kyrgyz Republic is limited. During the Soviet period, state authorities conducted regular monitoring of the status of pastures, however this practice has been ceased after collapse of USSR. Since 2009, in all village districts there were introduced local pasture committees that are tasked with monitoring over the pasture conditions, however this is rarely done. Without detailed monitoring information, it is impossible to make evidence-based estimates of carrying capacity of pastures and make recommendations to farmers about the sustainable number of livestock they should keep. With only 7% of land in Kyrgyzstan being used for crop agriculture, the majority of income in rural areas comes

[1] Apasov et al, 2016, The National Action Plan for implementing the UNCCD in the Kyrgyz Republic for 2015-2020. Kyrgyzstan.

from animal husbandry. This has created a strong incentive for households to increase the livestock they own. It is estimated that the number of livestock in the country has grown steadily in the past 10 years to reach about 15 million animals at the end of 2018. Some estimates suggest that livestock herders underreport the actual number of livestock they own (by as much as 30-50%) to avoid paying for pasture use rights. In six of the seven regions of the Kyrgyz Republic, livestock was found to exceed the allowable load on pastures. In an attempt to reduce the pressure on pastures and introduce more sustainable management practices, the Kyrgyz government introduced a major change in the pasture legislation in 2009, shifting the responsibility for pasture management to designated pasture committees. While pasture committees are well placed to monitor the condition of pastures and make decisions accordingly, the institutional capacities and resources of pasture committees have remained limited. While several projects supported by development partners have targeted capacity building measures and piloted sustainable pasture management practices at demonstration sites, there is still an acute need for research to assess the ongoing pasture degradation processes in the country at large and provide recommendations on sustainable management of our natural grasslands. An issue of increasing concern is the encroachment of pastures. In an attempt to assess the extent of shrub encroachment in pastures in Kyrgyzstan, this research focuses on the invasion of Caragana aurantica Koehne in the large high altitude valley of Suusamyr.

In acknowledgement of these challenges, the Government's National Strategy on the Sustainable Development of the Kyrgyz Republic for 2013 – 2017 years emphasized that "to date the degradation processes of the lands, purposed for crop agriculture and animal husbandry, represent significant threat to food security and undermine the sustainable development of the country".

Pastures are the most significant land resource in the Kyrgyz Republic as they cover more than 9 mln. hectares (around 46% of the country's land). Pasture degradation constitutes a serious threat to food security and wellbeing of rural inhabitants in the Kyrgyz Republic. Mountain pastures are vulnerable to a number of natural hazards like climate change, landslides, mudflows, pervasive weeds' expansion, etc. Swiftly and imminently growing numbers of livestock put additional pressure on pastures. If the current trends continue, pastures will become severely degraded in the coming years all over the country. Therefore, there is an acute need in research activities aiming to assess the ongoing pasture degradation processes in the country to make informed decisions on sustainable management of our natural grasslands.

The focus area for our research is the Suusamyr valley which is one of the most important mountain pasture areas in the country with total area of almost 500,000 hectares. Due to its highly nutritious grasses and vast area, rural population from 3 oblasts (Chuy, Talas and Jalalabad) graze their livestock in this valley during vegetation season.

Recently, pasture specialists have focused their attention on the extensive expansion of the weedy shrub caragana (locally called altygana), which is particularly visible all over the Suusamyr valley along the Bishkek-Osh road. This shrub is thorny and is not edible for animals. Sheep and cattle cannot graze in the areas covered by caragana. Its expansion is largely due to very strong root system and quick regeneration abilities[2]. Efforts to stop its spread have not proven successful, as the mechanical removal requires a lot of manual labor and chemical removal is costly. There are concerns in the community of pasture experts that further expansion of the species will reduce the area available for grazing significantly and thus the value of the Suusamyr pasture.

Below are some of the pictures of this weed downloaded from internet:

[2] Report of the Kyrgyz Research Institute on Livestock and Pasture Management, 2018.

Attempts to estimate the extent of caragana spread have been limited and there is no clear and precise data on the current area covered by caragana. The lack of studies on the spread of the species over the last years in Suusamyr valley makes it also difficult to predict how the plant will spread in the future and how the different communities' dependent on the pasture are impacted.

Study area

The study area for the project is the entire valley of Suusamyr which is located in the central part of Kyrgyzstan and lies geographically between 41° 60′ N and 42° 40′ N and 73° 10′ E and 74° 60′ E. It covers an area of around 471,000 ha spreading about 150 km from west to east and 60 km from north to south. The lowest point of the valley lies at around 1900 m a.s.l. The valley lies between the three major ridges of the northern Tien Shan: Kyrgyz, Suusamyr-Too and Jumgal-Too which reach heights of around 4500 m a.s.l. The territory is covered by heterogeneous landforms including ridges, hills with various altitudes, rocky outcrops, shallow river valleys and flat planes. The central part of the valley is wider, and forms a plateau, which ranges between 2200-2600 m a.s.l. About 200 rivers and streams, originating from glaciers, snowfields and natural springs feed into the main water body, the Suusamyr river. The climate of Suusamyr valley is influenced strongly by the mountainous terrain surrounding it. The area comprises of various ecological zones and biomes including steppes, hills, mountains, rocks, valleys and grasslands, as well as managed agricultural lands and pasture rangelands. The average annual temperature is below 0°C, precipitation averages around 345 mm. Snow covers the valley from November and lasts until the end of April. Pastures located on the slopes of the mountains surrounding the valley experience somewhat different climatic conditions characterized by smaller temperature fluctuations and higher precipitation. Suusamyr valley is the largest area of summer pastures for transhumance in the country and its importance for animal husbandry is significant. Administratively, the valley belongs to Panvilov and Jaiyl raons of Chuy province, but every year it draws hundreds of herders not only from Chuy, but also from Talas, Jalalabad and Naryn regions.

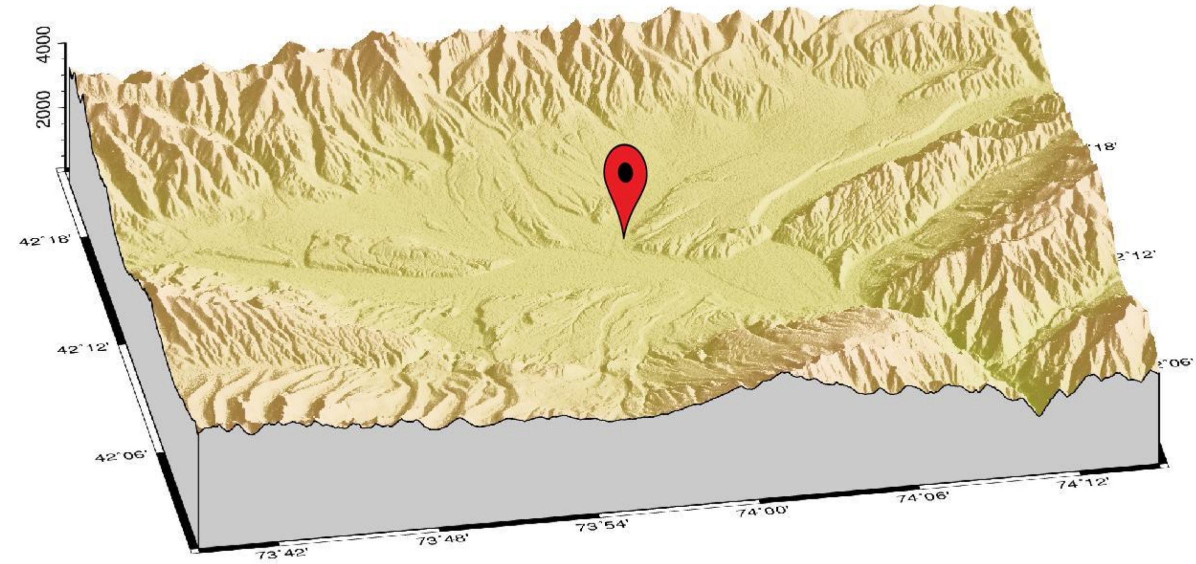


Figure 1: Study area location 3D model

State of pastures in Suusamyr valley

The total area of the Suusamyr valley is 471 655 Ha. It’s distribution by land use types is given in the table below.

Land use in Suusamyr (UNDP 2008)

Land use categories	Area in Ha
Pastures in general	300 890
Spring/Fall pastures	52 658
Summer pastures	231 589
Winter pastures	16 643
Hayfields	889
Crop land	21 050
Hayfields	889
Forests and shrubs	21 050
Unused lands	127 705
Other lands	4 196
For third parties use	2 721

As it is seen from the table above, Suusamyr has pastures for all seasons. The nutritional value of the pasture grasses is mainly good and average. Due to uneven pasture use there could be observed pockets of degraded vegetation where poorly edible plants prevails (e.g. tarragon, ferula, eremurus, etc.). Such pattern is seen in the basin of Karakol river, where overgrazing regularly occurs. Another pattern revealed by UNDP research: the main livestock is grazed along the Bishkek-Osh road, around settlements, that is, where the commercial retail of livestock products is mostly established. But there is also observed the highest degradation of pastures.

Cattle is moved in the valley through relevant mountains passes related to the neighbouring provinces. The main grazing season occurs from the beginning of June till first decade of September. However, these dates can vary depending on climate conditions and start of the sowing activities in incoming herders' communities.

Caragana (aka altygana, tookuiruk) is very invasive and expands quickly, impacting tangible pasture areas. Every year the area covered by caragana

increases and negatively affects livelihoods of herders in the Suusamyr valley. According to pasture inventory conducted in 2008 by UNDP, it's total area was more than 16,000 Ha. Common characteristic of the encroachment in arid and semi-arid grasslands is an increase in the area and density of the shrubs (Van Auken 2009). Such changes in the composition of pastures could mean a significantly reduction in the edible biomass in a given area, and hence decreasing the potential carrying capacity for livestock (Naito and Cairns 2011).
This is of significant concern in the Suusamyr valley as the encroachment of shrubs could be detrimental to the economic value and the potential for animal husbandry in the area. In Suusamyr, a species of the Caragana genus (Caragana aurantiaca Koehne), known locally as Altygana, is reported to cover an area of 16.8 thousand hectares (UNDP 2008). The area occupied by the shrub is estimated to have increased by 26% in the period 1999-2008. The Caragana genus includes about 90 species and most of them grow in Siberia, Central Asia and the Far East. Altygana have pinnate leaves and stipules, modified into subulate appendages, and sometimes thorns. The plant produces yellow flowers and forms bean pods at the end of flowering fruits. While some herders report that Altygana was used as a fuel or for the production of brooms in the past, its current practical use is limited and locals consider it problematic due to its limited value for livestock. Other species of the Caragana genus have also been identified to be of concern in parts of Northern China and Inner Mongolia (Cao et al. 2019; Zhang et al. 2017). In Suusamyr, the shrub is typically found along the valleys of rivers and streams. According to the State Agency for Environmental Protection and Forestry under the Government of the Kyrgyz Republic, Altygana is spreading in the Suusamyr valley as a result of improper use of pastures, overgrazing and constant use of the pasture resource (Akipress 2018).

Table 1: Scientific classification of Caragana aurantiaca Koehne (Roskov et al 2019)

Scientific classification	
Kingdom	Plantae
Phylum	Tracheophyta
Class	Magnoliopsida
Order	Fabales
Family	Fabaceae
Genus	Caragana Fabr.

Figure 2: Altygana growing in study area

Geospatial data

The external border of Suusamyr valley pastures was produced on the basis of Surochamar cartographic material on a scale of 1:50 000, performed by a group of experts from the Kyrgyzgiprozem in 2018. Landsat satellite images were downloaded from the United States Geological Survey website, particularly for Landsat 5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper + (ETM+) and Landsat 8 Operation Land Manager (OLI). Landsat 8 is the most up-to-date satellite in the Landsat program, having new features such as the Operational Land Manager (OLI) and Thermal Infrared Sensor (TIRS). OLI operates eight spectral bands collecting information within the visible electromagnetic spectrum (Loyd 2013), while TIRS has two bands capturing the thermal infrared part of the electromagnetic spectrum. Every band combination provides information about objects on the Earth's surface – vegetation, buildings, rocks and water. Image preprocessing included procedures such as radiometric calibration, atmospheric correction and conversion from Digital Number (DN) to surface reflectance. Pre-processing of satellite images is necessary to establish links between acquired data and biophysical phenomena. The pre-processing was carried out using the ArcGIS software package, creating a mosaic and a subset in accordance with the area of investigation (AOI).

Land cover classification

Land cover classification is commonly used method for the analysis of satellite imagery with the aim to identify and assess areas corresponding to a specific attribute (Foody 2002; Pal & Mather, 2003). Series of classified images can also be used to detect changes in land cover (Hermosilla et al. 2015). The two types of classification used are supervised and unsupervised. In this paper, we use supervised classification. Supervised classification requires the combination of satellite data with ground data about the terrain which is then used to train samples to classify the images.

The method that was used to carry out the supervised classification was maximum likelihood classifier as described by Otukei and Blaschke (2010). The ground data used was collected at 350 points across the Suusamyr valley and included attributes such as GPS coordinates, land cover type, presence of shrubs. The satellite images used for the classification were for the years 2000, 2010, and 2018 and included multi-sensor data from Landsat satellites in July, August and September.

Table 2: Satellite data specification

Source	Date of acquisition	Bands	Resolution (m)	Source
Landsat 7	7.07.2000	Multi-spectral	30	USGS, Earth explorer
Landsat 5	27.07.2010	Multi-spectral	30	USGS, Earth explorer
Landsat 8	1.07.2018	Multi-spectral	30	USGS, Earth explorer
Landsat 7	24.08.2000	Multi-spectral	30	USGS, Earth explorer
Landsat 5	28.08.2010	Multi-spectral	30	USGS, Earth explorer
Landsat 8	3.09.2018	Multi-spectral	30	USGS, Earth explorer

The land categories used for the classification are described in the following table:

Table 3: Land use categories

№	Categories	Description
1	Arable land	Fields, agricultural land
2	Water features	Rivers, lakes, marshes
3	Rocks	Boulders, steep slopes and sharp cliff edges
4	Pasture	Grasslands for livestock grazing
5	Shrubs	Perennial ligneous plants of low growth, including Caragana (Altygana)
6	Glaciers	Ice and snowfields

7	Forest	Land predominantly occupied by trees
8	Settlements	Urban areas, commercial and industrial facilities
9	Roads	Paved and unpaved roads used by motorised vehicles

NDVI calculations

NDVI is a widely used vegetation index, which is calculated based on the ratio of the difference and the sum of the values of reflected energy in the near infrared (NIR) and red regions (RED) of the spectrum (Tucker 1979). The mathematical formula used for the calculation of NDVI is presented below (1). Healthy vegetation is characterized by a large difference, and therefore, this index can be used to detect the health of vegetation. NDVI values are typically presented as a range from 0 to +1. Values close to 0 can be classified as scarce vegetation, while rich and dense vegetation are closer to 1. For example, sandy, snowy or exposed rocky areas have NDVI values equal to 0.1 or less. Grassland, shrubland and steppe biomes have NDVI values ranging from approximately 0.2 to 0.5. Densely vegetated areas such as tropical rainforests or healthy crops at their peak stage have very high NDVI levels, ranging from 0.6 to 0.9. NDVI can help identify areas where the vegetation is experiencing stresses and assist in making better decisions in the long term aimed at increasing yields. Plots with different vegetation states or the volume of green biomass can be depicted in different colors. With the help of statistical processing of NDVI maps, in addition to determining the quantity of biomass, it is also possible to identify areas with higher agricultural productivity (Babar et al 2006). There are numerous factors that influence NDVI values such as precipitation, temperature, landscape characteristics, biomass composition, plant and soil moisture, photosynthetic activity. Such multi-dependency opens room for researchers and scientists to investigate correlation coefficients within some ecosystem parameters.

(1)

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

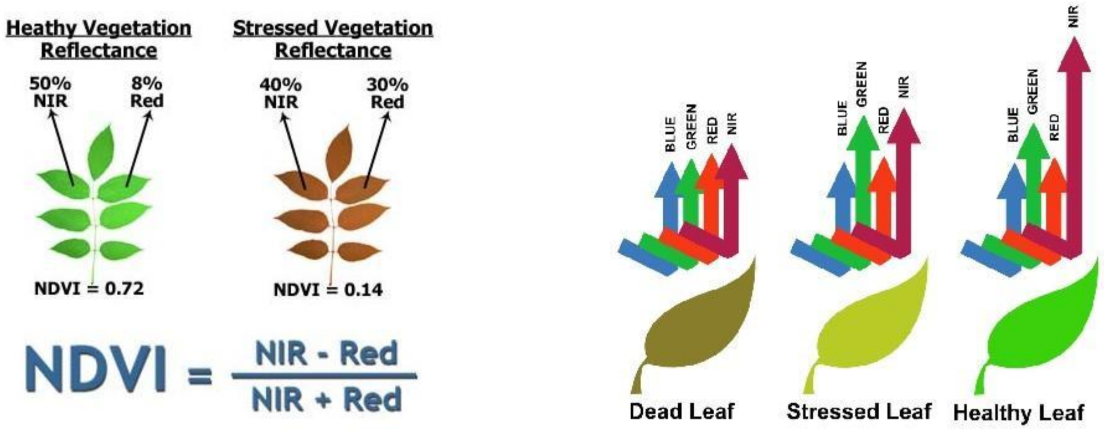


Figure 3: Representation of NDVI

For the analysis of NDVI and its correlation with biophysical parameters, precipitation and temperature data was obtained from the Kyrgyz National Meteorological and Hydrolgical Service (Kyrgyzhydromet). The data set included daily averages for both parameters from the automated weather station located in Suusamyr village and covered the period 2000-2018. For the analysis monthly averages and seasonal averages for spring and summer were produced.

Survey of pasture users

For the collection of qualitative data on the pasture use, pasture management practices and perceptions of shrub encroachment, we complemented the remote sensing analysis with semi-structured interviews with 34 pasture users in May 2019. The locations for the interviews were selected randomly, with the limitation that they were close to the Bishkek-

Osh road and the road to Kyzyl Oi which passes through the villages of Tunuk, Suusamyr, Birinchi May and Kojomkul). The majority of the respondents were men who were responsible for livestock. The respondents were selected on the basis of their involvement in animal husbandry and knowledge and experience with livestock. The interviews were carried out in 14 different locations in the valley and not more than 2-4 people per site were interviewed. This was done to ensure heterogeneity of the data obtained.

Discussion of findings

Initial analysis of NDVI for different years indicated that the highest values for NDVI are registered in July. An example of the vegetation dynamics for 2017 is shown in the figure below. Time series analysis of NDVI demonstrates gradual NDVI growth from March through July and a subsequent decrease in August (NDVI_MIN 0.05 for March; NDVI_MAX 0.82 in July).

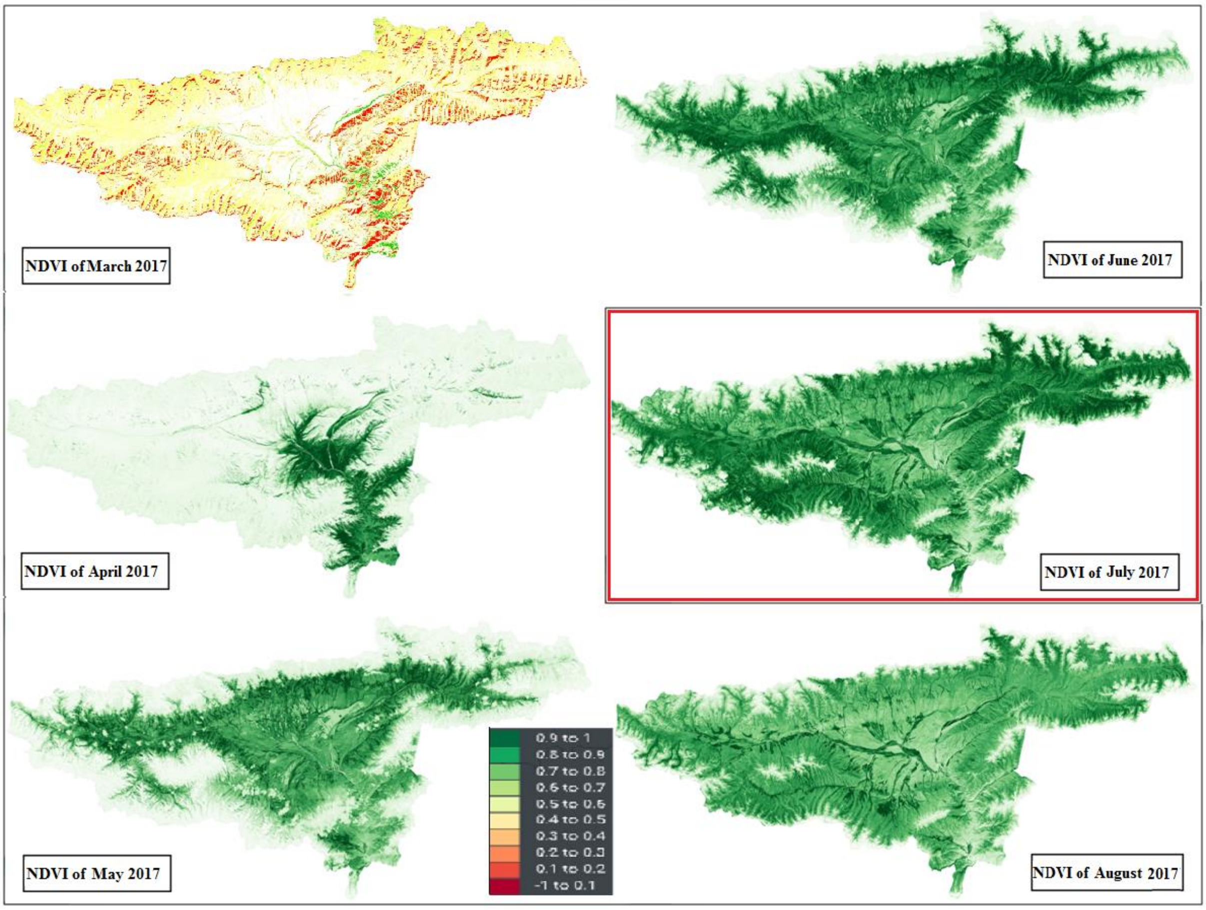


Figure 4: Map of NDVI values for spring and summer months of 2017

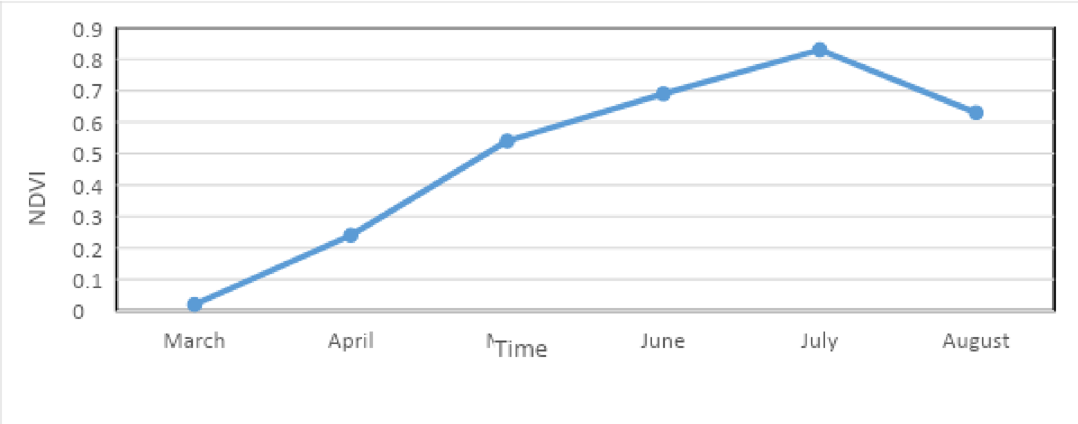


Figure 5: March-August NDVI distribution plot

Average spring and summer precipitation levels for the period 2000-2018 are presented in the figures below. Average precipitation ranges between 0 and 110 mm in spring and between 10 and 73 mm in summer. Average temperature during the period varied within the range between -2C to +4C in spring, and between +11C and +14C in summer.

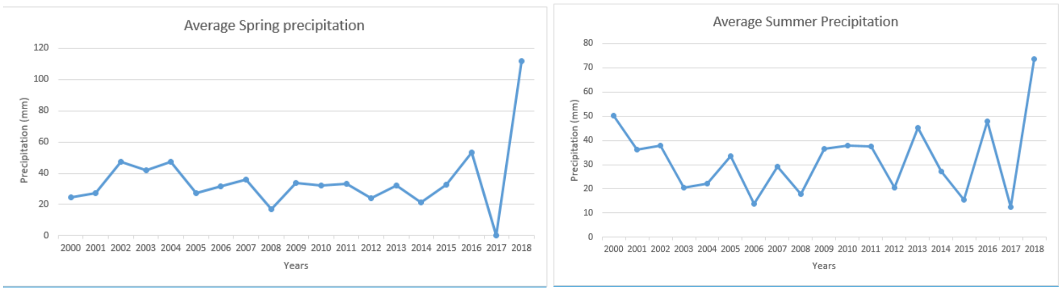


Figure 6: Average spring (left) and summer (right) precipitation in Suusamyr for 2000-2018

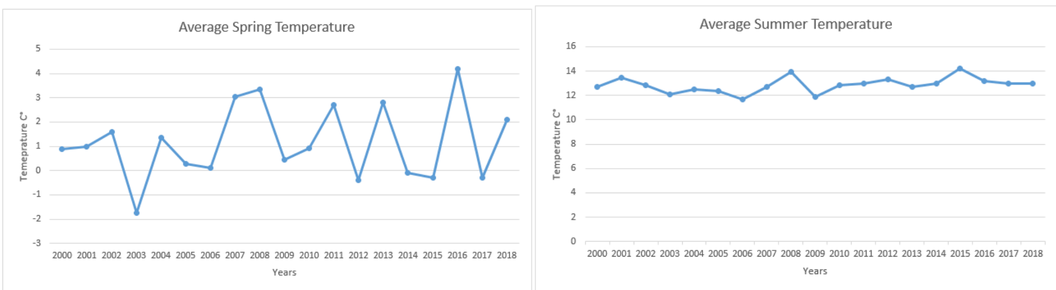


Figure 7: Average spring (left) and summer (right) temperature in Suusamyr for 2000-2018

NDVI time series for the period 2000-2018 is presented in the figure below. Variation is in the range 0.72-0.85. Notable is the gradual positive increase in NDVI over the last 10 years with stable NDVI values ranging around 0.83 to 0.84 during the last five years. Drops in NDVI values were identified for the years 2001, 2006-2007 and 2012-2013 with NDVI_MIN for the period in 2001. During the period NDVI averaged at around 0.79, which indicates healthy vegetation and biomass productivity. Over the 18 year period NDVI suggests an overall positive trend which could be representative of the growth of the shrub.

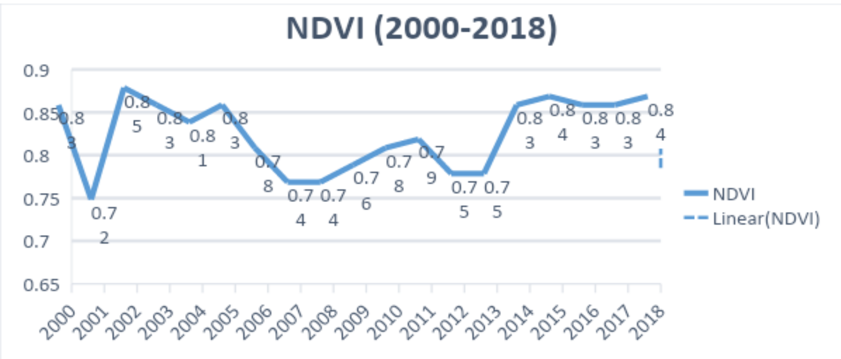
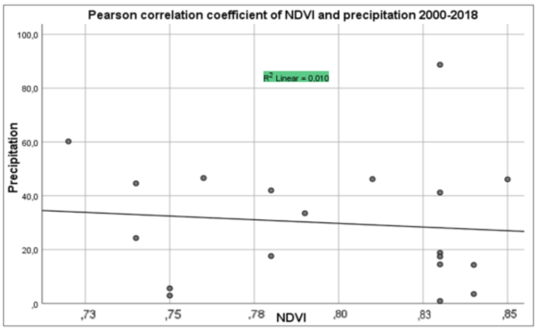
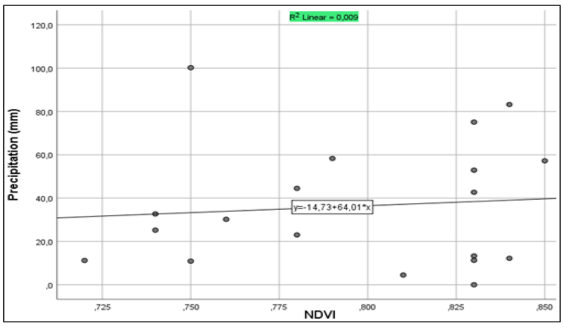


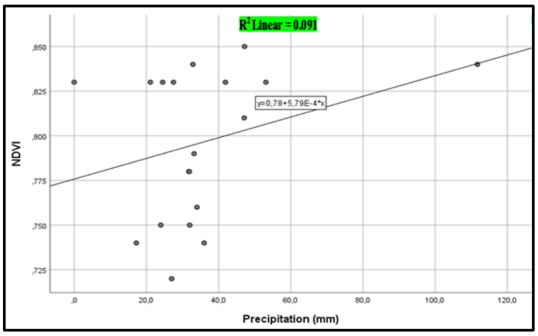
Figure 8: Time series plot of NDVI values over 2000-2018 period

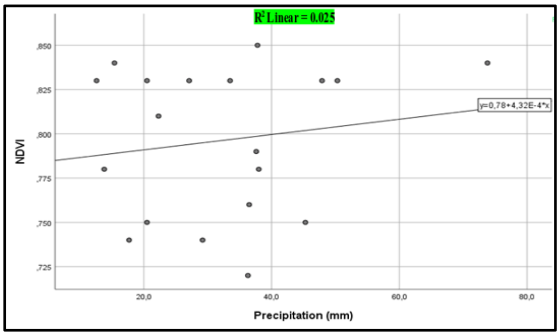
Bivariate Pearson correlation was conducted between NDVI and precipitation and NDVI and temperature over period of 2000-2018. The respective averages used for the calculation were annual, spring, summer and monthly for the month of June. Correlation between NDVI and both temperature and precipitation was found to be low and insignificant. The lowest value is -0.2 and the highest value is 0.3 and the mean is 0.05. P values ranged between 0.21 to 0.771. The low correlation suggests that precipitation and temperature might not be the only factors influencing biomass productivity. Considering the high number of rivers crossing the valley, it could be suggested that a stable supply of surface and groundwater is playing a role in the development of biomass in the area.





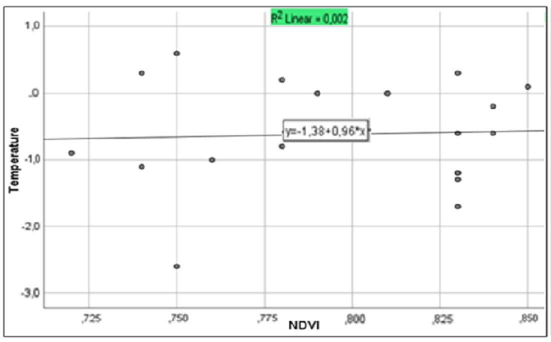
March-August average June

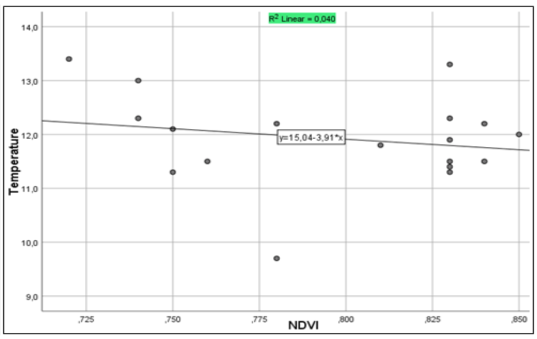




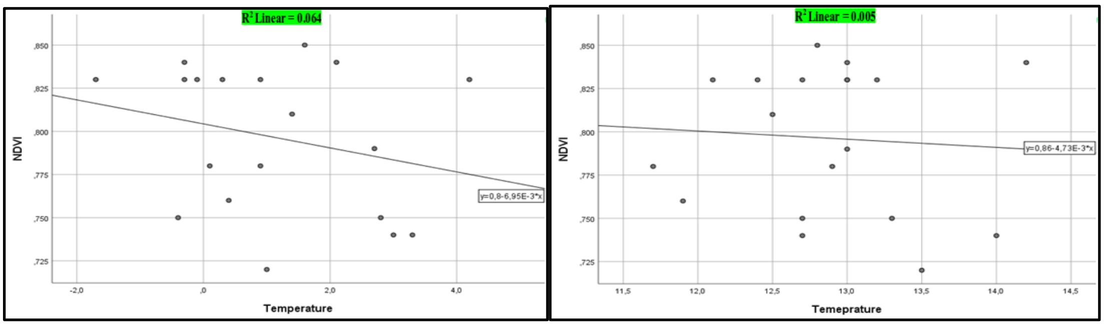
Spring Summer

Figure 9: Correlation between NDVI and precipitation averages for 2000-2018





March-August June



Spring Summer

Figure 10: Correlation between NDVI and temperature averages for 2000-2018

Land cover classification was performed according to the nine specified categories of land use. An accuracy assessment with ground data and locations of Altygana. Results of the land classification with images from July and late August/early September for the years 2000, 2010, 2018 are presented below:

Table 4: Areas by land use category in Suusamyr for July

№	Categories	Landsat 7 (7.07.2000)	Landsat 5 (27.07.2010)	Landsat 8 (1.07.2018)
		(ha)	(ha)	(ha)
1	Arable land	34594,56	32544,09	58559,85
2	Water bodies	37141,74	23417,64	18423,18
3	Rocks	43544,16	63466,2	74996,55
4	Pasture	87425,64	176479,74	258868,17
5	Shrubs	15377,58	19438,74	23272,92
6	Glaciers	73181,61	31910,4	16829,73
7	Forest land	52361,64	11416,14	4836,87
8	Settlement	78644,25	22029,12	18143,28
9	Roads	55663,2	97385,85	3863,16
	Total	477934,38	478088	477794

Table 5: Areas by land use category in Suusamyr for August/September

№	Categories	Landsat 7 (24.08.2000)	Landsat 5 (28.08.2010)	Landsat 8 (3.09.2018)
		(ha)	(ha)	(ha)
1	Arable land	38097,63	135756,36	24811,92
2	Water bodies	21231	23748,84	12736,44
3	Rocks	90299,25	58919,94	71479,53
4	Pasture	196297,74	150766,92	247295,25
5	Shrubs	13450,23	18048,24	23252,76
6	Glaciers	25380,72	10451,79	6945,03
7	Forest land	16009,65	8039,79	2491,29
8	Settlement	9838,08	48666,24	81264,78
9	Roads	67185,45	23689,8	7512,75
	Total	477789,75	478088	477790

The table below shows the area changes between the years.

Table 6: Comparison of area changes between the years

№	Categories	Area change for July		Area change for August/September	
		2000-2010 (ha)	2010-2018 (ha)	2000-2010 (ha)	2010-2018 (ha)
1	Arable land	-2050,47	26016	97659	-110944
2	Water bodies	-13724,1	-4994	2518	-11012
3	Rocks	19922,04	11530	-31379	12560

4	Pasture	89054,1	82388	-45531	96528
5	Shrubs	4061,16	3834	4598	5205
6	Glaciers	-41271,21	-15081	-14929	-3507
7	Forest land	-40945,5	-6579	-7970	-5549
8	Settlement	-56615,13	-3886	38828	32599
9	Roads	41722,65	-93523	-43496	-16177

Table 7: Accuracy assessment

№	Image source	Accuracy (%)
1	Landsat 7 (7.07.2000)	70,9
2	Landsat 5 (27.07.2010)	72,1
3	Landsat 8 (1.07.2018)	73,5
4	Landsat 7 (24.08.2000)	62,3
5	Landsat 5 (28.08.2010)	65,5
6	Landsat 8 (3.09.2018)	77,8

Of all above performed analyzes, it was shown that the classification of the satellite image with Landsat 8 (3.09.2018) has the maximum accuracy, which is 77.8%. It needs to be pointed out that the category shrubs does not distinguish between different types of shrub. It is therefore not possible to ascertain the area covered by Altygana. It is however possible to establish that the area taken up by shrubs has been increasing over time 26% between 2000 and 2010 and 19% between 2010 and 2018. As Altygana is the dominant shrub type in the valley it can also be suggested that its area has increased in that period. These findings are in accordance with estimates of UNDP (2008) for the period 1999-2008 for Altygana.

The analysis of the interviews with herders suggests fit with the results of the remote sensing results. 67% of respondents perceive that the pastures in Suusamyr are in poorer condition now compared to a few years ago, giving the encroachment of Altygana as one of the main indicators for the deterioration. Another indicator of degradation identified by the respondents was overgrazing by increased numbers of livestock.

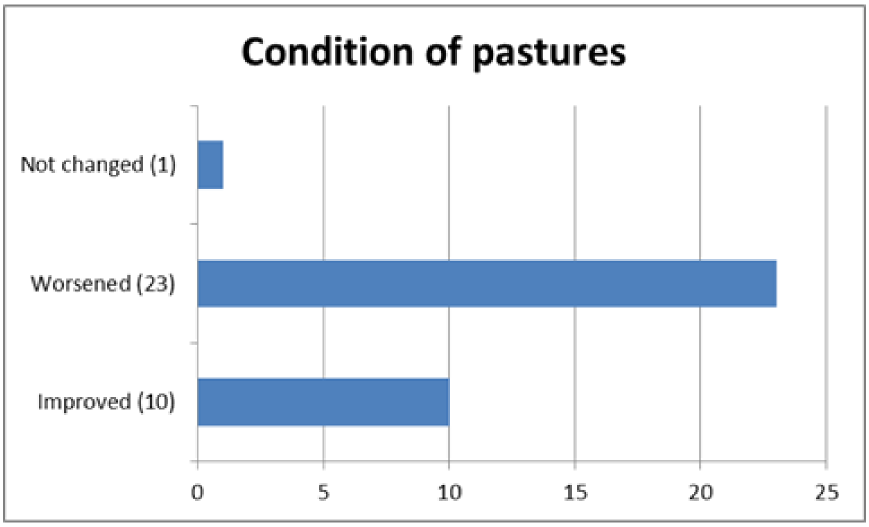


Figure 11: Respondents' perceptions of current condition of Suusamyr pastures

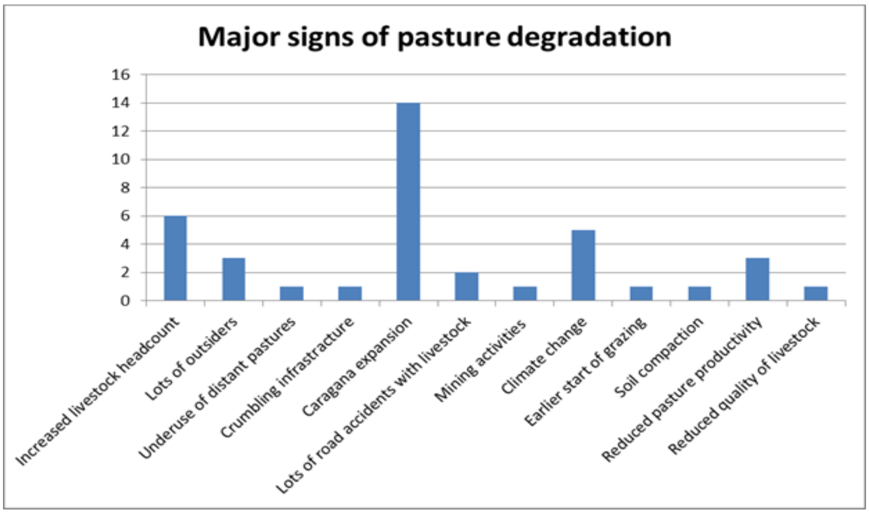


Figure 12: Major signs of pasture degradation mentioned by respondents

In an attempt to combat the spread of the Altygana shrub, with the support of UNDP, a project was initiated by the Kyrgyz National Institute for Livestock and Pastures to test chemical methods. Treatment with two herbicides, Garlon and Glyphosate, was carried out in test plots of 1000 m2 and 1500m2 respectively. The test was used to estimate the effect of different doses of the herbicides on Altygana and grasses. Garlon provded to be more effective at eliminating Altygana. Another method of combaring Altygana is mechanically. However due to the costs this is not practiced. According to the Department of Pastures under the Ministry of Agriculture, there is currently no effective methods to control the shrub. During the Soviet time, the shrubs were mainly treated with a 2-4 D brand herbicide. Some of the interviewed pasture users, believe that Altygana is listed in the Red Book of Kyrgyzstan, and this is what is preventing them to combat the shrub.

The findings of our research confirm the hypothesis that Altygana is expanding and thereby taking up land that is used by livestock. It was beyond the scope of this research to assess the ecological value of the shrub, however with increasing livestock numbers and interest by herders to use more intensively the pasture area, the question arises about what should be done with the shrub encroachment. In any case, plans for dealing with the shrub should be informed by comprehensive assessment of its ecological value. If deemed appropriate, strategies for combating with the shrub should be designed in a way that has no negative impact on the environment, animals or humans using the ecological services provided by the valley.

Conclusion

Our analysis in Suusamyr valley has demonstrated an increase in pasture productivity in recent years. During the period 2000-2018, NDVI averaged at around 0.79, which indicates healthy vegetation and biomass productivity. Over the 18 year period NDVI suggests an overall positive trend which could be representative of the growth of the shrub which could enhance the overall vegetation growth in the valley.

Analysis of spatial distribution of Caragana Aurantica Koehne over the last 18 years also clearly indicated that the area covered by the shrub has been increasing. Our estimate is that the area has increased by 9,802 ha in the period from 2000 till 2018. These developments correspond with findings from interviews with pasture users. For the development of strategies on pasture management, further research is necessary. Some of the areas that have been identified are on the ecological value of the shrub as well as on more benign approaches for containing the expansion of the shrub.

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