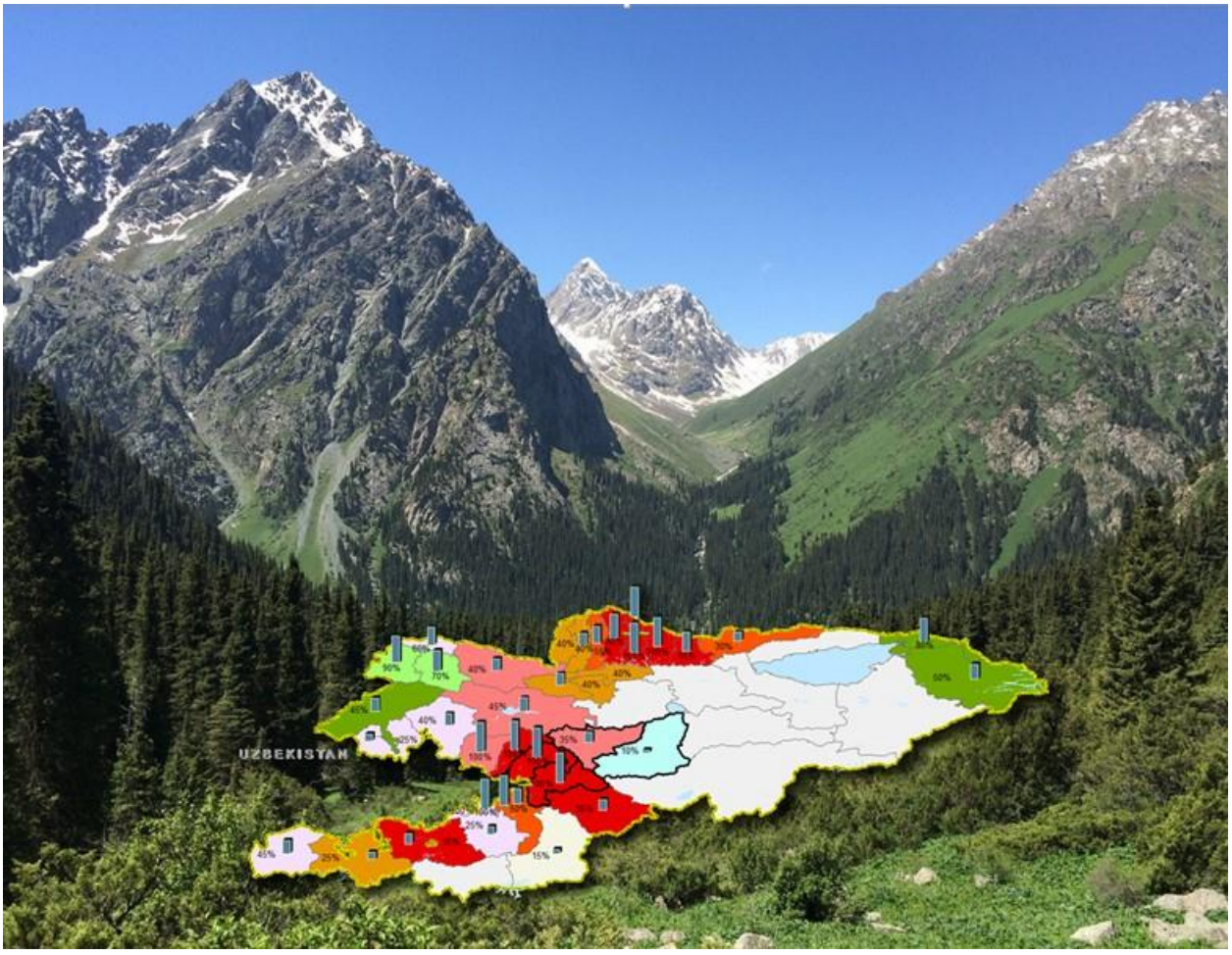
GCF/FAO Project Proposal:

"Carbon Sequestration through Climate Investment in Forests and Rangelands (CS-FOR)"

The Kyrgyz Republic

BASELINE ATLAS

Report



FAO

2018

INDEX

1. INTRODUCTION

This report describes the content of the baseline Atlas of Climatic, Topographic, Land Use and Population Resources in Kyrgyzstan, which is the result of collecting information, maps and statistics on national and sub-national resources in Kyrgyzstan, focusing the analysis on 4 *Rayons* (districts) identified as target areas for the proposing Green Climate Fund project: "Carbon Sequestration through Climate Investment in Forests and Rangelands".

The ATLAS aims at depicting, based on historical data, current conditions and future trends of natural and anthropic resources, which will be the basis for the assessment of the level of impact of the changing climate, likelihood to occur, and capacity to cope with it by the communities, in order to identify vulnerabilities and assess risks. Such analysis will be used to develop mitigation and/or adaptation strategies and propose related actions.

This report is structured similarly to the structure of the ATLAS, with a national overview that anticipates the detailed descriptions of the core target area and then the priority expansion area. Two additional sections describe the models and the results of specific analysis performed on pastures and forests of the core target area.

2. NATIONAL OVERVIEW

2.1 Demography

The Kyrgyz Republic covers an area of 199,900[1] km^2 with a population of 5.835 million in habitants (2014), 1.7 % increase per year (2010-2014). The national average population density is 29 inhabitants/km^2, with an urban population of 35.7%, of which more than 40% concentrated in the capital city, Bishkek.

The territory of Kyrgyzstan is organized[2] in 7 *Oblasts* plus municipalities of Bishkek and Osh; 40 *Rayons* plus 12 cities of oblast significance and 11 cities of rayon significance; 440 *Ayil* and 19 township councils (average municipal size: 12 712 inhabitants).

Oblast/City	Area (km²)	Population	Pop density (km²)	Capital
Batken	16,607	382,426	23.0	Batken
City of Bishkek	215	762,308	3,539.4	Bishkek
Chüy	19,795	770,811	38.9	Tokmok
Jalal-Abad	33,480	869,259	26.0	Jalal-Abad
Naryn	45,334	249,115	5.5	Naryn
Osh	29,354	1,175,998	40.1	Osh
Talas	11,434	199,872	17.5	Talas
Ysyk-Köl	43,022	413,149	9.6	Karakol

Table 1: Oblasts of Kyrgyzstan[3]

[1] *Source: World Bank Development Indicators, UNDP - HDI, ILO*
[2] *Source: IMF-GFS, October 2016*
[3] *Source: FAO Global Administrative Unit (GAUL)*

Most of the populated places are located on nearly flat areas (slopes less than 5°) or foothills at low altitude, making them at risk of climatic hazards such as landslides, mudflows, flooding etc.

Figure 1: Map of settlements over slopes 0-5 deg (green) and 5-15deg (yellow). FAO

2.2 Topography

The Kyrgyz Republic is one of the most mountainous countries in the world**.** It is landlocked with many tall peaks, glaciers, and high-altitude lakes. 94% of the surface of Kyrgyzstan lies at an elevation exceeding 1,000 m above sea level, 41 % at an elevation exceeding 3,000 m above sea level, and the average elevation is 2,750 m above sea level[4]. Mountains in the central part of the country effectively isolate the northern and southern populations of Kyrgyzstan, especially in the winter, when snow closes many of the roads.

[4] *Source: http://www.geominprojects.com/5-kyrgyzstan.html?jazyk=en#pohori*

Figure 2: Elevation[5] Map

The Pamir with its highest peak, Pik Lenina (7,134 m a.s.l.), straddles the south-eastern border of the country with Tadzhikistan. The large Pamir-Alay mountain range runs along the southern and south-western border of the country. It consists of the Alay range to the east and the Turkestani, Zeravshany and Hisar ranges to the west. The ranges reach altitudes of 4,000 – 5,000 m above sea level, the highest peak being Pik Skalistyi (5,621 m a.s.l.). Glaciers are found in all the mountain ranges at elevations around 4,500 m above sea level and higher.

The northern and central parts of the country are occupied by the mountain ranges of the Tien Shan. As far as the extent of glaciation is concerned, the most important ranges are the Kyrgyz Ala-Too to the west (Pik Semyonova Tian-Shanskeho 4,855 m a.s.l., south of the capital Bishkek), the Kungey Ala-Too located north of lake Issyk Kul, the Terskey Ala-Too south of the lake (Pik Karakol 5,280 m a.s.l.) and the Kakshal Tau range running along the border with the People's Republic of China with the Pik Pobeda marking the highest point at 7,439 m above sea level.

Altogether, 8,208 glaciers covering a total area of 8,169.4 km^2 are registered in Kyrgyzstan, which is approximately 4.2 % of the total territory of the country.

2.3 Natural Conditions and Land Cover, Land Use

The natural conditions[6] of Kyrgyzstan are the product of the local climate, the altitude above sea level and the position with respect to mountain massifs and to Lake Issyl-Kul. The north of Kyrgyzstan (portion of Chu valley) is part of the northern desert eco-system of Central Asia. Here, the deserts pass into semi-desert and arid steppe. In the area of the city of Bishkek and in the central axis of the valley formed by the Chu River, the land is intensely irrigated for the cultivation of corn, sugar cane, water melons and vegetables.

As of 1ST January, 2015, the total area of agricultural lands was 10,625,200 hectares (53% of total land reserves), listed under various land categories including croplands, perennial plantations, deposits, hay fields, pastures, tree and shrubbery plantings, marshes, forest lands and others. The largest share (85 %) of agricultural lands is comprised of pastures, which is constantly decreasing, and croplands (irrigated and non-irrigated) for a 12.1% of all agricultural lands[7].

At higher altitudes, the Tien-Shan foothills form an arid steppe eco-system. Higher precipitation gives rise to a thick grass cover with shrubs growing in river valleys. This vegetation zone is used as pasture for grazing herds of cattle and horses.

[5] *Source: ASTER Global Digital Elevation Model (GDEM)*
[6] *Source: http://www.geominprojects.com/5-kyrgyzstan.html?jazyk=en#pohori*
[7] *Source: IOM International Organization for Migration*

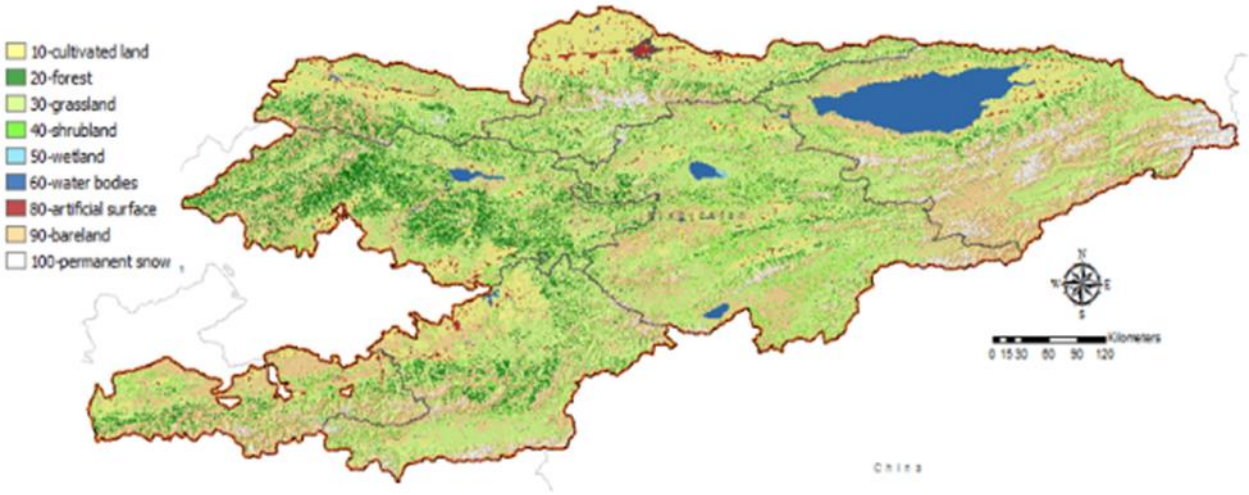


Figure 3: Land Cover Map 2010[8]

The contrasting eco-systems of coniferous woods and alpine meadows are found in the Tian-Shan at altitudes exceeding 1,700 m above sea level. At altitudes of 2,500 – 3,500 m above sea level there are exceptionally rich sub-alpine and alpine meadows with hundreds of alpine species flowering during the early summer months.

The Kyrgyz Republic is covered by **forested areas** for only 4-5% of the total land area. These forests are, however, rich in biodiversity and perform important environmental roles. On the slopes of the Fergana and Chatkal Mountain ridges of the Tien Shan mountain system grow *natural walnut–fruit forests*, considered unique in the world. This area have a vast diversity of tree and shrub species including walnut, apple, pear, plum, almond, and pistachio. *Almonds and pistachios* occupy the lower slope areas.

According to an article on forest cover mapping in post-Soviet Central Asia (May 2017)[9], the composition of land area covered by forests and forest types among different Countries in Central Asia shows the following:

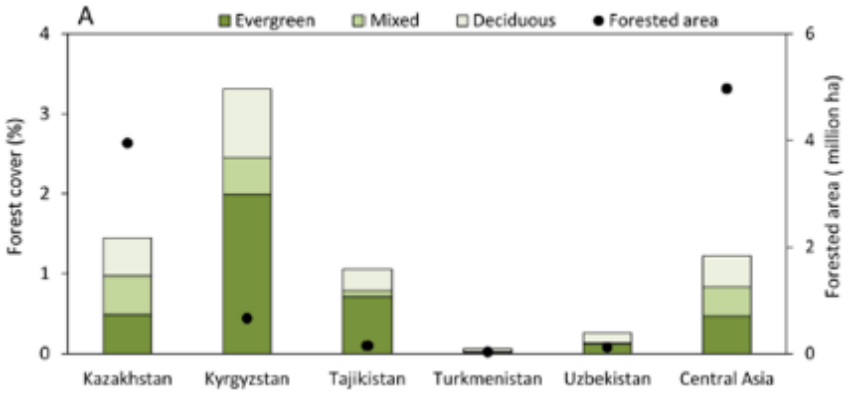


Figure 4: Land area covered by forests (A) and the composition of forest types (B)

Kyrgyzstan as the Country with the highest % of forest cover, of which the evergreen type is the most represented compared to other types of forest.

[8] *Source: GlobeLand30*
[9] *Source: https://www.nature.com/articles/s41598-017-01582-x.pdf*

According to the latest global forest change 2016 database[10], the overall forested area in Kyrgyzstan (tree cover more than 10%) is 1,076,800 ha (estimation year 2000), with a net loss of about 260 ha up to 2016. The largest forested area is concentrated in Jalal-Abad oblast:

Figure 5: Distribution of tree cover > 10% by Oblast

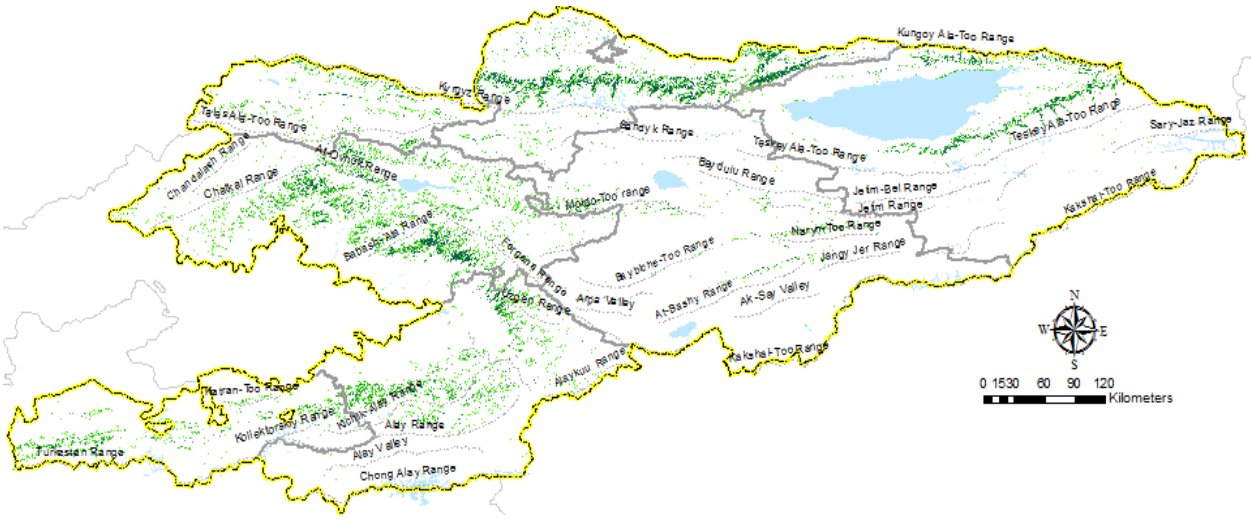


Figure 6: Map of forests (tree cover > 10%)

The forests in Kyrgyzstan can be classified in four types: the **Spruce Forests** in the north and north-east, mostly in Issyk-Kul, Naryn oblasts and in Kemin rayon of Chuy oblast, as well as in the high areas of the Fergana Valley; the **Walnut Forests** in the north and north-east of the Fergana valley (south-west of the country), mostly at the lower mountain slopes (mostly ranging from 11 to 35 degrees; about 58 percent of the walnut trees grow on northern facing slopes) with an altitude of roughly from 1,300 to 1,800 meters above sea level; the **Juniper Forests** in the south and the **Riverside (riparian) Forests**. Being located mainly in the mountains, these forests are of particular interest for biodiversity conservation and rural development.

[10] *Source: Global Forest Change 2000–2016 (Hansen, https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.4.html)*

According to the 2008 Forest Typology publication[11], the distribution of forests in Kyrgyzstan (ha) is the following: shrubs 470,900, Juniper 503,600, Spruce/fir 149,400, Other Broadleaved except walnut and pistachio 162,600, Walnut 47,000 and Pistachio 57,600.

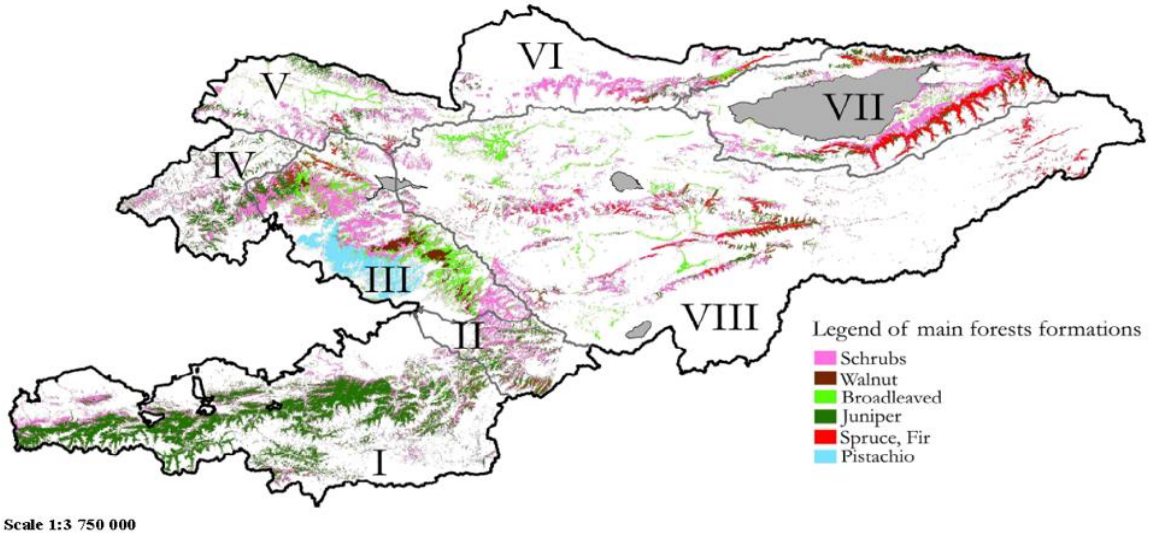


Figure 7: Map main forest formations in Kyrgyzstan

The **walnut forests** occupy the northern and north-eastern slopes of the Fergana valley. The formation of certain forests depend on site conditions: the walnut forest stands use the most favorable habitats, i.e. the sites with the most moistened and fertile soils; in areas with severe conditions (dry soils of poor fertility) there grow shrubs and partly hawthorn and juniper stands, in the better forest growth conditions – maple forests.

The **juniper forests** occupy large tracts representing zones of coniferous tree vegetation. They are located mainly on steep slopes and have a very important ecological role. They grow under arid conditions or in very high altitudes up to 3,500 m a.s.l. in the very south of the country and dispersed over the country. These forests are typically open stands, formed by tree and crawling forms of Juniper.

The **Spruce forest o**ccur in the west, in the center of the country and in the higher parts of the ranges north of the Fergana valley, mainly in altitudes between 1,700 and 3,000 m a.s.l. Small areas of stands with the endemic species can be found in the very west of the country. In the area of their distribution, the spruce forests grow on the slopes in a mosaic-like pattern. The spruce trees are grouped in strips and small arrays interspersed with glades, debris, and rocks. The spruce forest stands occupy, mainly, the slopes of the northern expositions (shadowed), while on the sunny slopes they grow only when there is additional moisture supply resulting from the condensation of moisture received from the nearby rocks.

2.4 Protected areas in Kyrgyzstan

Kyrgyzstan has a relatively well-established system of **protected areas**[12]. Altogether they cover 13,403 km^2, which is about 6.7% of the country's total area (2018). They include 29 national designations (1

11 Source: 2008 Grisa E. Forest typology in the Kyrgyz Republic (http://msri-hub.ucentralasia.org/node/4483)

[12] UNEP-WCMC (2018). Protected Area Profile for Kyrgyzstan from the World Database of Protected Areas, February 2018. www.protectedplanet.net/country/KGZ

national park, 4 nature parks, 15 wildlife refuge, 7 state nature reserves) and 6 international designations (2 UNESCO-MAB Biosphere reserves, 1 world heritage site, and 3 Ramsar/wetland sites). Lake Issyk-Kul is included in the list of world famous wetlands (Ramsar Convention on Wetlands).

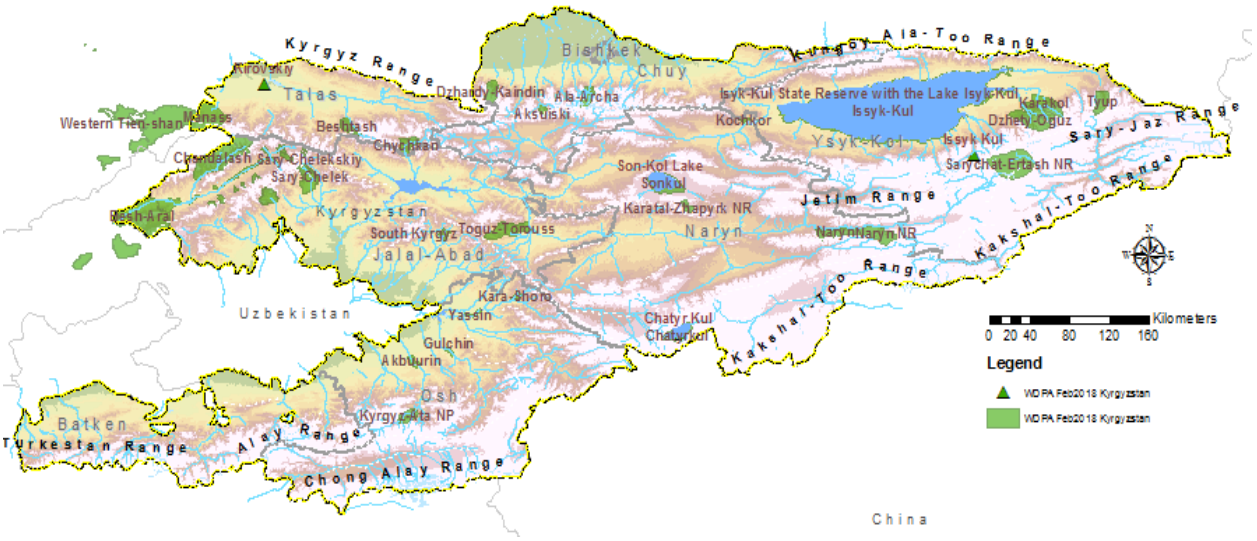


Figure 8: Map of World Protected Areas 2018. FAO

2.5 Climate

Kyrgyzstan lies in a zone of dry continental climate. However, a number of regions with their own microclimate occur in Kyrgyzstan. These are governed by altitude and their position relative to the larger climatic zones.

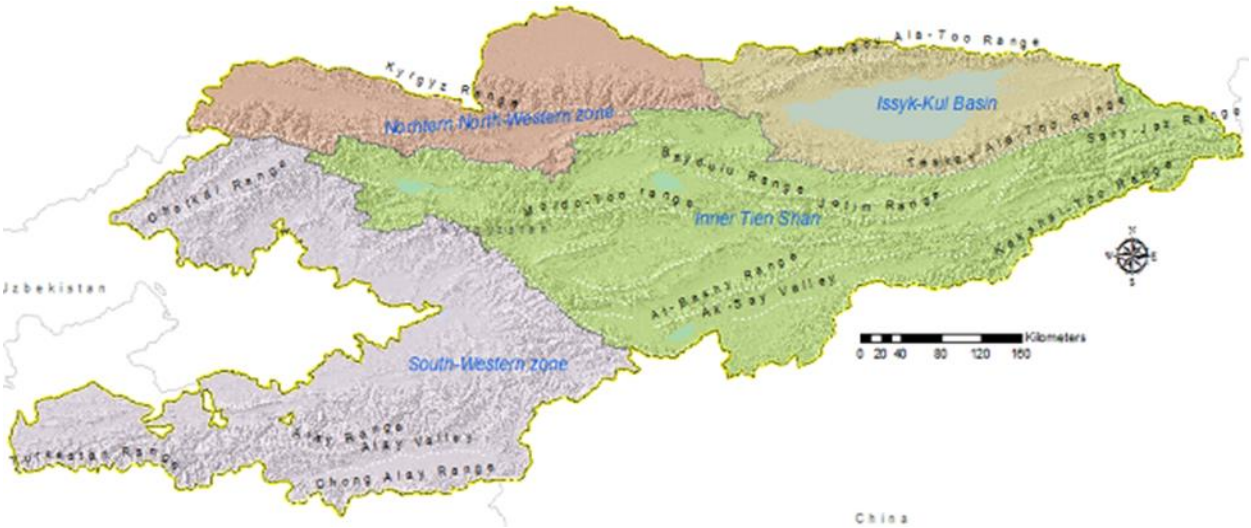


Figure 9: Map of Climatic Zones

1. **Northern- north-western:** it includes the Chui, Talas and Kemin valleys**.** They are surrounded by the Talas, Kyrgyz and Cho-Kemin mountain ranges. It has a relatively humid climate with mean annual temperature between 5 – 10◦C, minimum -10 to -5◦C and maximum around 35◦C. Precipitation in the northern part of the Chui valley averages around 370 mm a year, whereas in the upper part of the valley precipitation increases to 425 – 500 mm up to 1 000 mm/year.
2. **South-western**: i.e. it includes margins of the broad Fergana valley, the Chatkal and Alai valleys and the adjacent mountain ranges. Relative to other climatic zones, this is the warmest and most humid with maximum rainfall in winter.
3. **North-eastern**: it includes Lake Issyk Kul and the Kungey Ala-Too and Terskey Ala-Too mountain ranges. This zone is evidently affected by the lake that lies at an altitude of 1 609 m above sea level and does not freeze during the winter. The lake therefore has a stabilizing influence on the local climate.
4. **Inner Tien-Shan.** Closed climatic zone bounded by adjacent mountain ranges. It is characterized by low precipitation, and a marked continental climate with distinctive local contrasts

Precipitations

The annual distribution of precipitations[13] in Kyrgyzstan shows an inter-annual variability with a trend of increase according to historical data of the last 35 years.

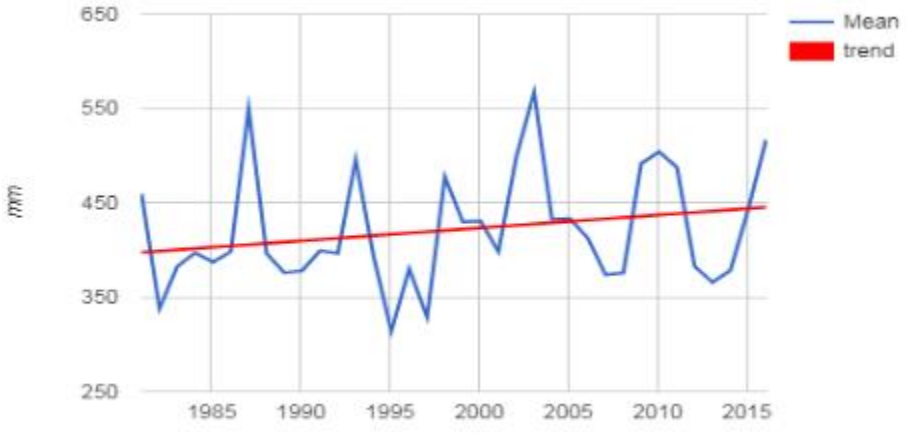


Figure 10: Rainfall distribution 1981-2016

Temperature

Mean annual max temperatures distribution[14] shows also a trend to a slight increase:

[13] *Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)*
[14] *Source: European Centre for Medium-Range Weather Forecast (ECMWF)*

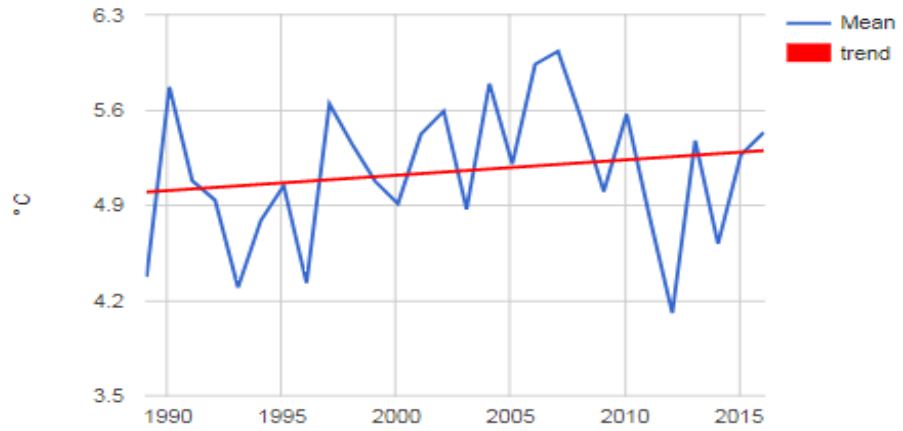


Figure 11: Max temperature distribution 1989-2016

Mean annual min temperatures distribution[15] shows as well a trend to a slight increase, with a lower inter-annual variability:

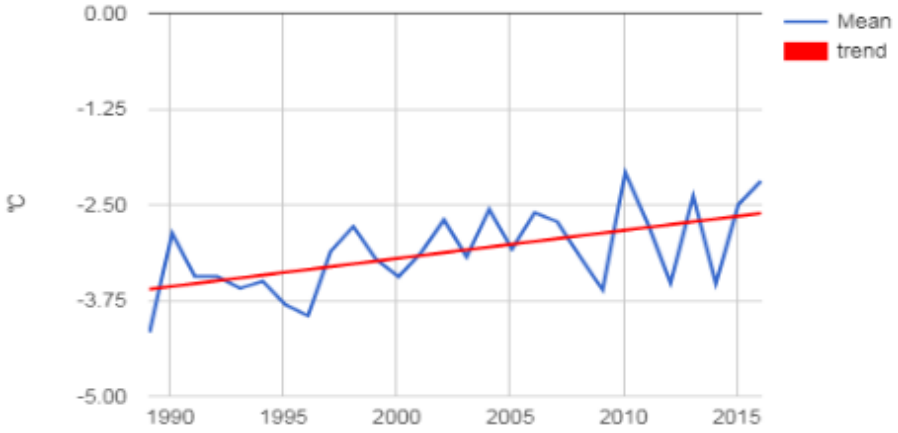


Figure 12: Min temperature distribution 1989-2016

Potential Evapotranspiration

Potential evapotranspiration is defined as the amount of evaporation that would occur if a sufficient water source were available. If the actual evapotranspiration is considered the net result of atmospheric demand for moisture from a surface and the ability of the surface to supply moisture, then PET is a measure of the demand side. Surface and air temperatures, insolation, and wind all affect PET. A dryland is a place where annual potential evaporation exceeds annual precipitation. PET time series derived from remote sensing[16] for Kyrgyzstan shows an extreme inter-annual variability, but an overall steady trend.

[15] *Source: European Centre for Medium-Range Weather Forecast (ECMWF)*
[16] *Source: MOD16A2 MODIS/Terra Net Evapotranspiration 8-Day L4 Global*

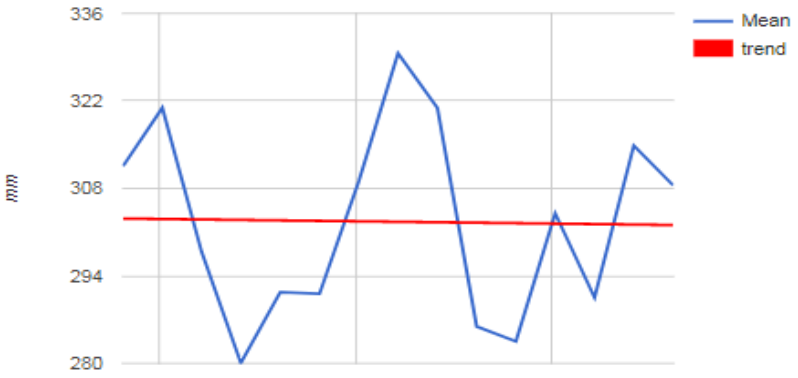


Figure 13: Potential evapotranspiration 2000-2014

Altitudinal zonation

The **valley-sub-mountain zone** (from 900-1,200 m) experiences hot summers, snowless and temperate winters, and low precipitation.

The **mountain zone** (from 900–1,200 to 2,000–2,200 m) is characterized by a temperate climate, which has warm summers and cold, snowy winters.

The **high-mountain zone** (from 2,000–2,200 to 3,000–3,500 m) is cooler in the summer and has relatively cold, snowless winters, with temperatures ranging from well below zero to 16 °C.

The **nival belt zone** (from 3,500 m and higher), covered in snow throughout most of the year, has a polar climate and is covered by numerous snowfields and glaciers.

2.6 Hazards

Kyrgyzstan is frequently affected by various types of hazards, mostly triggered by climate, but also not climate related such as earthquakes. Three-quarters of the population reside at the foothills of mountain slopes or along flood basins of rivers, which makes settlements particularly vulnerable to climatic and man-made hazards. The most destructive hazardous natural processes and phenomena that inflict significant damage to the population and the economy include earthquakes, mudflows, floods, landslides, avalanches, heavy rains, floods, salinization of soils, rise of groundwater levels and others[17].

Of all natural hazards taking place in Kyrgyzstan, earthquakes are the most dangerous. The map below of seismic hazards[18] shows the expansion of territories prone to earthquakes with indication of various intensities (7-9 and above) where three levels of seismic hazard prone areas are identified.

[17] *Environment, Climate Change and Migration in the Kyrgyz Republic. IOM, 2016*
[18] *The UN International Strategy for Disaster Reduction (UNISDR). In-depth Review of Disaster Risk Reduction in the Kyrgyz Republic. 2010.*

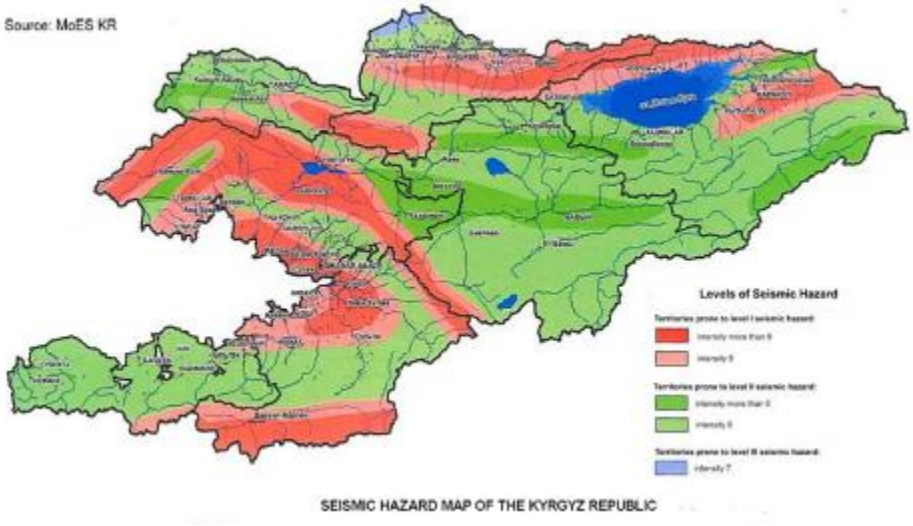


Figure 14: Map of seismic hazards

There are more than 5,000 active landslides on the territory of the Kyrgyz Republic, of which 3,500 are located in the southern regions. During the past decades, over 8.5 thousand residential homes were destroyed as the result of disasters caused by landslide processes. Here is the landslide hazard map[19] showing location and level of hazard.

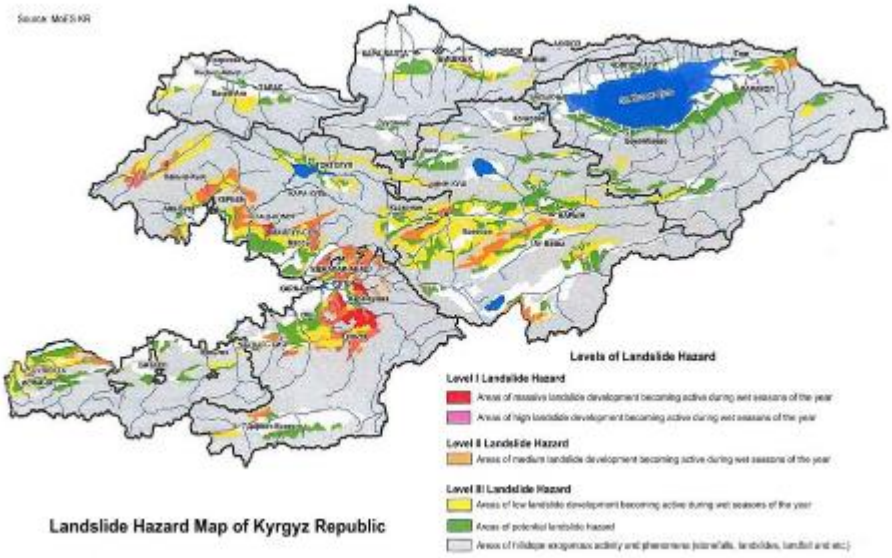


Figure 15: Landslides Hazard Map

In addition to landslides, avalanches occur frequently in the Kyrgyz Republic. More than one-half of the territory of the Republic is exposed to the avalanche hazard. The geomorphological structure of deeply cut mountain relief determines intensive avalanche activity in case of active precipitation and presence of a steady deep snow cover. This map shows areas at various degree of avalanche hazard with a gradation in terms of volumes, frequency of occurrence, and concentration density[20].

[19] *The UN International Strategy for Disaster Reduction (UNISDR). In-depth Review of Disaster Risk Reduction in the Kyrgyz Republic. 2010.*
[20] *The UN International Strategy for Disaster Reduction (UNISDR). In-depth Review of Disaster Risk Reduction in the Kyrgyz Republic. 2010.*

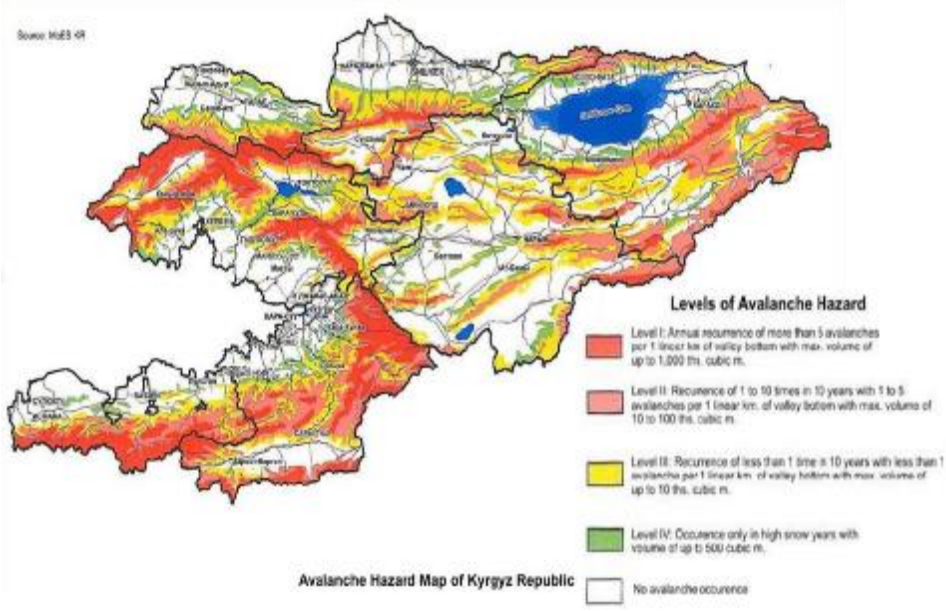


Figure 16: Avalanche Hazard Map

There are around 3,900 mudflow and flood prone river basins on the territory of the Kyrgyz Republic with the length of 10km and more. There are cases of mudflow registered in 1,153 settlements, which resulted in various damages. Also, there are around 2,000 high altitude lakes, of which 330 have unsustainable water dams and are included in the catalogue of water outburst prone lakes. During the hot season, due to melting of moraine and glacial dams, these lakes pose a risk of a catastrophic outburst of large volumes of water in the river basins. Here is the map of mudflow hazard forecast[21] with levels of hazards.

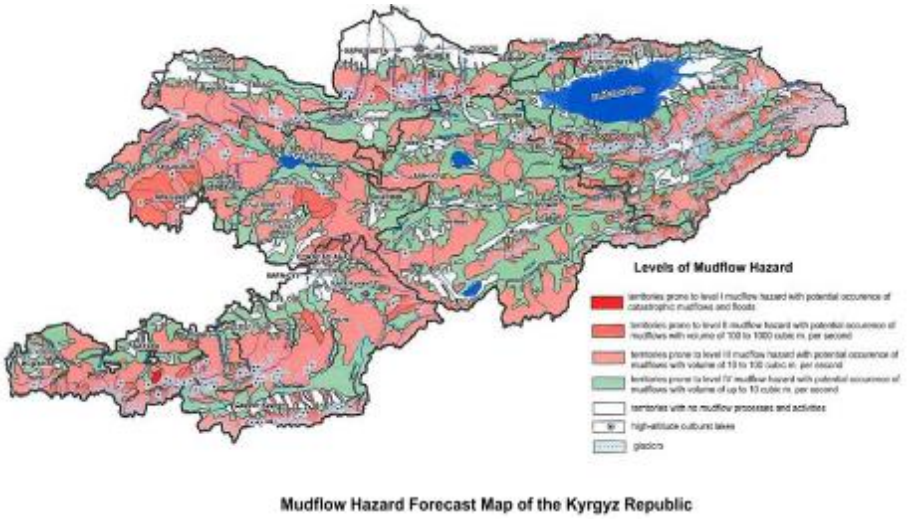


Figure 17: Mudflow Hazard Forecast Map

The flooding of territories due to the high standing of the groundwater level is one of the most widespread dangerous processes in the territory of Kyrgyzstan. Causes of flooding are natural factors caused by tectonic, geological-lithological, geomorphological, hydrological, climatic conditions and artificial, associated with human activities. Currently, the flooding processes cover mostly flat, most suitable and

[21] *The UN International Strategy for Disaster Reduction (UNISDR). In-depth Review of Disaster Risk Reduction in the Kyrgyz Republic. 2010.*

favorable regions for the residence and development of agriculture. Here is the groundwater flooding forecast map[22] with areas of potential under flooding of 0-3 m from the surface.

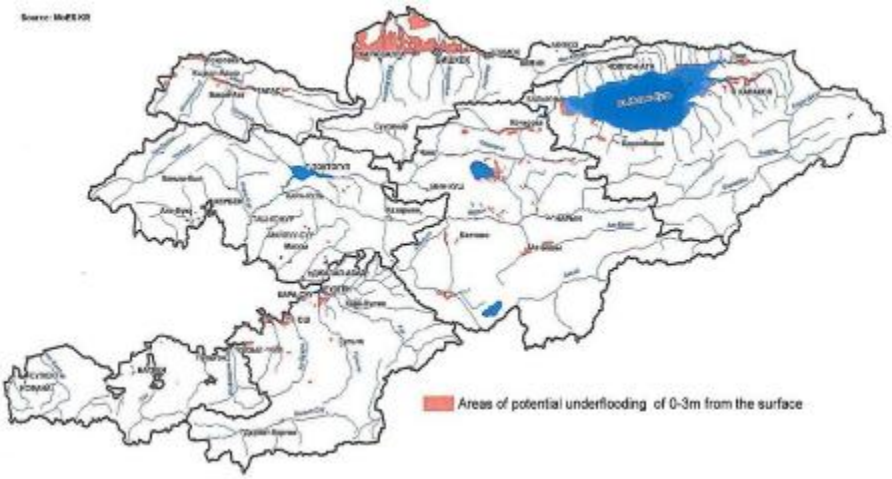
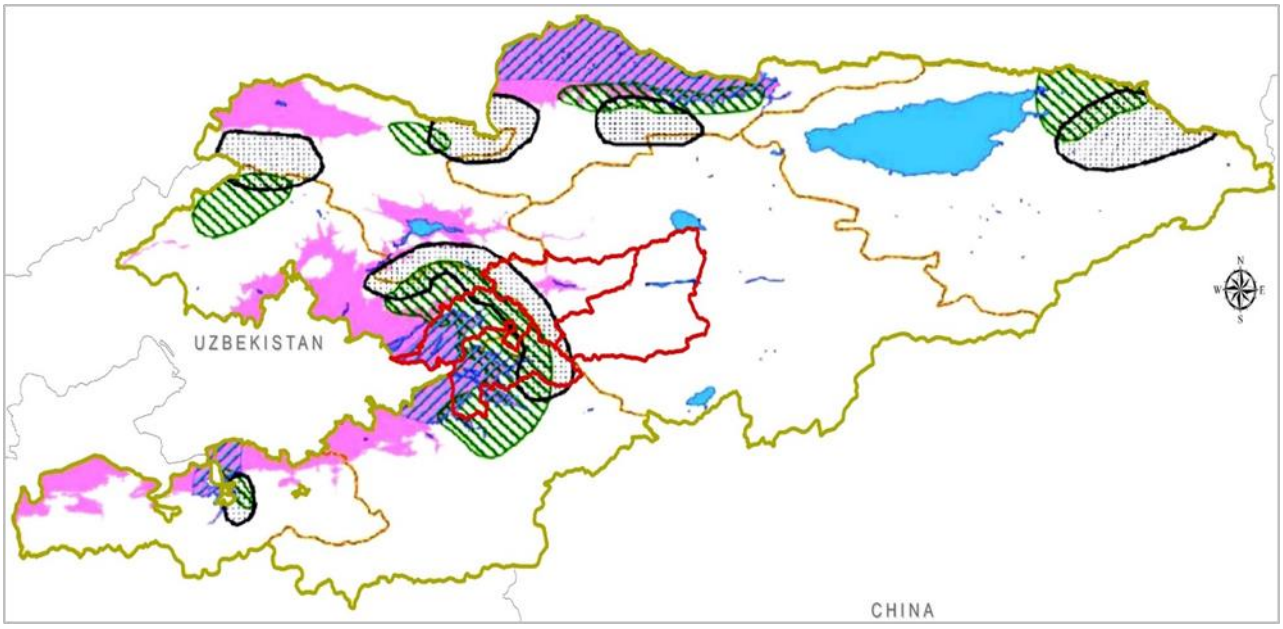


Figure 18: Groundwater Flooding Forecast Map

2.7 Project Priority Areas

Following the results of a study commissioned by IFAD[23] predicting the effects of climate change on the major climate related hazards affecting Kyrgyzstan, 4 rayons located in climate vulnerable areas (Oblasts of Naryn, Jalal-Abad and Osh in the Naryn river watershed) were selected as target for the implementation of this project. Then, additional 6 rayons were included in a "priority expansion area", located at the norther-west side of the Country.

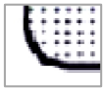


[22] *The UN International Strategy for Disaster Reduction (UNISDR). In-depth Review of Disaster Risk Reduction in the Kyrgyz Republic. 2010.*
[23] *Climate Change Impact on Pastures and Livestock Systems in Kyrgyzstan. Summary Report 2013*

Figure 19: Map of main hazards due to climate change

Mudslides related to more intense rainfall in the spring at medium altitudes (and in a lesser degree also high altitudes);

River floods and water logging in spring, due to more intense rainfall. This will mainly affect lower altitudes and areas susceptible to flooding;



Flush floods in the summer especially at higher altitudes, related to higher temperatures together with the increase in winter, spring and autumn rainfall (snow at higher altitudes);

Heat stress in the summer, especially at lower altitudes;

3. CORE TARGET AREA

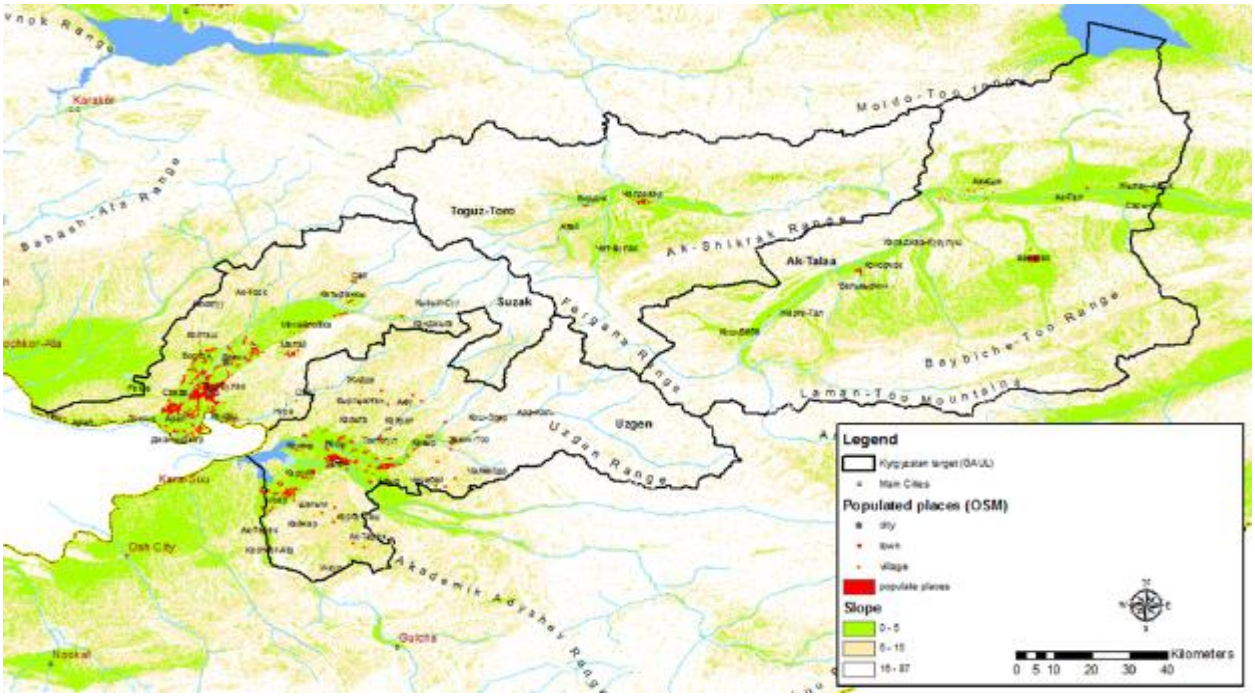
3.1 Demography

In this project 4 Rayons at the West side of Kyrgyzstan have been identified as core target area: Suzak, Toguz-Toro, Ak-Talaa and Uzgen.

			Census 2009	Population Estimate 2016[24]		
Rayon	Oblast	Area (km²)	Total resident population	Total	Urban	Rural
Suzak	Jalal-Abad	3,019	241,200	277,500	11,300	266,200
Toguz-Toro	Jalal-Abad	3,816	22,100	24,000	0	24,000
Ak-Tala	Naryn	7,266	30,600	32,100	0	32,100
Uzgen	Osh	3,308	228,600	256,400	56,100	200,300
TOT		17,409	522,500	590,000	67,400	522,600

Table 2 Population by rayon in target area

This area covers 17,409 km2, which is about 8.7% of the national extent. The target area is made by four rayons from three oblasts, and include 60 villages, 25 pasture user associations, 14,500 households and 580,000 beneficiaries (Sources: GCF/FAO). Most of populated places are located on flat areas or foothills at low altitude, making them at risk of climatic hazards such as landslides, mudflows, flooding etc.



[24] *Source: Kyrgyzstan Population Statistics. OCHA. https://data.humdata.org/dataset/kyrgyzstan-population-statistics*

Figure 20: Map of settlements in target area over slopes between 0-5 (green) and 5-15 (yellow) deg. FAO

3.2 Topography

The target area includes tall mountains and flat low altitude valleys. The elevation stretches from 500 m to almost 4,700 m. The major mountain ranges are Fergana (middle), Ak-Shikrak at South of Toguz-Toro, and Laman-Too mountains at South of Ak-Talaa. Here is a stratification of altitude in 4 significant classes of elevation:

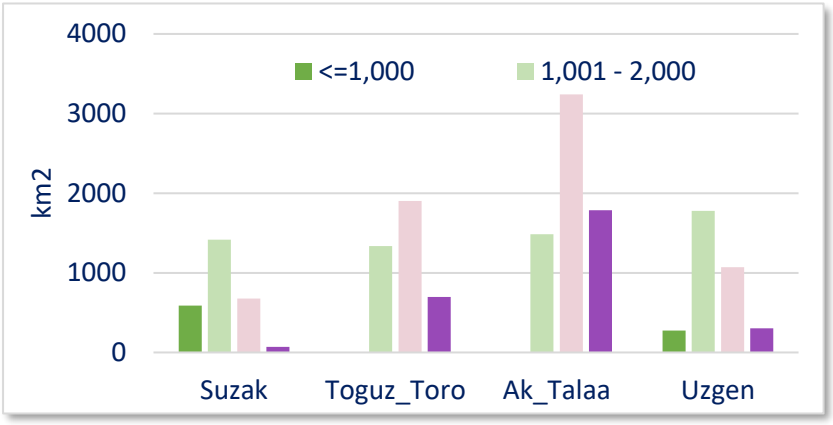


Figure 21: Chart area distribution of altitude ranges, core target area

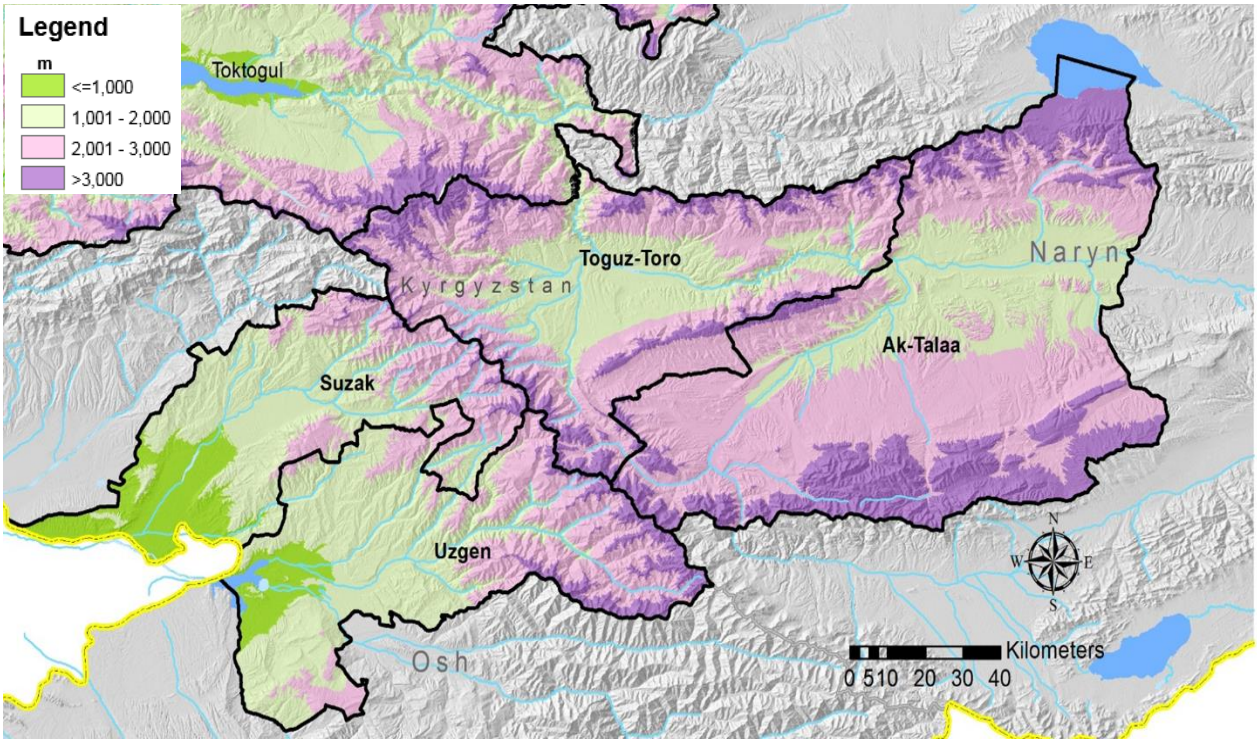


Figure 22: Map elevation with four classes of altitude, core target area. GCF/FAO

3.3 Climate

The four Rayons of the target area are part of two climatic zones: the **South-western**, which includes margins of the broad Fergana valley, the Chatkal and Alai valleys and the adjacent mountain ranges. Relative to other climatic zones, this is the warmest and most humid with maximum rainfall in winter; and the **Inner Tien-Shan,** which is a closed climatic zone bounded by adjacent mountain ranges. It is characterized by low precipitation, and a marked continental climate with distinctive local contrasts.

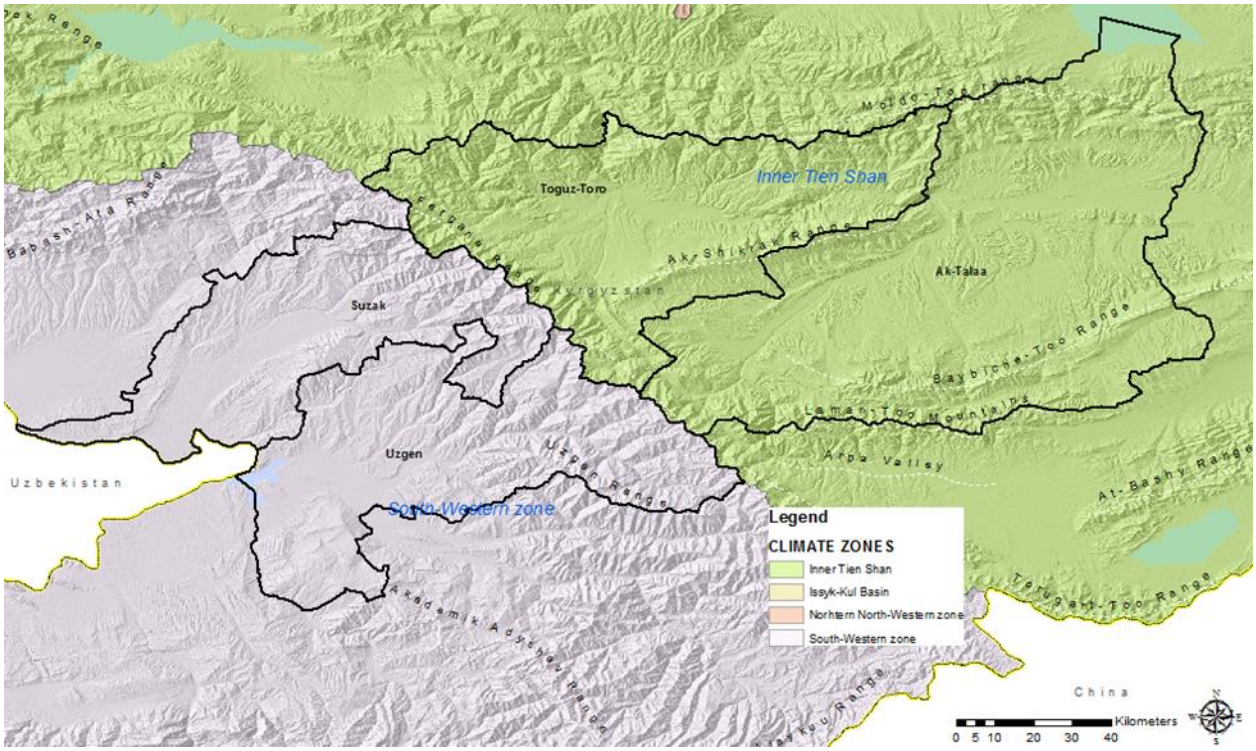


Figure 23: Map climate zones, core target area

Climate in the area is heavily affected by topography.

The valley-sub-mountain zone (from 900-1,200 m) experiences hot summers, snowless and temperate winters, and low precipitation.

The mountain zone (from 900–1,200 to 2,000–2,200 m) is characterized by a temperate climate, which has warm summers and cold, snowy winters.

The high-mountain zone (from 2,000–2,200 to 3,000–3,500 m) is cooler in the summer and has relatively cold, snowless winters, with temperatures ranging from well below zero to 16 °C.

The nival belt zone (from 3,500 m and higher) has a polar climate and is covered by numerous snowfields and glaciers.

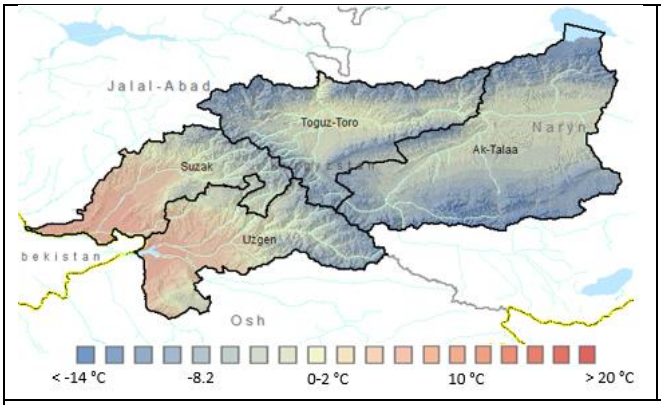
The table below shows long term averages[25] of **temperatures and precipitation** in each of the four target rayons:

Rayon	PRECIPITATIONS (mm)	MAX TEMPERATURE (°C)	MIN TEMPERATURE (°C)
Suzak	556	14.5	1.7
Toguz-Toro	476	9.0	-3.7
Ak-Talaa	347	8.0	-4.7
Uzgen	511	13.3	0.6

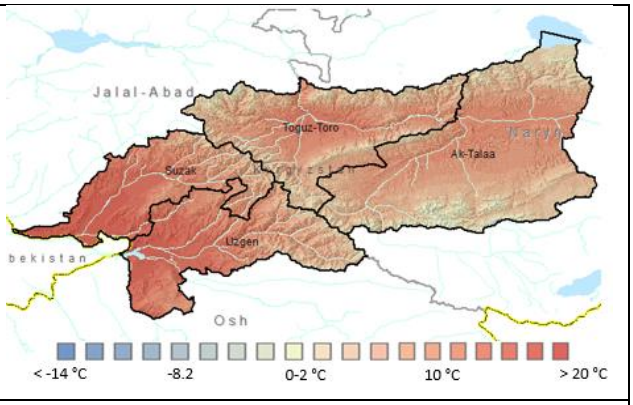
Table 3: Precipitation-Temperature Averages 1970-2000, core target area

Below are maps of spatialized temperature and precipitations resulting of long (1970-2000) time series averages:

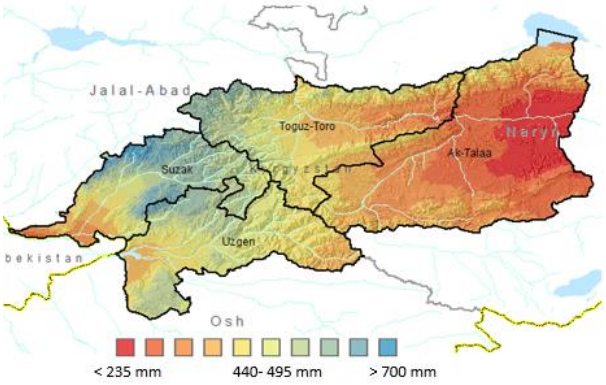
Annual mean of MIN Temperature



Annual mean of MAX Temperature



Annual Total Precipitations



Time series of precipitations[26] and temperatures[27] have also been used to run pixel based linear regressions and extract annual (trend) and total change according to historical observations.

[25] *WorldClim Version2 - http://worldclim.org/version2*
[26] *Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)*
[27] *Source: European Centre for Medium-Range Weather Forecast (ECMWF)*

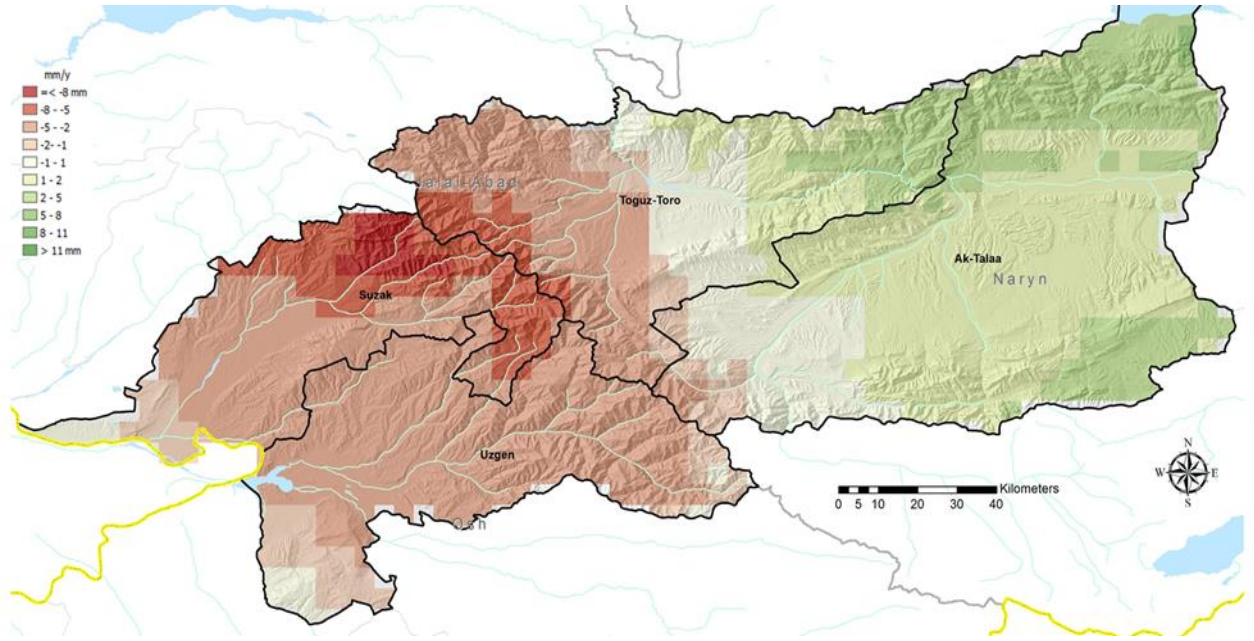


Figure 24: Map annual precipitation trend 1981-2016, core target area

The map above shows annual precipitations trend based on past (1981-2016) observations. It is evident a tendency to reduce rainfalls on the West side of the 4 Rayons, fully involving Uzgen and Suzak, with a hot spot in North Suzak (reduction up to 8 mm/year and more), just around the Walnut fruit forests. This is also the area where average total annual precipitations are higher. The East part of the area shows instead a tendency to increase rainfalls, in the order of 1 to 10 mm/year.

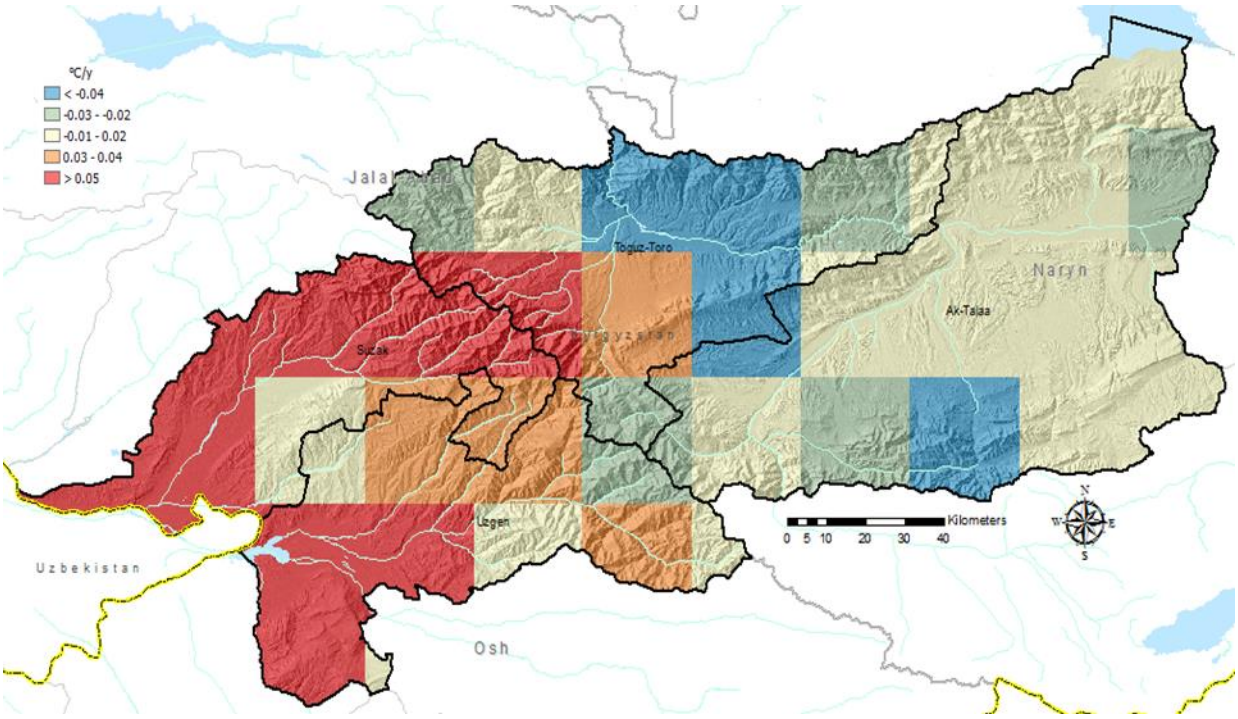


Figure 25: Map annual MAX temperature trend 1989-2016, core target area

The map above shows trends in absolute MAX temperatures (°C) per year based on historical (1989-2016) time series. The variation is in the order of a fraction of degree and is distributed from West (increase) to East (stable or decrease). Considering 27 years of observations, the total change in the period is from 1 °C decrease to 1.5 °C increase or more.

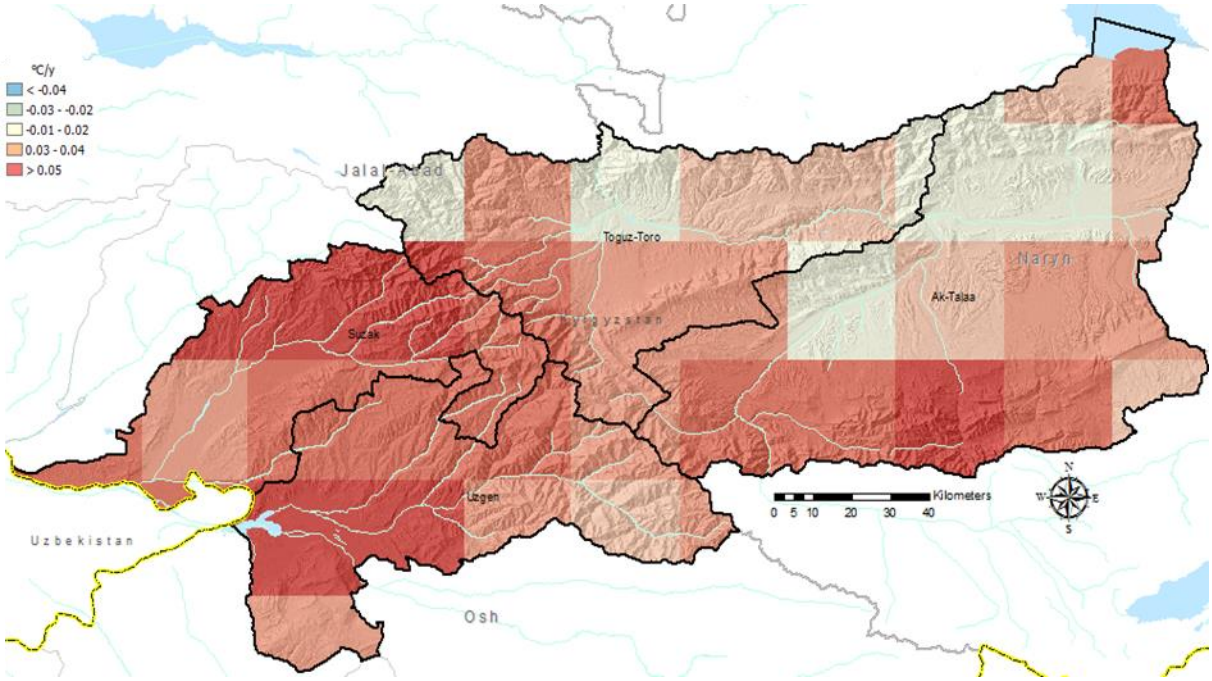


Figure 26: Map annual MIN temperature trend 1989-2016, core target area

The map above shows trends in absolute MIN temperatures (°C) per year based on historical (1989-2016) time series. The variation is almost only in increasing values from West to East in the order of a fraction of degree, with slightly higher increases in the Western Rayons and the Southern area of Ak-Talaa.

An additional climatic variable analyzed for the core target area is the **Potential Evapotranspiration (PET).** PET is the amount of evaporation, expressed in mm that would occur if a sufficient water source were available. It is a measure of the demand for moisture from a surface, and it is affected by temperature, insolation and wind. PET is higher in the summer, on less cloudy days, and closer to the equator, because of the higher levels of solar radiation that provides the energy for evaporation. PET is also higher on windy days because the evaporated moisture can be quickly moved from the ground of plants, allowing more evaporation to fill its place.

Hotter temperatures result in greater PET which requires more precipitations just to meet the greater demand. Climates where PET is always greater than P are termed arid climates.

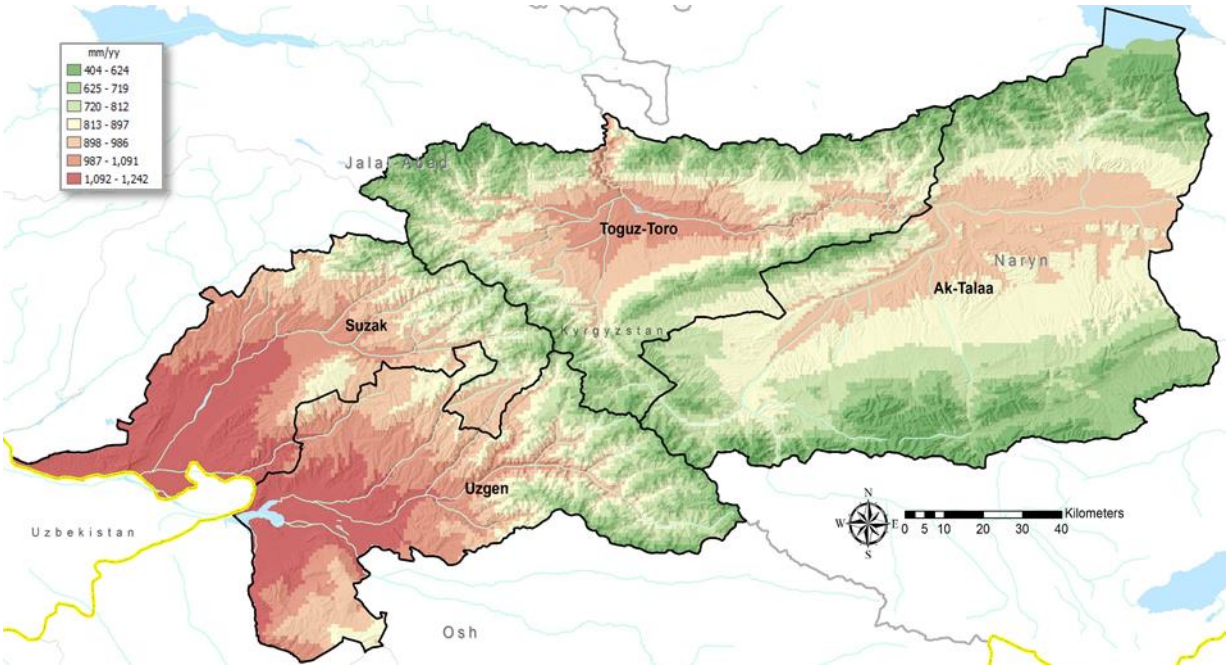


Figure 27: Map annual PET long term average 1950-2000, core target area

The map here shows the average potential evapotranspiration derived from the global database (1950-2000) produced by CGIAR-CSI[28], in which source climatic data FAOCLIM2 was used in the PET equation (FAO application of the Penman-Monteith). The areas with higher values exceeding the annual precipitations are the western part of Suzak and Uzgen (low land) and the main valley in the other two Rayons.

[28] *Source: CGIAR-CSI Global Potential Evapo-Transpiration (Global-PET), http://www.cgiar-csi.org/?s=global-pet&submit.x=0&submit.y=0*

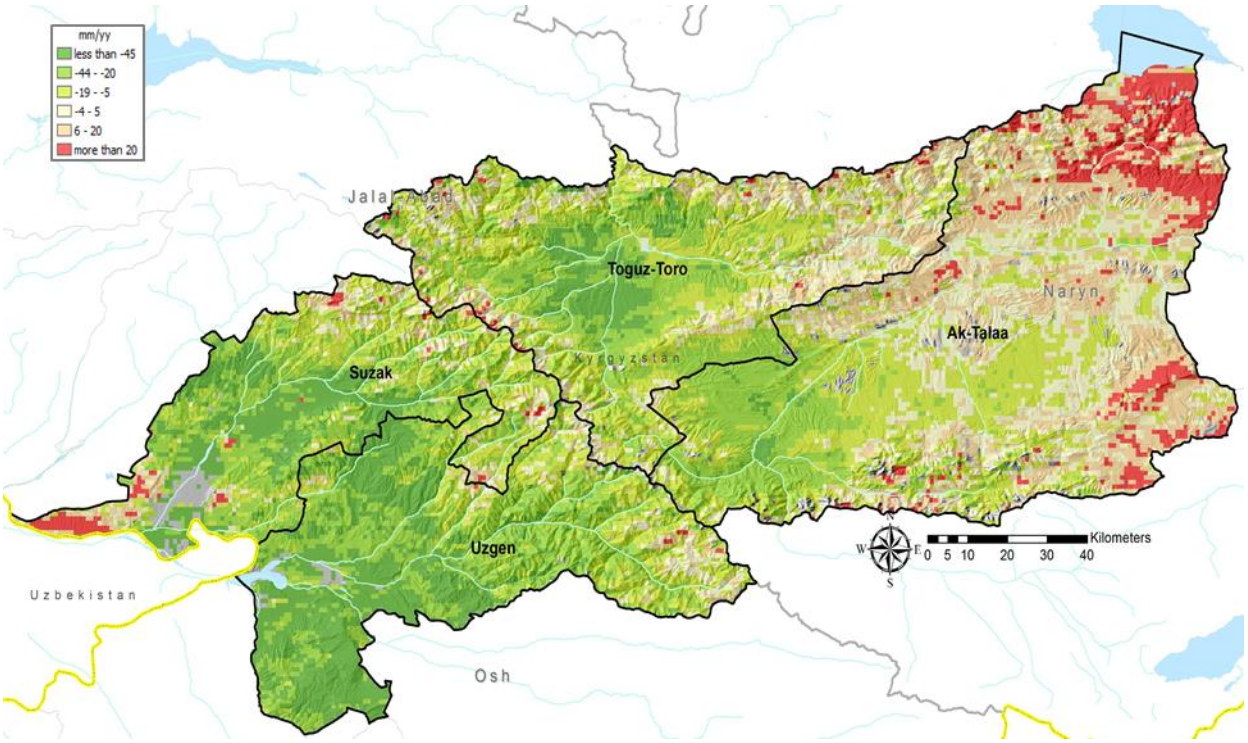


Figure 28: Map annual PET trend (MODIS) 2000-2014, core target area

This map shows the trend in mm (absolute increase or decrease per year) of annual potential evaporation from ground and transpiration from plant surfaces where there is sufficient soil moisture. It is based on 2000-2014 satellite data[29] and shows a general reduction of PET in lowland and valleys, with a tendency to increase in the most Eastern-Northern part of the area.

Because prevalently mountain area, Kyrgyzstan is particularly sensitive to a changing climate, through increases in temperature coupled with changes in precipitation regimes. These driving factors strongly influence the variability of the mountain snow-pack through a decrease in seasonal reserves and earlier melting. Snow monitoring from remote sensing provides a unique opportunity to address the question of **snow cover regime** changes.

[29] *Source: Global MOD16A2 MODIS/Terra Net Evapotranspiration 8-Day L4*

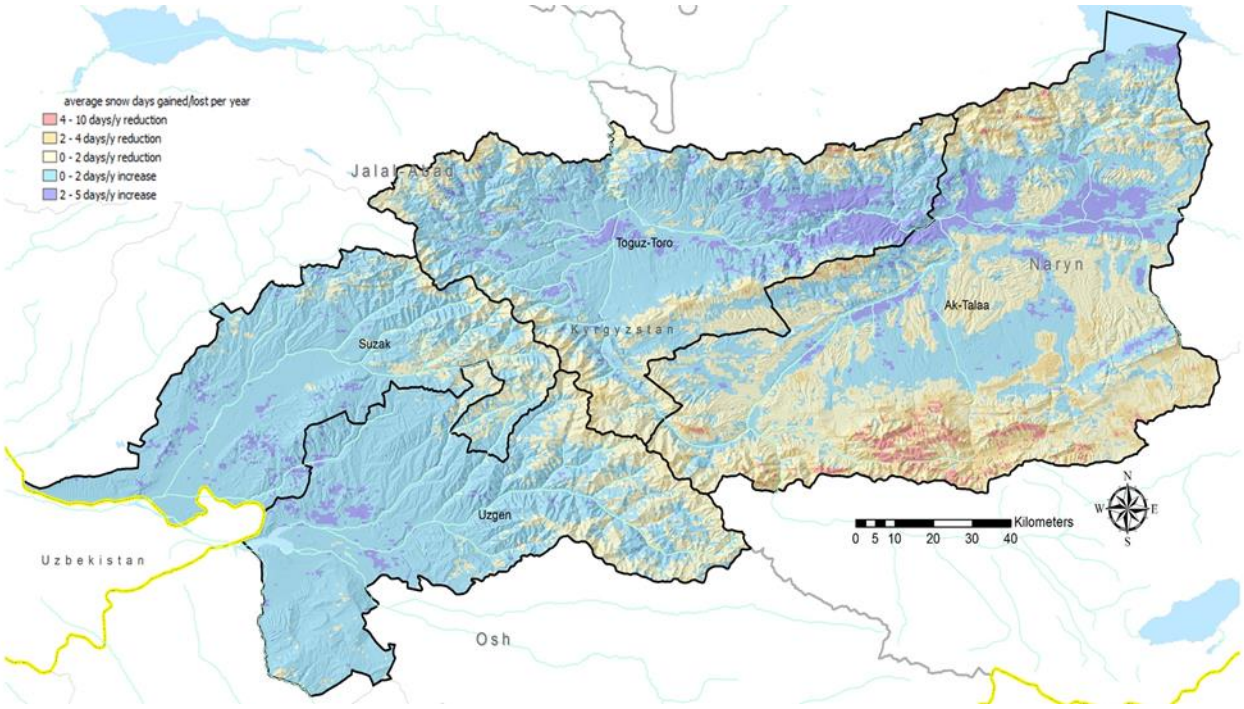


Figure 29: Map annual Snow Cover Frequency trend (MODIS) 2002-2016, core target area

The map above shows trends in number of days of snow covered areas per year, lost or gained, according to a time series of satellite based images[30] between 2002 and 2016. Brown areas are where the frequency is reducing, and it spreads along the main mountain ranges of the four Rayons, with highest percentage in Southern Ak-Talaa. Bluish areas are those where it is increasing, even though mostly by only 0-2 days per year.

3.4 Vegetation

One of the most used proxy to detect status and trend of vegetation using remote sensing is the **Normalized Difference Vegetation Index (NDVI)**. NDVI determines the density of green on a patch of land by observing and comparing visible and near-infrared sunlight reflected by the plants. Healthy vegetation absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light, resulting in higher values of NDVI. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light, resulting in lower values of NDVI. This index ranges from -1 to 1. However, no green leaves gives a value close to zero. A zero means no vegetation and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves.

The map below shows a satellite[31] based annual mean NDVI, averaged in the years 2014-2016. Suzak and Uzgen Rayons are particularly "green" (irrigated cropland in low land, orchards, forests) compared to Toguz-Toro and especially Ak-Talaa. Note how high is the intensity of the green by the zone of the Walnut fruit forests, North of Suzak!

[30] *Source: MOD10A1.005 MODIS/Terra Snow Cover Daily L3 Global 500m*
[31] *Source: MOD13Q1.005 Vegetation Indices 16-Day Global 250m*

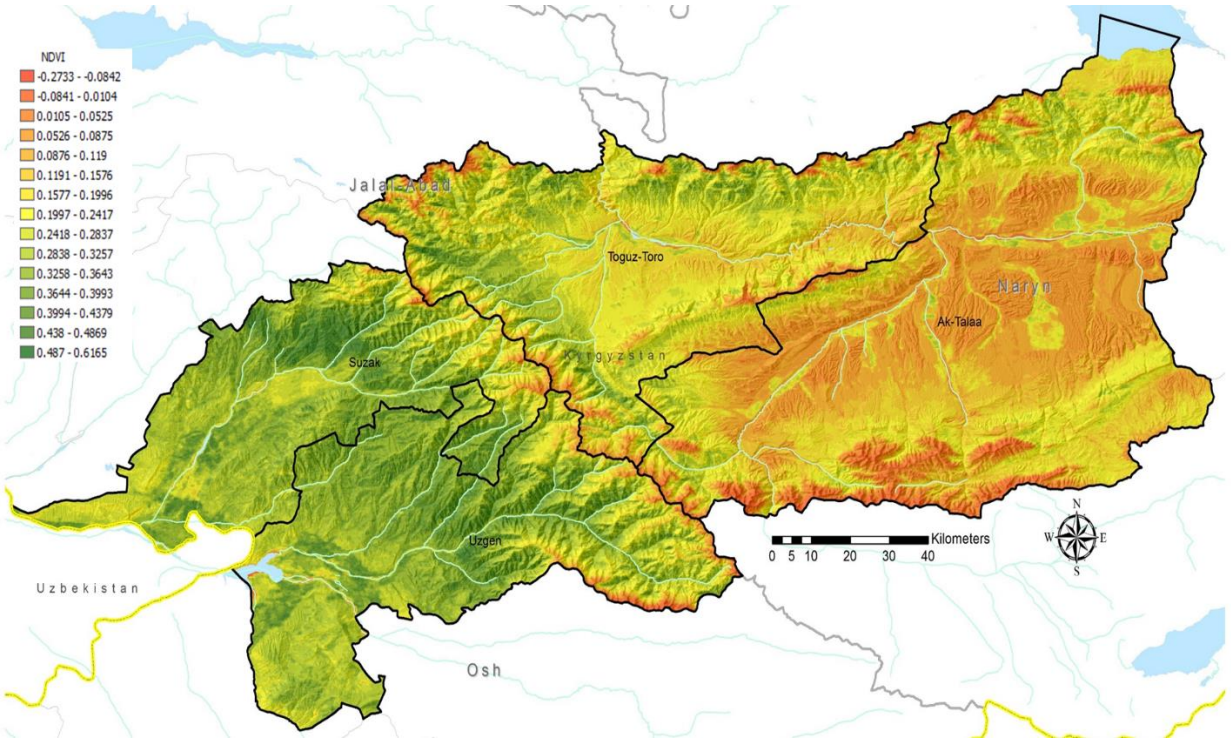


Figure 30: Map annual mean NDVI (MODIS) averaged in the years 2014-2016, core target area

One variant of the NDVI to proxy the "greenness" productivity in an area is the **annual Sum NDVI**. The chart below sums annual mean NDVI by Rayon, filtering however, only values above 0.2, which is considered the threshold between vegetation and non-vegetation (approximation).

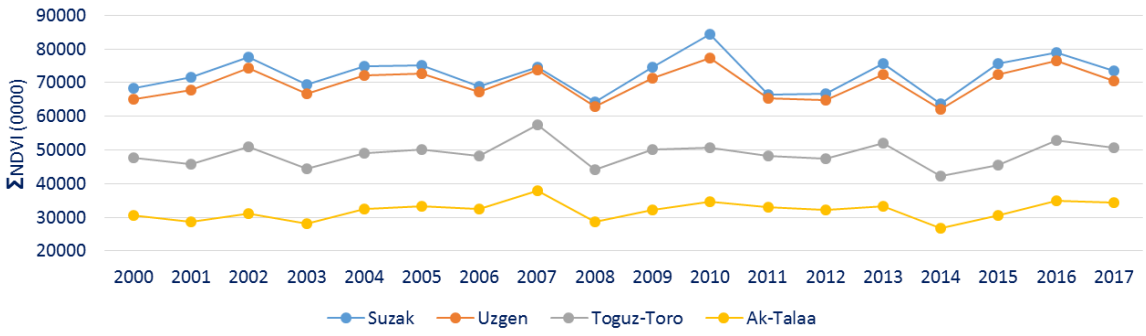


Figure 31: Chart annual accumulated NDVI (MODIS) 2000-2017, core target area

Clearly the level of accumulate greenness is very different between Suzak (higher) and Ak-Talaa (larger bare areas or glaciers). Note also that 2014 was a year particularly penalized for vegetation biomass production (year of low precipitations) while 2010 was highly productive, especially in Suzak and Uzgen.

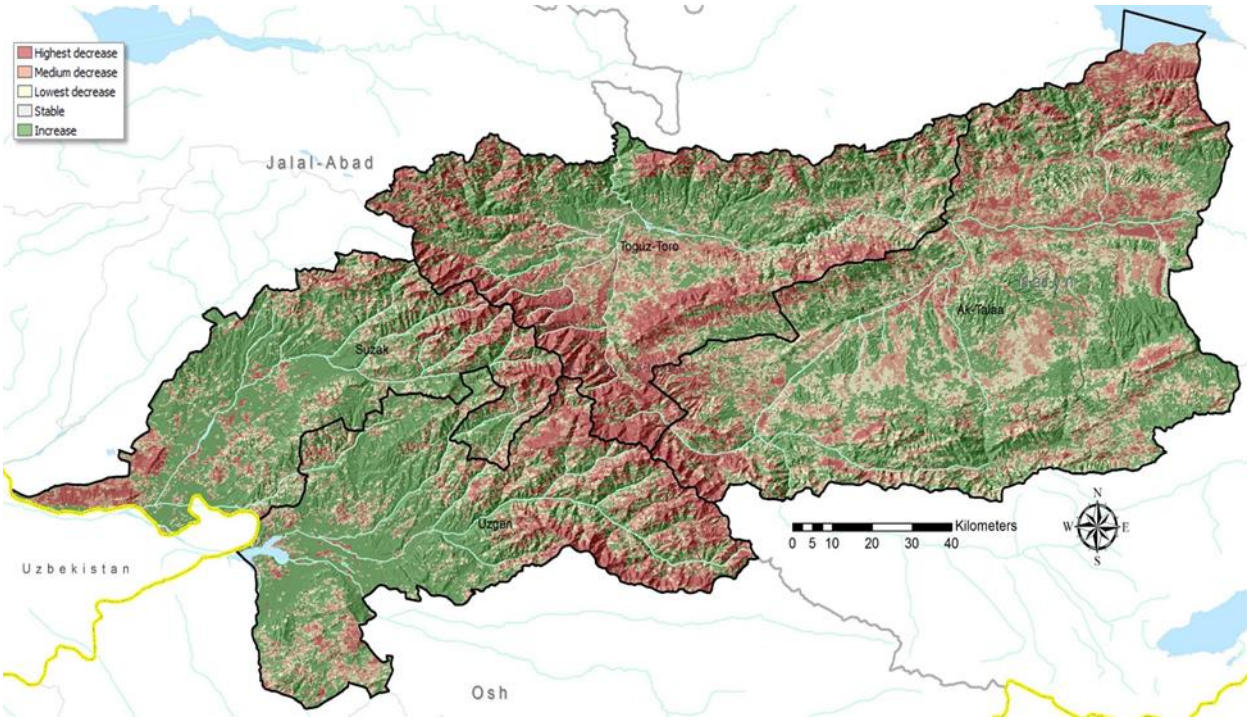


Figure 32: Map annual NDVI trend (MODIS) 2003-2016, core target area

This map depicts annual trend in NDVI based on a time series of 16-day image composites from 2003 to 2016[32]. Shades of red show different degrees of vegetation loss (spread mostly on high altitudes). Green shows areas where the trend is positive (vegetation increase). Negative trends do not imply necessarily land degradation processes, however they should raise a flag for more detailed investigations.

3.5 Protected areas

The 4 target Rayons are covered by 5 national designated **protected areas**[33] for an overall area of 49,052 ha (2.95% of total target area):

- Gulchin Wildlife Refuge (Uzgen),
- Kara-Shoro Nature Park (Uzgen),
- Sonkul Wildlife Refuge (Ak-Talaa),
- Toguz-Torouss Wildlife Refuge (Toguz-Toro), and
- Yassin Wildlife Refuge (Uzgen).

The map below shows the location of these 5 protected areas:

[32] *Source: MOD13Q1.005 Vegetation Indices 16-Day Global 250m*
[33] *UNEP-WCMC (2018). Protected Area Profile for Kyrgyzstan from the World Database of Protected Areas, February 2018. www.protectedplanet.net/country/KGZ*

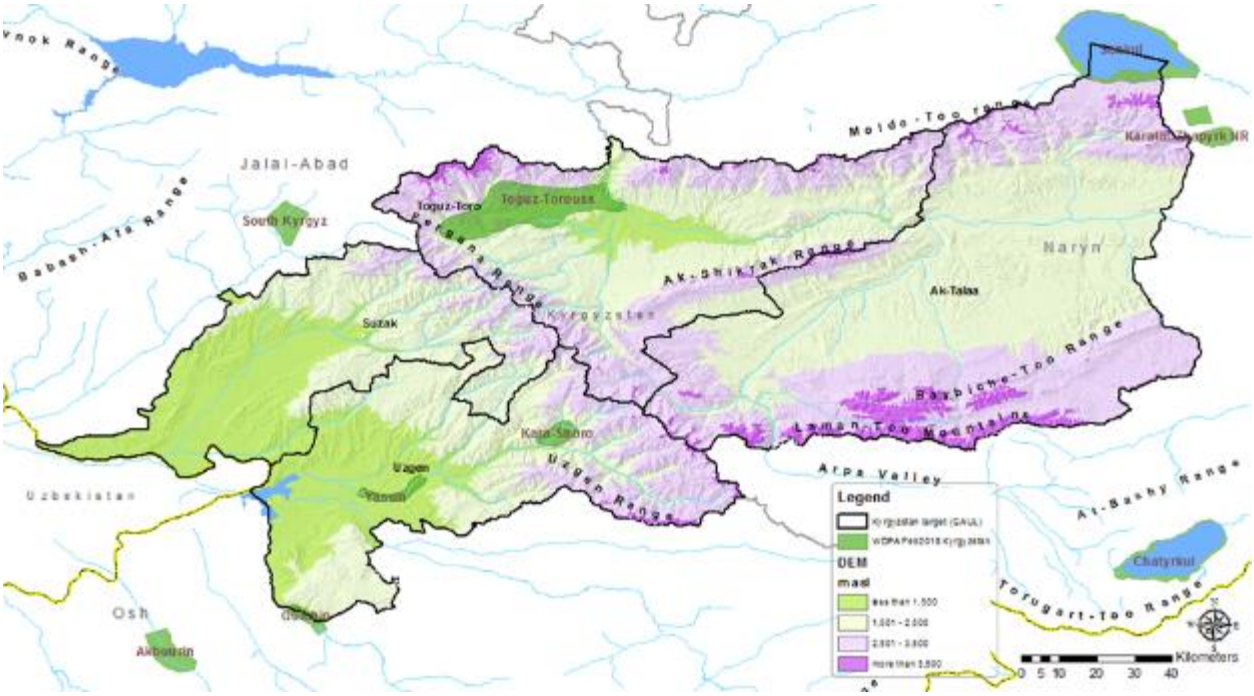


Figure 33: Map World Designated Protected Areas feb2018, core target area

3.6 Land Cover

The two land cover / land use classes of major interest for this project are **Forests** and **Pastures**.

One of the most used satellite based forest database worldwide is the Global Forest Change 2016[34]. It provides the % of tree cover in each pixel, considering "tree cover" as any all vegetation type taller than 5 meters in height. It was produced by using data of Landsat missions from 2000 to 2016 at 30m resolution. Actually, the available datasets are the reference tree cover map dated 2010, and gains/losses on yearly basis. By combining these layers, the tree cover of 2016 can be mapped.

[34] *Source: https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.4.html*

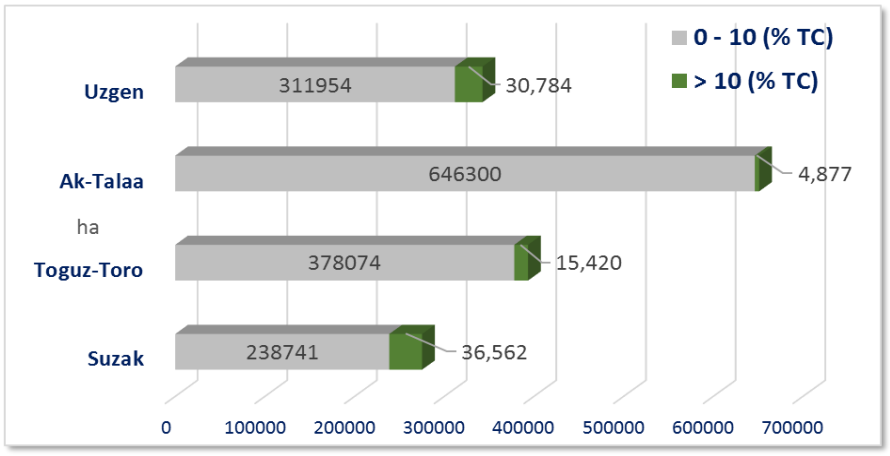


Figure 34: Chart Forest (2016 Hansen's tree cover > 10%) / non forest, core target area

The chart above shows the distribution of "forest" (land with a tree cover percentage higher than 10) versus what is lower in TC% or zero. Here is the correspondent summary table:

Class	Suzak (ha)	Toguz-Toro (ha)	Ak-Talaa (ha)	Uzgen (ha)	TOTAL (ha)
0 - 10 (%TC)	238741	378074	646300	311954	**1575068**
10.1 - 100 (%TC)	36562	15420	4877	30784	**87643**
Rayon (ha)	**275302**	**393494**	**651177**	**342738**	**1662712**

The map below displays the geographic distribution.

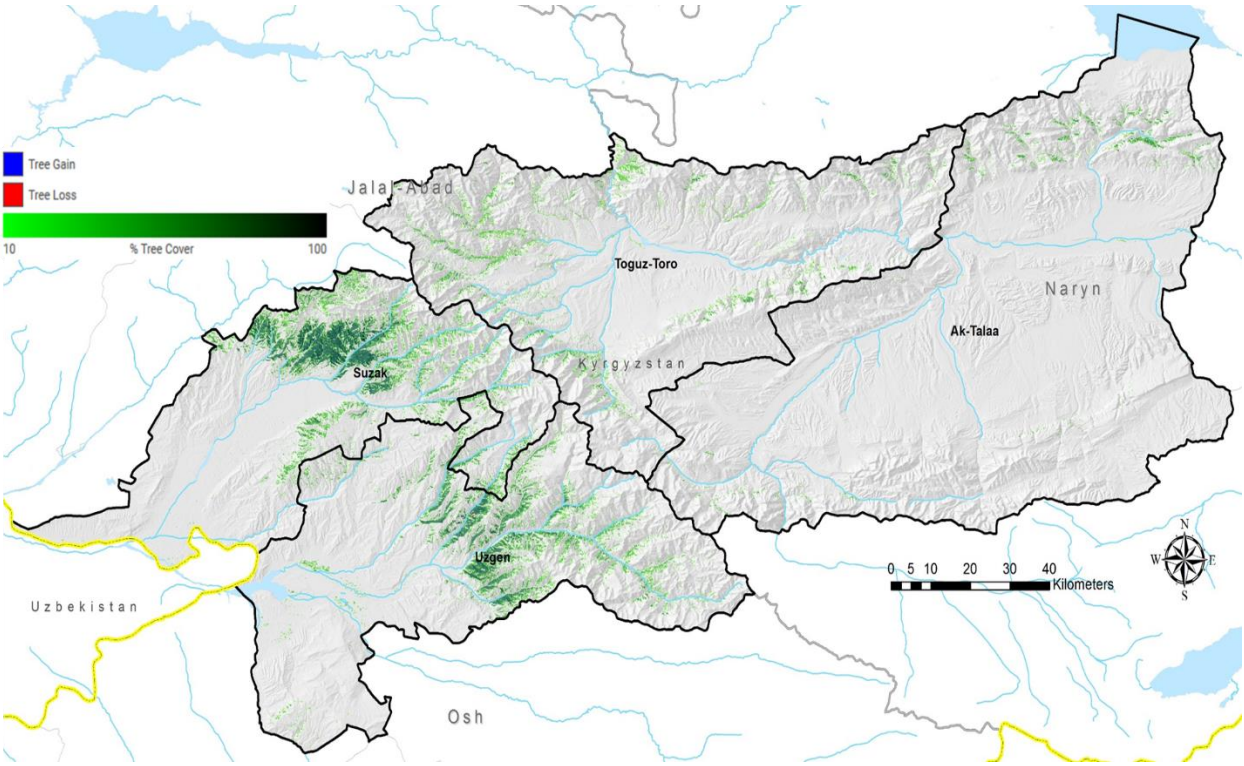


Figure 35: Map Forest (2016 Hansen's tree cover > 10%), core target area

In terms of percentage, Suzak contains the largest amount of forests (11.8), followed by Uzgen with 7.9%, Toguz-Toro with 3.9, and finally Ak-Talaa with only the 0.7%.

Note that “tree cover” is the biophysical presence of trees and may take the form of natural forests or plantations, existing over a range of canopy densities.

A **Pasture coverage** for these 4 Rayons was generated by extracting this class of land use from databases provided by the local Pasture Users Unions (PUU) and then consolidating them in one topological corrected data layer. The coverage is incomplete and the process of generating a full consistent database is ongoing.

40 PUUs were identified in the core target areas, covering 73% (12,162 km2) of the total land area (16,558 km2). Of the PUUs total area, 61% was classified pasture (7,385 km2). Below is the map of pastures and PUU boundaries.

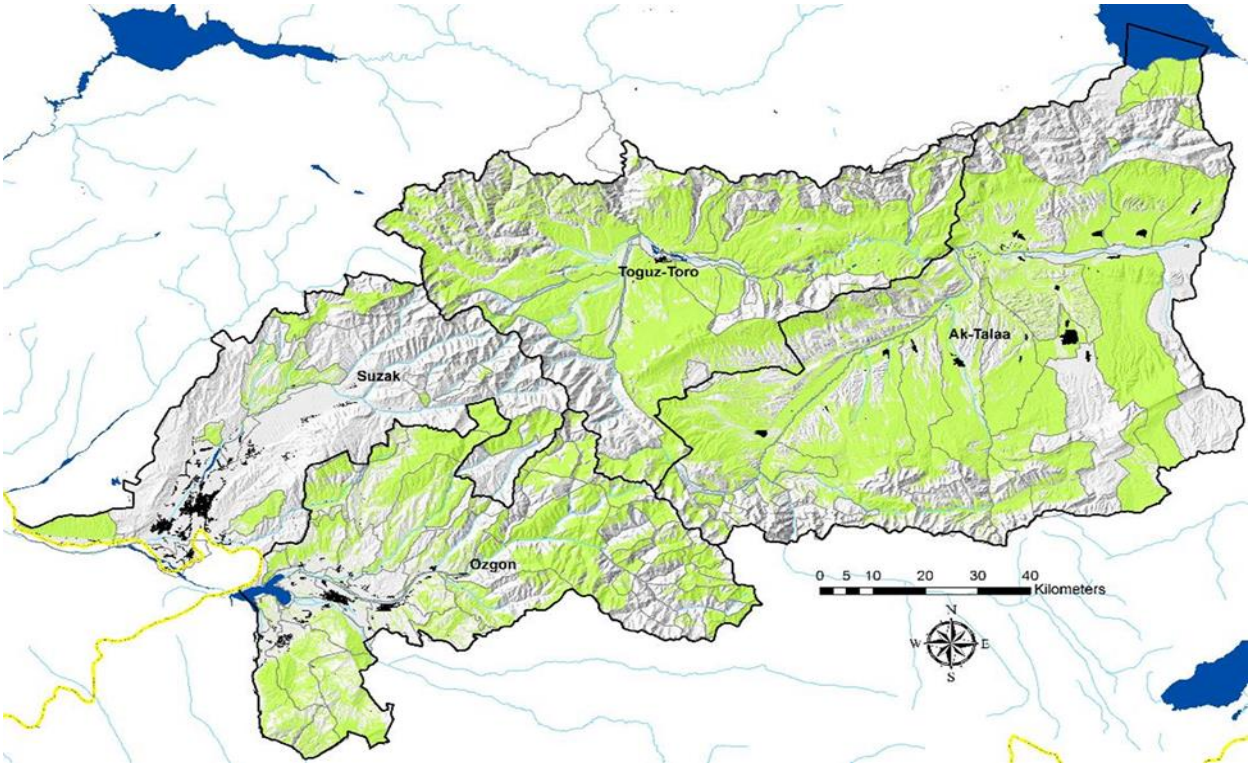


Figure 36: Map Pasture (Pasture Users Union databases), core target area

By combining pastures in PUUs with the forest layer, the following area distribution has been calculated:

Rayon	PUU area (ha)	Forest only (ha)	Pasture only (ha)	mix pasture/forest (ha)	TOT pastures (ha)	TOT forests (ha)
Ak-Talaa	505,785	170.38	321890.39	526.19	322416.58	696.57
Suzak	67,856	4047.42	29808.29	2319.62	32127.91	6367.03
Toguz-Toro	339,610	9924.78	202942.09	4258.44	207200.53	14183.22
Uzgen	325,992	19478.82	144598.70	9830.24	154428.94	29309.06
TOTAL	**1,239,243**	**33621.40**	**699239.47**	**16934.48**	**716173.96**	**50555.88**

Table 4: Distribution of pasture/forest, core target area

In this table, the second column quantifies the portion of just forest in the PUU area; the third column quantifies the portion of just pasture; the fourth column tells us the area in which pastures and forests overlay. By summing only forest and mix the total forest cover in the PUUs is quantified; same for pastures (last two columns).

More details analysis on forest and pasture areas are described in the specific sections of this report.

Other land covers were estimated in the area using the 2010 global database GlobeLand30[35]. It was generated from 30m Landsat satellite imagery around the year 2010, and includes 10 main classes. Here below are the table describing area distribution by class and rayon, and the related map.

Land cover	Ak-Talaa km^2	Toguz-Toro km^2	Uzgen km^2	Suzak km^2	TOT km^2	TOT %
10-cultivated land	368.8	108.7	1054.6	679.7	**2211.7**	13.3%
20-forest	199.0	650.2	314.9	488.4	**1652.4**	9.9%
30-grassland	3031.6	2228.3	1676.3	1051.3	**7987.5**	48.0%
40-shrubland	582.3	263.1	86.8	184.9	**1117.0**	6.7%
50-wetland	6.1	0.0	1.1	0.0	**7.2**	0.0%
60-water bodies	113.0	18.1	47.3	2.8	**181.2**	1.1%
80-artificial surface	24.9	15.3	45.9	96.7	**182.8**	1.1%
90-bareland	2133.4	626.1	195.8	246.2	**3201.4**	19.3%
100-permanent snow	52.9	25.2	4.7	3.1	**85.9**	0.5%
TOTAL	**6511.8**	**3934.9**	**3427.4**	**2753.0**	**16627.1**	

Table 5: Distribution of land cover types (Globe:and30), core target area:

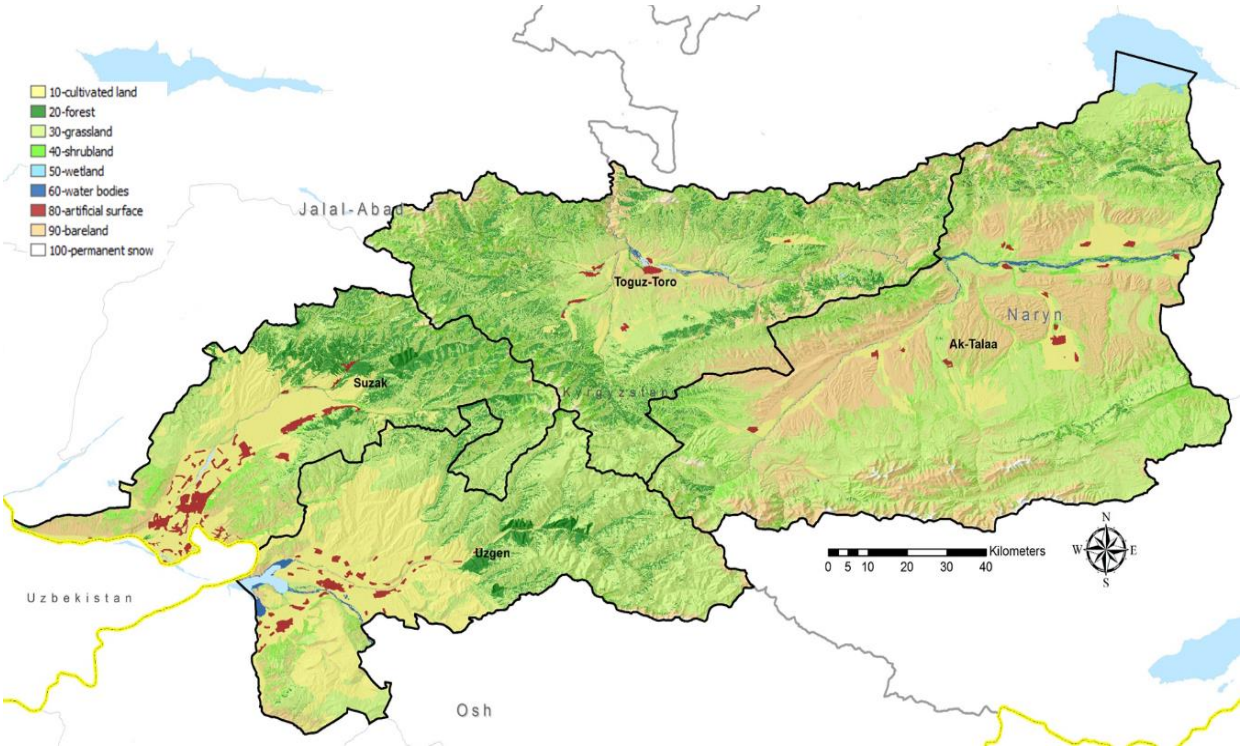
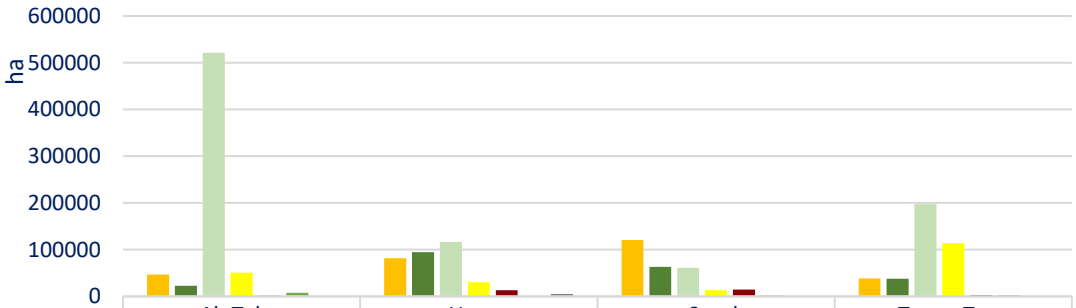


Figure 37: Map Land Cover 2010 (GlobeLand30), core target area

[35] *Source: GlobeLand30, http://www.globallandcover.com/home/Enbackground.aspx*

In 2016, a sample based survey by using the FORIS Collect Earth tool[36] was conducted in Kyrgyzstan by local experts. 13,200 sample points were characterized for a number of variables, including the land use, in order to estimate distribution and conditions based on what could be detected by analyzing high resolution imageries and other indicators available through the Google platform.

In the target area, the estimate from the samples falling in the four rayons of interest has given the following results:



	Ak-Talaa	Uzgen	Suzak	Toguz-Toro
Cropland	47114	81844	120893	38437
Forest	23131	94439	63229	37921
Grassland	521084	116494	61250	197361
Other Land	50758	30109	13381	113610
Settlement	1488	13490	14522	3180
Wet Land	7596	1130	2028	2985
No data		5233		

Table 6: Land uses out of sample based survey 2016 (Collect Earth), core target area

[36] *Collect Earth: http://www.openforis.org/tools/collect-earth.html*

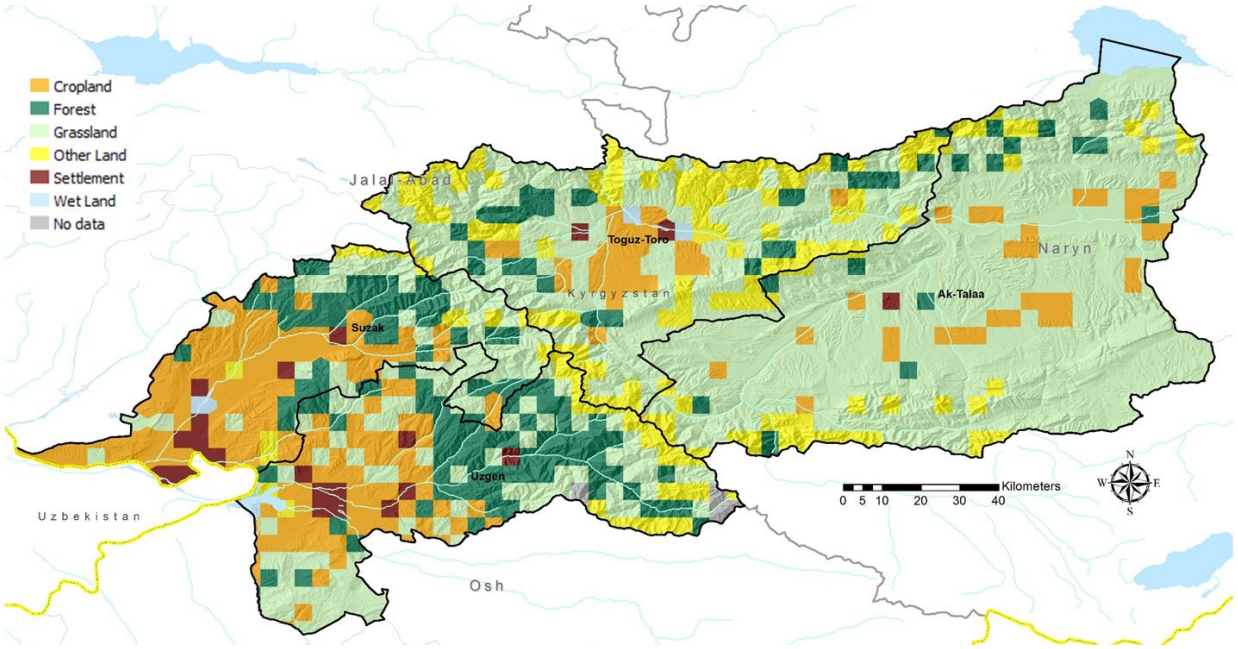


Figure 38: Map land uses out of sample based survey 2016 (Collect Earth), core target area

This map gives an indication of hot spots for the presence of land covers such as croplands, forests or grasslands.

4. PASTURE ANALISYS TARGET AREA

4.1 Objective

Analyze vegetation status and climatic conditions for pasture areas stratified according to topographic characteristics (slope and range of altitude). These data, summarized and presented here for a subset of 26 identified areas in the 4 core target Rayons, intend to provide objective and evidence based elements for targeting pasture areas for potential mitigation/adaptation actions to climate change.

4.2 Data

Here is the list of data layers used in this analysis:

- Pasture and boundaries from Kyrgyzstan's Pasture Users Unions (PUU) geodatabases
- Climatic data from Google Earth Engine's cloud
- Historical 2003-2016 vegetation indices (NDVI) from Google Earth Engine's cloud
- Topography from ASTER GDEM 30m

4.3 Outputs

- Pasture Users Unions (PUU)'s pasture layer
- PUU's borders layer
- Stratified pasture layer per slope (<25%) and type (<1500m, 1500-2500m, and > 2500m)
- 2003-2016 NDVI trend map
- Classified map of pastures based on average NDVI trend value (annual increment/reduction of vegetation) in the area.

4.4 Methodology and Results

Methodology

I. PUU's pasture and border layers

Geodatabases of PUU data were processed to extract pasture areas and PUU borders.

II. Elevation / slope layers

The *Elevation layer* has been derived from ASTER GDEM (30m) by aggregating 3 classes of altitude consistent with common distinction of seasonal pastures:

- winter (<1500m),
- spring/autumn (1500-2500m),
- summer (>2500m)

The *Slope layer* has been derived from ASTER GDEM (30m) by selecting slopes less than 25%.

III. Unique pasture areas per topographic and administrative characteristics

The overall pasture layer has been combined with classes of altitude and the slope layer to identify 165 unique pasture areas per topographic and administrative characteristics.

IV. Classified map of pastures based on average NDVI trend

The 165 pasture units have been used to extract from the historical NDVI trend map the average value in the area, and categorize it in 5 classes of trends:

- Highest index decrease
- Moderate decrease
- Low decrease
- Very low decrease
- Index increase

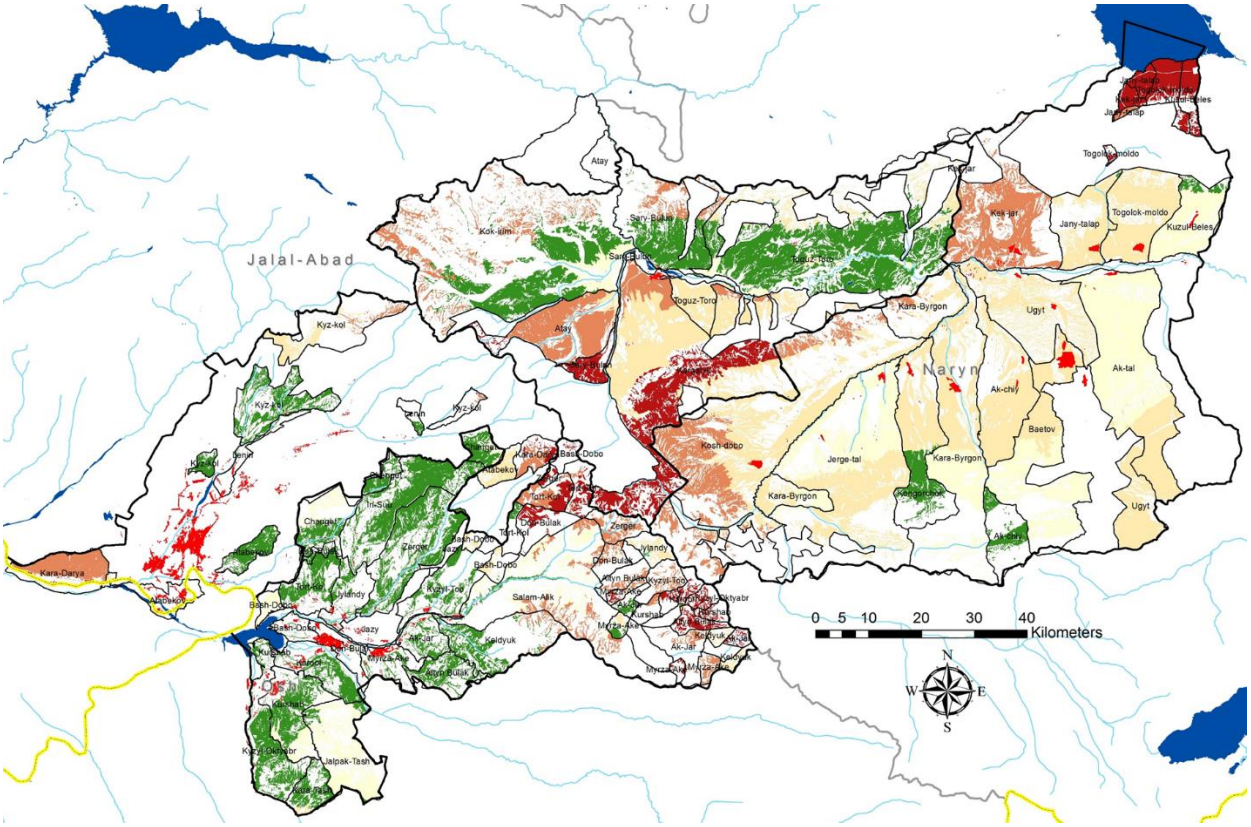


Figure 39: Classified Map of pastures based on NDVI trend in period 2003-2016

61 areas were found with positive trend and excluded; 104 areas were found with negative trends and processed for extracting:

1. Historical NDVI profiles from 16 day composite, 250m resolution NDVI data for the period 2003-2016, and
2. Climatic trends for precipitations, temperatures, potential evapotranspiration and annual snow cover frequency.

Results

A detailed description of the results are described in the ATLAS for 26 out of the 104 areas detected with negative vegetation trends. This selection was made to represent examples for each of the 4 target rayons, for different type of pastures (three altitude ranges) and for category of negative trend (1st to 4th group) created according to level of NDVI reduction in the time series.

Note that this sample of 26 "cases" is 25% of all pasture units detected with negative trend, and 16% of all unique pasture areas identified with the adopted stratification approach. It is not exhaustive but it provides a picture of the characteristics of pastures in various conditions.

4.5 Pastures in Kyrgyzstan

A common definition of pastures is that are "*land with grass or herbage, used or suitable for the grazing of livestock*".

Kyrgyz Republic is a small mountainous country in Central Asia. More than 80 percent of the agricultural land is classified as pastures which play an important role in livelihoods of rural livestock communities for grazing of animals, collecting medicinal and aromatic herbs, berries and mushrooms, timber and dung for heating and cooking, as well as being recreational areas for hunting and tourism.

Having Kyrgyzstan an extremely mountainous terrain, it is suitable for grazing at different times of the year at different altitudes which hence naturally supports pastoral herding. In the past, Kyrgyz tribes would spend winters in encampments in valleys and lower areas with no snow cover, then move with their herds to spring pastures at medium altitudes, and then further move to summer pastures, only to return via autumn pastures to their encampment.

There are clear signs that some pasture land, especially around villages is heavily overgrazed and degraded, others are polluted with weeds being unused. With the livestock number growing, there have been more and more conflicts around the access to pastures by small farmers and community herds.

Here is an attempt to describe status and trend of pasture areas with different topography and administration characteristics using geospatial techniques and remote sensing data. Long term vegetation information and climatic conditions will support a comprehensive description of such important resource in four selected rayons and their 40 Pasture User Unions territory.

PUU Borders

Overall, 40 PUUs were identified, covering 73.4% of the total target area. Toguz Toro, Ak-talaa and Uzgen are covered between 80 and 90%, while Suzak near 25% (a portion of Suzak territory is covered by State

Forest Fund / national park areas). The process to complete the coverage of PUUs in the 4 target Rayons is ongoing.

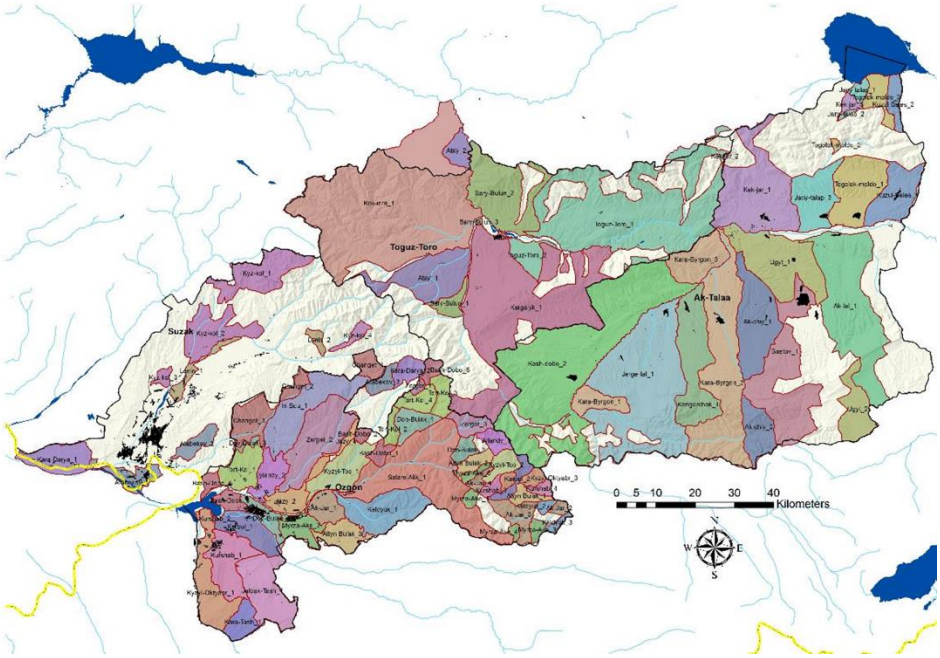


Figure 40: Map of PUU boundaries in 4 target rayons

Rayon	Rayon area (km²)	No. PUUs	PUA area (km²)	% PUU area
Suzak	2669.03	4	677.73	25%
Toguz-Toro	3958.42	5	3353.08	85%
Ak-Talaa	6484.51	12	5101.89	79%
Uzgen	3446.18	19	3029.5	88%
TOTAL	**16558.14**	**40**	**12162.2**	**73.45%**

Table 7: Pasture User Union territories, core target area

PUU Pastures

Pastures were found in 40 PUUs covering 59% of the total PUUs area. The process to complete the coverage of pastures in the 4 target Rayons is ongoing.

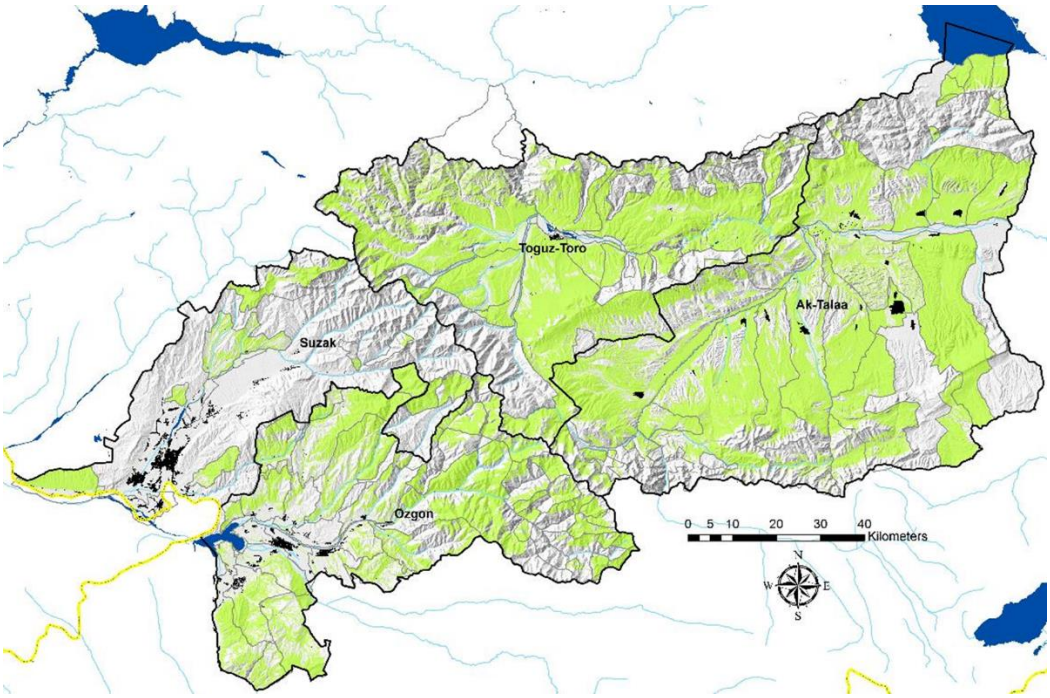


Figure 41: PUU assembled pastures in target rayons

Rayon	Rayon area (km²)	PUA area (km²)	No. PUUs	Pasture area (km²)	% Pasture area
Suzak	2669.03	677.73	5	321.27	47%
Toguz-Toro	3958.42	3353.08	12	2065.73	62%
Ak-Talaa	6484.51	5101.89	4	3223.87	63%
Uzgen	3446.18	3029.5	18	1544.26	51%
TOTAL	**16558.14**	**12162.2**	**39**	**7155.13**	**59%**

Table 8: Distribution of pastures in Pasture User Union territories, core target area

Topography

The Elevation layer was generated from the ASTER GDEM 30m, aggregated in 3 classes consistent with common distinction of seasonal pastures:

- winter (<1500m),
- spring/autumn (1500-2500m),
- summer (>2500m)

The slope layer was also derived from the ASTER GDEM 30m. Two only classes were considered:

- Slopes 0-25%: interest for pastures analysis
- Slopes > 25%: not of interest

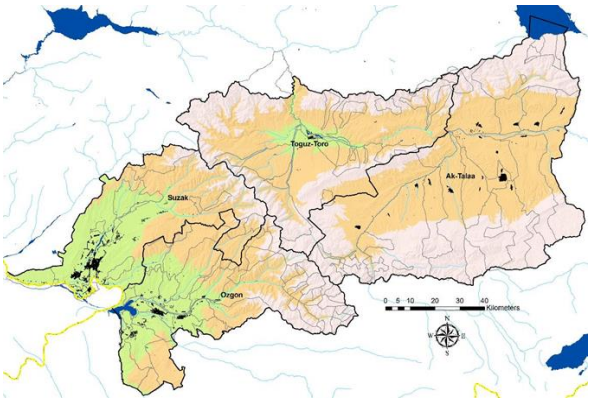


Figure 42: Elevation Map, 3 classes, core target area

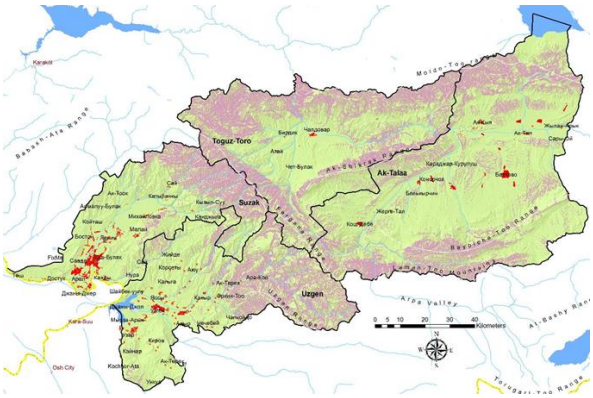


Figure 43: Slope Map, 2 classes, core target area

Altitude	Area (ha)
less than 1500 m	282,456
1500-2500 m	807,496
more than 2500 m	572,759
Grand Total	**1,662,711**

Table 9: Elevation 3 classes, core target area

Slope	Area (ha)
Slope 0-25%	1,237,927
Slope > 25%	424,784
Grand Total	**1,662,711**

Table 10: Slope 2 classes, core target area

NDVI trend 2003-2016

Using MODIS based NDVI data, this map depicts annual trend in NDVI index based on 16 days composite time series from 2003 to 2016. Shades of red show different degrees of vegetation loss. Green shows area where the trend is positive (increase vegetation).

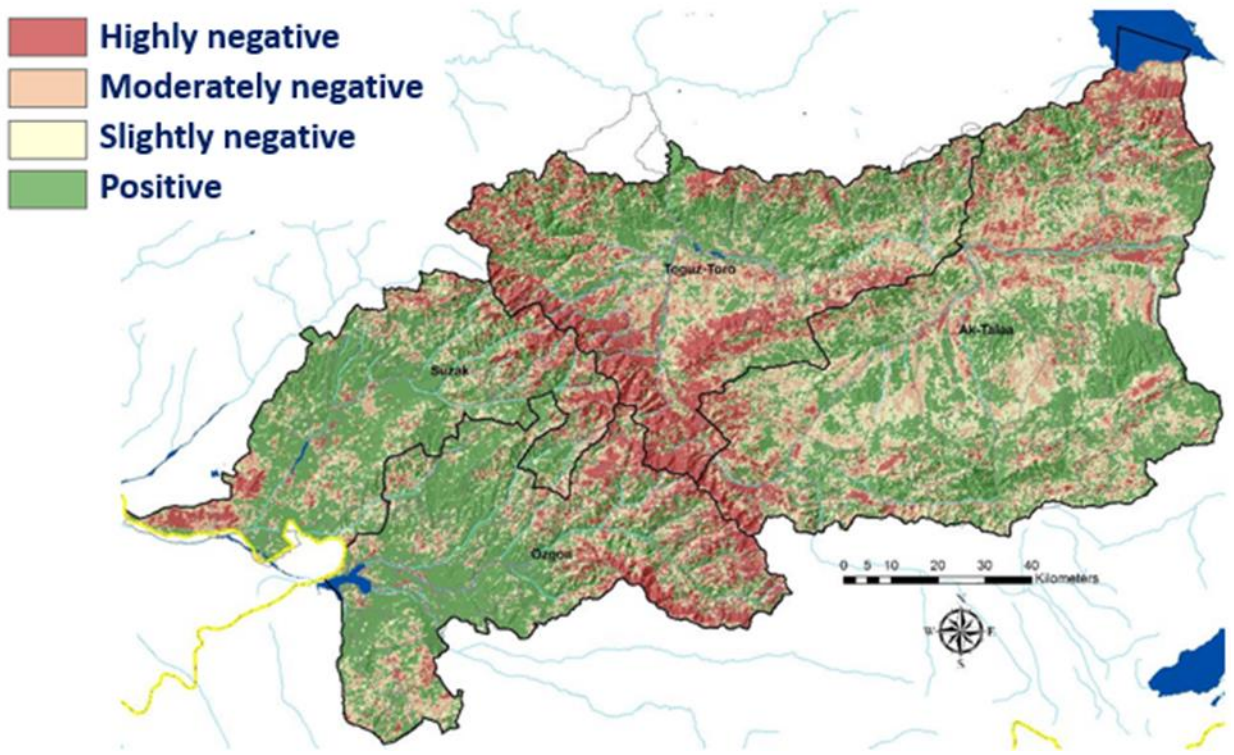


Figure 44: Classified Map of NDVI Trend 2003-2016, 4 target rayons

Rayon	highly negative	moderately negative	slightly negative	total negative km²	Positive km²	total area km²
Suzak	347.42	430.85	443.83	1222.11	1530.91	2753.02
Toguz-Toro	1024.61	826.93	687.94	2539.48	1395.46	3934.94
Ak-Talaa	763.31	1407.11	1737.45	3907.87	2603.90	6511.77
Uzgen	545.79	576.58	526.70	1649.07	1778.31	3427.38
TOTAL	**2681.13**	**3241.47**	**3395.93**	**9318.53**	**7308.58**	**16627.11**

Table 11: Summary classification by NDVI trend, core target area

Pasture units and vegetation trend analysis

Pastures, elevation classes, slope and trend NDVI have been combined in a spatially enabled model to produce a classified map of pasture areas, stratified per topography and PUU, based on mean NDVI trend.

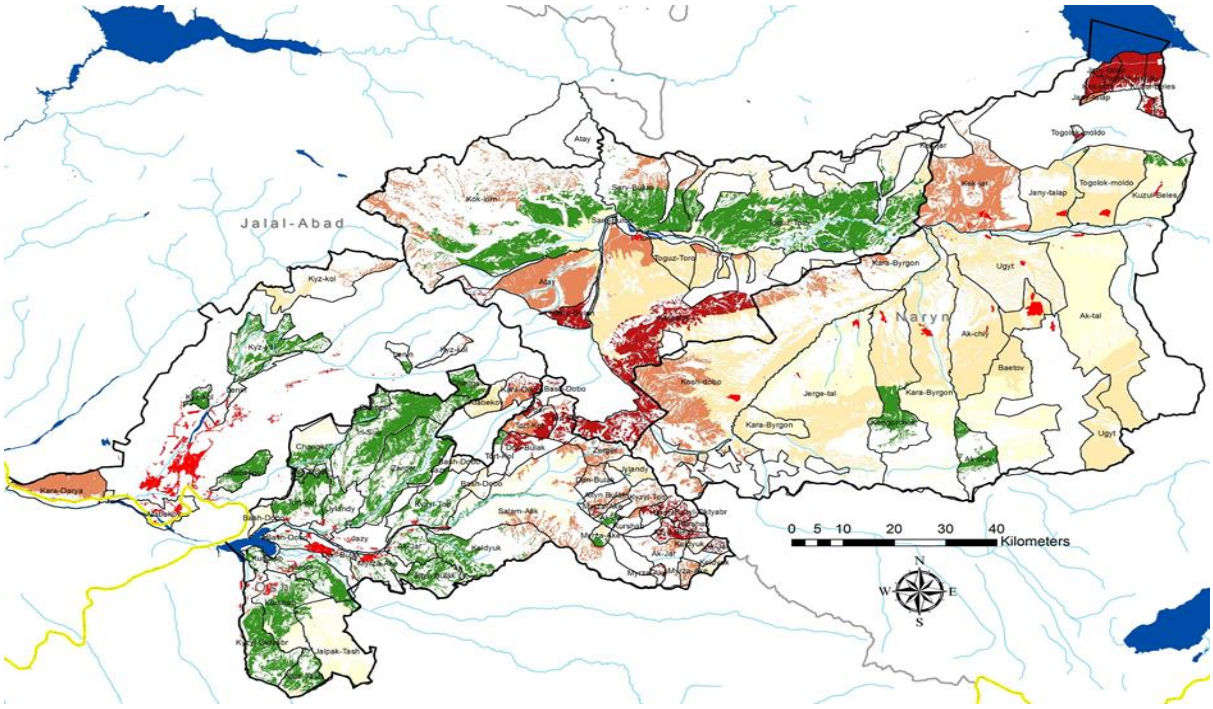


Figure 45: Classified map of pasture areas, stratified by topography and PUU

	Highly negative	Moderately negative	Slightly negative	Very slightly negative	POSITIVE	tot
less than 1500 m	**0**	2	4	3	29	**38**
1500-2500 m	**6**	7	20	8	25	**66**
more than 2500 m	**18**	20	13	3	7	**61**
Grand Total	**24**	**29**	**37**	**14**	**61**	**165**

Table 12: Summary vegetation classification pasture units, number

	Highly negative	Moderately negative	Slightly negative	Very slightly negative	POSITIVE	tot
less than 1500 m	**0**	12011.8	3721.8	7355.4	47904.6	**70993.6**
1500-2500 m	**4581.5**	32338.4	142069.7	75728.0	96277.1	**350994.8**
more than 2500 m	**37672.8**	47918.1	48322.1	26350.2	9494.9	**169758.1**
Grand Total	**42254.3**	**92268.3**	**194113.6**	**109433.6**	**153676.6**	**591746.4**

Table 13: Summary vegetation classification pasture units, area

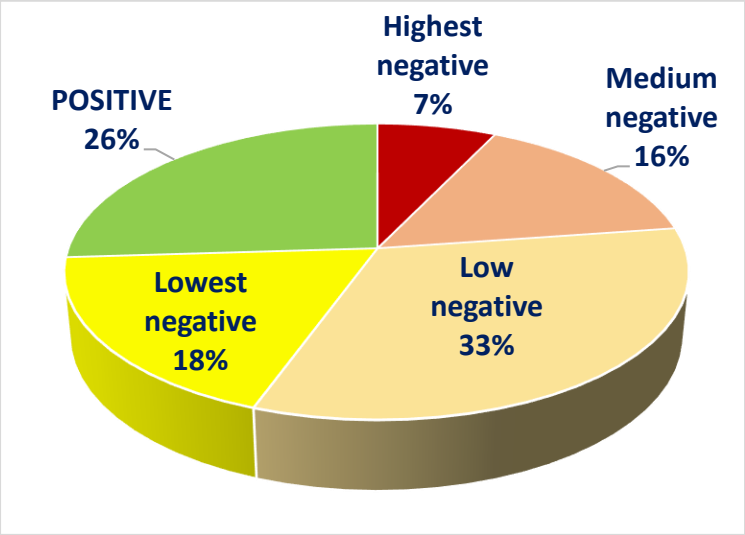


Figure 46: Chart Summary vegetation classification pasture units, percentage

Out of the 165 unique pasture units, 26 were selected representing the four groups of negative NDVI trends identified by this analysis, and analyzed in more detail against NDVI time series profile, accumulated annual NDVI (proxy for greenness production), precipitation temperatures, potential evapotranspiration and percentage of days in the year covered by snow.

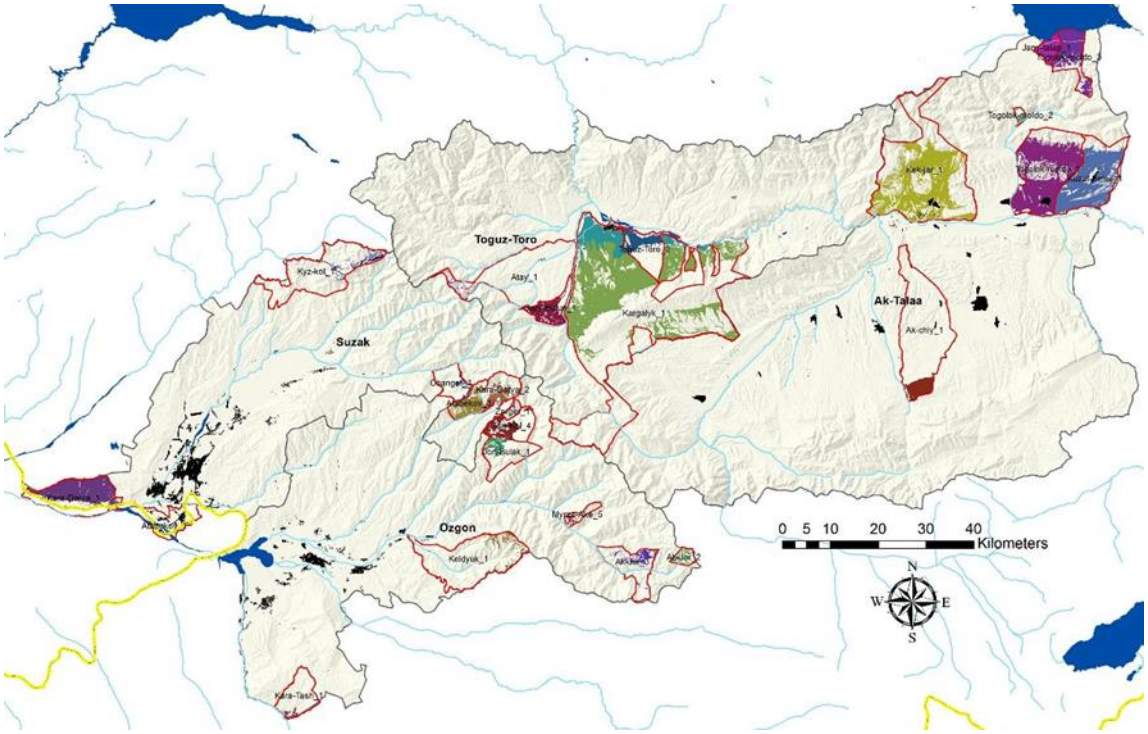


Figure 47: map of the 26 selected pasture unit for further vegetation and climatic description

Here is one example out of the 26 available in the pasture atlas.

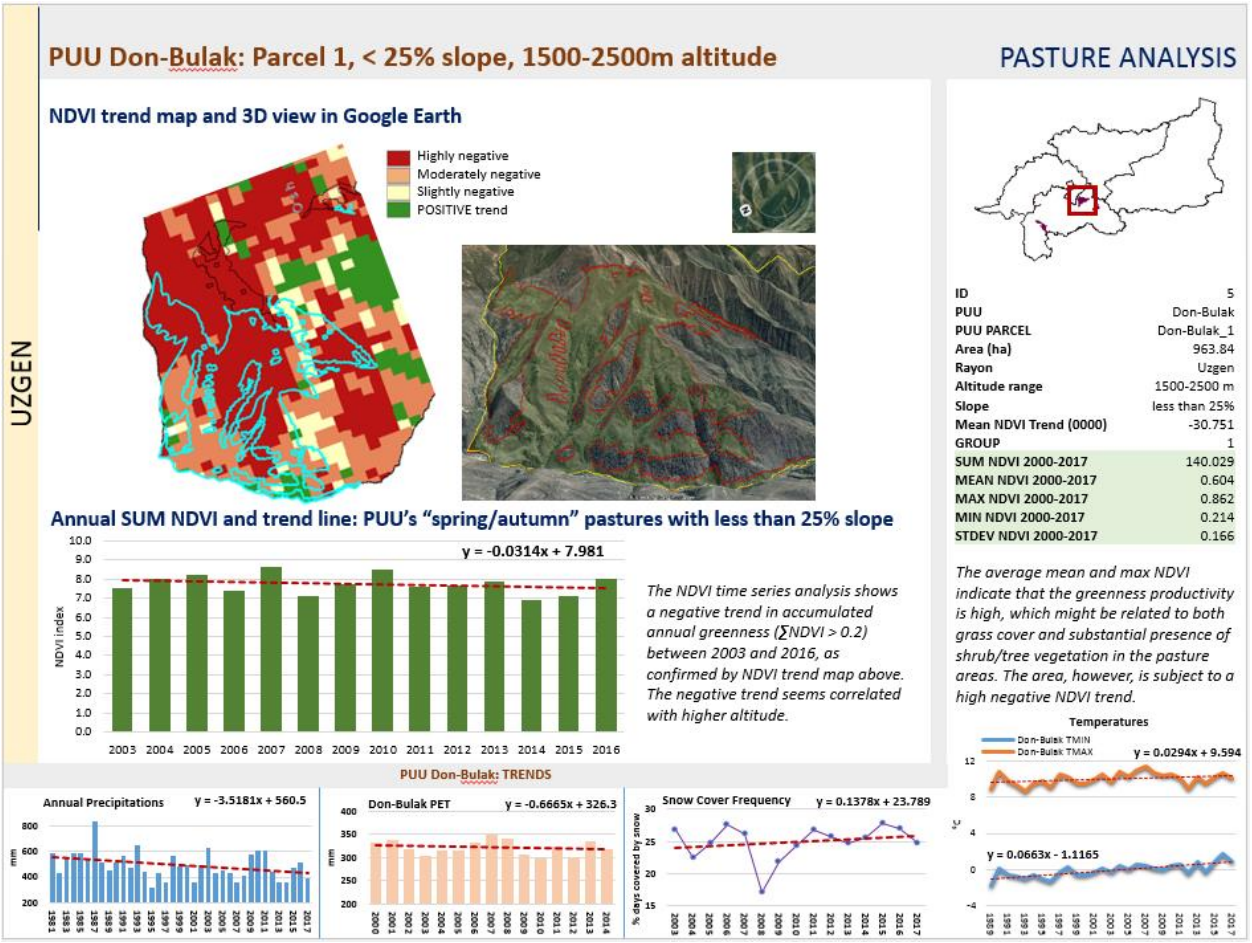


Figure 48: Sample descriptive form on pasture unit

The following interpretation of the data can be made:

- The NDVI time series analysis shows a negative trend in accumulated annual greenness (∑NDVI > 0.2) between 2003 and 2016, as confirmed by NDVI trend map above. The negative trend seems correlated with higher altitude.
- The average mean and max NDVI indicate that the greenness productivity is high, which might be related to both grass cover and substantial presence of shrub/tree vegetation in the pasture areas. The area, however, is subject to a high negative NDVI trend.
- Temperatures tend to increase, as generally detected in the area.
- Precipitations trend is quite strongly decreasing, with a 3.5 mm of rain annually lost in the last 325 years of observations
- Years of particularly low precipitation seems affecting the greenness production of the same year or the following.
- The number of snowy days is increasing in the period of observation, from 86 to 100.

5. FOREST ANALISYS TARGET AREA

6.1 Objective

Provide a basic overview of forest resources in the project target area by using previously developed databases and information. The forest layer has been stratified by 45 State Forest Fund (leshoz) and 2 National Reserve territories in the target Rayons and used to extract statistics, compare with NDVI time series trend, and develop informative slides with graphic, text, vegetation and climatic statistics for 8 selected territories with different vegetation conditions and located in different Rayons: Suzak, Toguz-Toro, Ak-Talaa and Uzgen.

6.2 Data

Here is the list of data layers used in this analysis:

- Forest data from Hansen's Global Forest Change database 2016
- State Forest Fund boundaries from 2009 Map of forestry mandate area distribution in Kyrgyz Republic
- Forest types from 2009 Forest Map of forest location of Kyrgyzstan (Kyrgyz/Swiss Project, KIRFOR)
- NDVI trend 2003-2016 from MODIS MOD13A1 product
- Topography from ASTER GDEM 30m

6.3 Outputs

- Forest territories border layer
- Forest layer stratified by forest territory (leshoz and national reserve)
- Classified map of forest territories by mean NDVI trend 2003-2016.
- Detailed analysis for 8 selected territories.

6.4 Methodology and Results

Methodology

Forty-seven (47) territories in the target rayons have been used to extract the mean NDVI trend value 2003-2016 by using a zonal statistics technique, and have been classified by using 3 classes of negative trend and 1 for all positives.

6.1.1. Forest layer

In absence of a recent, official national forest map, the forest layer here adopted is derived from the Hansen's Global Forest Cover Change 2016, v 1.4 dataset.

6.1.2. SFF and National Reserve borders layer

In absence of official boundaries, leshoz and reserve territories in the target Rayons have been derived digitizing boundaries from the a geo-referenced version of the layer available at the Kyrgyzstan's REACH Mapping Tool [http://reach-initiative.kg/].

6.1.3. NDVI 2003-2016 trend layer

The NDVI trend layer is generated using the Google platform and is derived from processing MOD13A1 Vegetation Indices 16-Day L3 Global time series available from 2003 to 2016.

Results

By using the forest layer, territories, the NDVI trend and various databases from the Google platform, statistics on percentage of forests and level of greenness have been generated. For a selection of 8 territories in the range of worse NDVI trend and representing the 4 target rayons, text, graphic and charts have been collected and assembled for each area to provide a comprehensive and holistic overview.

6.5 Forests in Kyrgyzstan

Forests of Kyrgyzstan are significantly divided into three typical forest vegetation: **Spruce forests** of the northern mountainous region, **Walnut forest** of southwest, and **Juniper forest** towards the southern border of Tajikistan. In addition, the willows and gummy forests have been distributed throughout as **shrub and riparian forests**. According to the 2008 Forest Typology publication[37], the distribution of forests in Kyrgyzstan (area ha) is the following: shrubs 470,900, Juniper 503,600, Spruce/fir 149,400, Other Broadleaved except walnut and pistachio 162,600, Walnut 47,000 and Pistachio 57,600.

Following is the map of type and distribution of main forests in Kyrgyzstan:

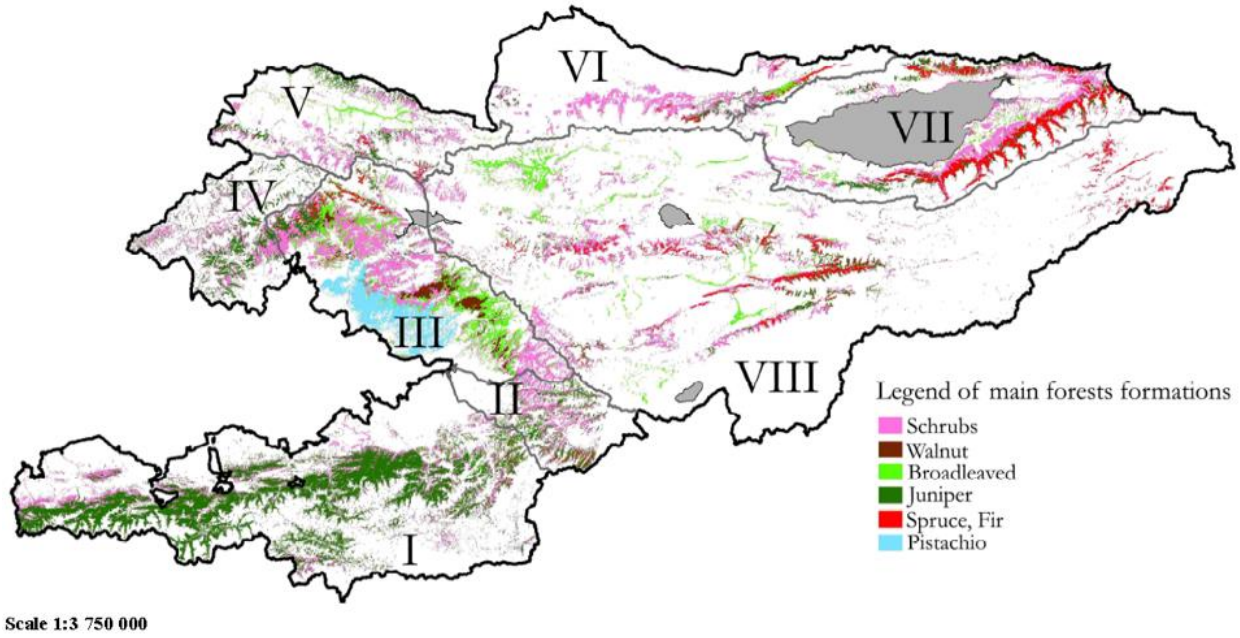


Figure 49: Map main forest formations in Kyrgyzstan

37 Source: 2008 Grisa E. Forest typology in the Kyrgyz Republic (http://msri-hub.ucentralasia.org/node/4483)

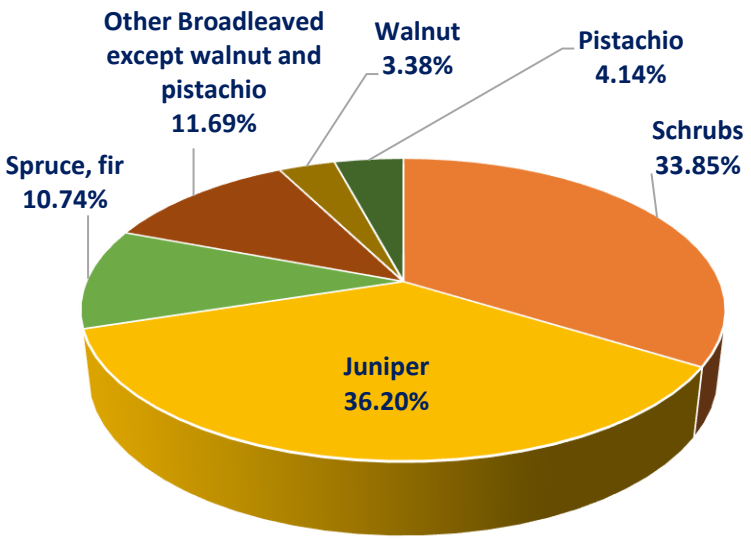


Figure 50: Chart of main forests distribution in Kyrgyzstan, percentage

Walnut Fruit Forests

The walnut forests occupy the northern and north-eastern slopes of the Fergana valley. The formation of certain forests depend on site conditions: the walnut forest stands use the most favorable habitats, i.e. the sites with the most moistened and fertile soils; in areas with severe conditions (dry soils of poor fertility) there grow shrubs and partly hawthorn and juniper stands, in the better forest growth conditions – maple forests.

Juniper forest

In Kyrgyzstan, the juniper forests occupy large tracts representing zones of coniferous tree vegetation. They are located mainly on steep slopes and have a very important ecological role. They grow under arid conditions or in very high altitudes up to 3,500 m a.s.l. in the very south of the country and dispersed over the country. These forests are typically open stands, formed by tree and crawling forms of Juniper.

Spruce forest

Occur in the west, in the center of the country and in the higher parts of the ranges north of the Fergana valley, mainly in altitudes between 1,700 and 3,000 m a.s.l. Small areas of stands with the endemic species can be found in the very west of the country. In the area of their distribution, the spruce forests grow on the slopes in a mosaic-like pattern. The spruce trees are grouped in strips and small arrays interspersed with glades, debris, and rocks. The spruce forest stands occupy, mainly, the slopes of the northern expositions (shadowed), while on the sunny slopes they grow only when there is additional moisture supply resulting from the condensation of moisture received from the nearby rocks.

State Forest Fund (SFF) and National Reserve Territories in target Rayons

The forests of the Kyrgyz Republic are State property and form a unified State Forestry Fund (SFF) which includes forests and lands that are not covered with forest but earmarked for future forestry activities. In 2003, the total area of the State Forest Fund lands was reported to be 3.3 million ha.

By using a geo-referenced version of the of the layer available at the Kyrgyzstan's REACH Mapping Tool for Kyrgyzstan[38], the 45 SFF territories and two large national reserves falling in the 4 target Rayons have been digitized and used to extract the total area of state forests and the proportion of forests according to the Hansen's Global Forest 2016 database[39] (Tree cover > 10%).

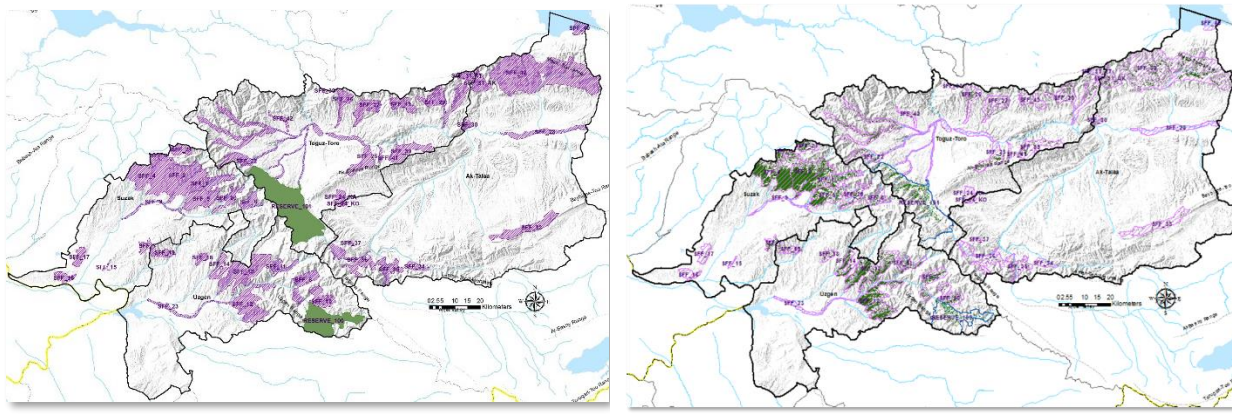


Figure 51: Maps of State Forest Fund territories and forests, core target area

The following table shows the results:

name	area (ha)	Area Forest (ha)	Area Forest (%)
RESERVE_100	14946.55	1251.66	8.37%
RESERVE_101	32792.31	2472.68	7.54%
SFF_1	10868.93	4853.27	44.65%
SFF_2	10255.71	5334.68	52.02%
SFF_3	2664.40	1063.49	39.91%
SFF_4	15148.99	8190.57	54.07%
SFF_5	7781.34	3153.13	40.52%
SFF_6	2734.42	333.63	12.20%

[38] *http://reach-initiative.kg/*

[39] *https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.4.html*

SFF_7	1485.29	483.83	32.57%
SFF_8	5515.16	1095.93	19.87%
SFF_9	1725.21	18.72	1.09%
SFF_10	4966.95	659.84	13.28%
SFF_11	3137.10	788.61	25.14%
SFF_12	12011.53	6228.65	51.86%
SFF_13	13870.07	5289.23	38.13%
SFF_14	2957.38	1674.54	56.62%
SFF_15	259.96	0.00	0.00%
SFF_16	2048.24	0.00	0.00%
SFF_17	2250.63	0.00	0.00%
SFF_18	1365.19	202.67	14.85%
SFF_19	2210.04	306.22	13.86%
SFF_20	3557.24	973.50	27.37%
SFF_21	3021.18	988.23	32.71%
SFF_22	19675.92	2837.08	14.42%
SFF_23	3051.54	133.00	4.36%
SFF_24_KA	1870.38	4.51	0.24%
SFF_24_KO	623.11	5.26	0.84%
SFF_25	7139.56	600.15	8.41%
SFF_26	3919.71	269.91	6.89%
SFF_27	5350.85	149.61	2.80%
SFF_28	5039.14	35.35	0.70%
SFF_29	10319.23	645.47	6.25%
SFF_30	1305.89	1.50	0.11%
SFF_31_AK	3772.54	215.15	5.70%
SFF_31_TT	2051.50	18.72	0.91%
SFF_32	45227.09	3302.26	7.30%
SFF_33	7613.48	121.09	1.59%
SFF_34	1806.02	88.69	4.91%
SFF_35	4330.60	121.47	2.80%
SFF_36	6719.83	269.91	4.02%
SFF_37	190.01	30.91	16.27%
SFF_38	235.17	49.59	21.09%
SFF_39	6404.94	589.70	9.21%
SFF_40	2265.20	0.74	0.03%
SFF_41	671.44	66.69	9.93%
SFF_42	1128.24	112.82	10.00%
SFF_43	4043.33	63.62	1.57%
	302328.55	**55096.30**	**18.22%**

Table 14: Distribution of forests in State Forest Fund and National Reserve territories

State Forest Fund / National Reserve territories and vegetation analysis

The analyzed territory occupies about 18% of the 4 rayons land, and include nearly 18.2% of forest.

By measuring the mean DDVI trend for the period 2003-2016 in each SFF, a classification of these territories was made to identify the ones with worse tendency in greenness productivity.

The table and map below show the distribution of SFFs according to 4 classes of NDVI trend:

Mean NDVI trend	area (ha)	Forested area (ha)	% Forest
Highly negative	**43731.29**	**3111.97**	**7.12%**
Moderately negative	38243.31	3933.75	10.29%
Slightly negative	143402.95	24627.99	17.17%
Positive	76951.00	23422.60	30.44%
	302328.55	**55096.30**	**18.22%**

Table 15: Summary classification of SFFs by mean NDVI trend and forest area

Few very negative territories in terms of vegetation trend have been identified in the Toguz-Toro rayon, where most forests are exposed to the North. The Walnut forest areas (Suzak) are the ones showing positive NDVI trends. The national reserves are showing negative trends.

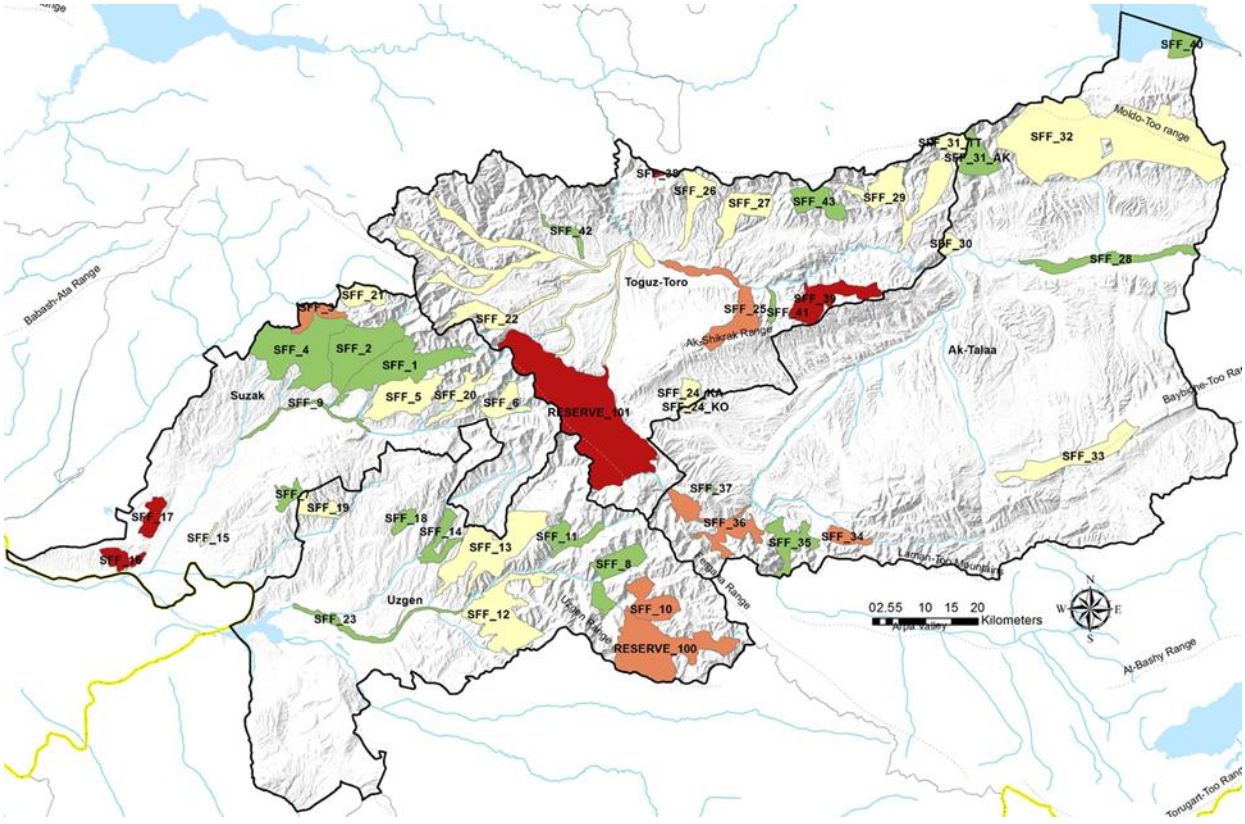


Figure 52: Map of classified SFFs based on mean NDVI trend

Following is the table of all statistics at SFF/National Reserve level. The highlighted territories (8) have been analyzed in detail. The keys to read these data are:

Forest: statistics of forest presence by using the Hansen's database

Altitude: statistics from Digital Elevation Model (ASTER GDEM 30m) in the SFF area

Trend: mean 2003-2016 annual NDVI trend 2003-2016 (0000) in SFF

NDVI 2000-2017: overall statistics from 16 day based time series

			HANSEN Forest		ALTITUDE (m)				NDVI Trend 2003-2016	NDVI 2003- 2016				
name	name2	area (ha)	area (ha)	area (%)	MIN	MAX	MEAN	MAJORITY	Mean (0000)	SUM	MEAN	MAX	MIN	STDEV
RESERVE_101	RESERVE_101_Toguz-Toro	32792.31	2472.68	7.54%	1644	3674	2716	2924	-38.441	72.98	0.4770	0.7050	0.2010	0.1418
SFF_38	SFF_38_Sary-Bulun	235.17	49.59	21.09%	2508	3028	2765	2766	-37.806	88.97	0.5327	0.7699	0.2057	0.1577
SFF_17	SFF_17_Kara-Almin	2250.63	0.00	0.00%	791	1242	1019	1020	-27.203	75.39	0.3128	0.5725	0.2009	0.0926
SFF_39	SFF_39_Toguz-Toro	6404.94	589.70	9.21%	1371	3760	2609	2704	-26.532	59.51	0.3696	0.5149	0.2011	0.0900
SFF_16	SFF_16_Kara-Almin	2048.24	0.00	0.00%	712	1140	959	1026	-24.583	65.18	0.2963	0.5704	0.2000	0.0898
RESERVE_100	RESERVE_100_Uzgen	14946.55	1251.66	8.37%	1774	4206	2863	2669	-18.133	76.66	0.4791	0.6862	0.2053	0.1439
SFF_3	SFF_3_Kara-Almin	2664.40	1063.49	39.91%	1472	2680	2040	2085	-15.069	108.47	0.5620	0.8455	0.2056	0.1584
SFF_36	SFF_36_Kosh-dobo	6719.83	269.91	4.02%	2113	3817	2712	2535	-14.736	62.91	0.3957	0.6158	0.2021	0.1143
SFF_25	SFF_25_Kargalyk	7139.56	600.15	8.41%	1252	3621	2049	1277	-14.189	55.63	0.3477	0.4951	0.2051	0.0807
SFF_34	SFF_34_Jerge-tal	1806.02	88.69	4.91%	2689	3538	3008	2858	-13.915	67.59	0.4446	0.6661	0.2018	0.1167
SFF_10	SFF_10_Karool	4966.95	659.84	13.28%	1957	3192	2574	2618	-10.956	88.61	0.5306	0.7777	0.2090	0.1585
SFF_20	SFF_20_Kara-Almin	3557.24	973.50	27.37%	1581	2941	2115	1932	-9.632	100.18	0.5692	0.8228	0.2042	0.1732
SFF_26	SFF_26_Sary-Bulun	3919.71	269.91	6.89%	1439	3319	2541	2884	-8.389	77.13	0.4791	0.6866	0.2003	0.1401
SFF_13	SFF_13_Kyzyl-Too	13870.07	5289.23	38.13%	1211	2918	1872	1875	-8.341	119.80	0.5872	0.8532	0.2006	0.1740
SFF_15	SFF_15_Tash-Bulak	259.96	0.00	0.00%	766	1082	930	1030	-8.331	92.59	0.3534	0.6748	0.2012	0.1192
SFF_21	SFF_21_Kyz-kol	3021.18	988.23	32.71%	1646	3860	2457	2105	-8.091	90.58	0.5328	0.7505	0.2078	0.1464
SFF_31_TT	SFF_31_Toguz-Toro	2051.50	18.72	0.91%	2628	3911	3150	3014	-7.860	49.05	0.3744	0.5637	0.2044	0.0940
SFF_22	SFF_22_Kara-Suu	19675.92	2837.08	14.42%	1224	3862	1990	1241	-7.190	84.82	0.4610	0.6770	0.2027	0.1438
SFF_32	SFF_32_Kek-jar	45227.09	3302.26	7.30%	1976	3904	2935	3197	-7.099	64.74	0.4098	0.5954	0.2009	0.1093
SFF_24_KA	SFF_24_Kargalyk	1870.38	4.51	0.24%	2293	2718	2447	2450	-7.037	57.21	0.3488	0.6030	0.2012	0.1064
SFF_30	SFF_30_Kek-jar	1305.89	1.50	0.11%	1532	2468	2011	2130	-5.599	25.31	0.2556	0.3343	0.2009	0.0354
SFF_19	SFF_19_Changet	2210.04	306.22	13.86%	1247	2270	1752	1642	-4.529	112.65	0.5168	0.8094	0.2099	0.1561
SFF_5	SFF_5_Kara-Almin	7781.34	3153.13	40.52%	1378	2894	1929	1943	-3.506	116.36	0.5936	0.8412	0.2006	0.1654
SFF_6	SFF_6_Kara-Almin	2734.42	333.63	12.20%	1835	3192	2263	2191	-3.464	83.40	0.5054	0.7346	0.2163	0.1374
SFF_33	SFF_33_Baetov	7613.48	121.09	1.59%	2409	3541	2976	3051	-2.630	63.68	0.3980	0.6147	0.2001	0.1102
SFF_27	SFF_27_Toguz-Toro	5350.85	149.61	2.80%	1392	3387	2547	2991	-1.676	80.35	0.4727	0.7299	0.2004	0.1508
SFF_12	SFF_12_Salam-Alik	12011.53	6228.65	51.86%	1240	2744	1950	2027	-0.755	119.20	0.5960	0.8446	0.2110	0.1795
SFF_29	SFF_29_Toguz-Toro	10319.23	645.47	6.25%	1495	3661	2517	2749	-0.143	66.13	0.3694	0.5535	0.2015	0.0989
SFF_24_KO	SFF_24_Kosh-dobo	623.11	5.26	0.84%	2301	2740	2511	2519	-0.026	63.59	0.3785	0.6388	0.2024	0.1221
SFF_35	SFF_35_Kosh-dobo	4330.60	121.47	2.80%	2158	3766	2716	2783	0.131	40.28	0.2857	0.3985	0.2005	0.0533
SFF_41	SFF_41_Kargalyk	671.44	66.69	9.93%	1357	2576	1889	1687	0.857	53.99	0.3067	0.4398	0.2007	0.0692
SFF_4	SFF_4_Kara-Almin	15148.99	8190.57	54.07%	1341	2929	1818	1738	1.147	125.18	0.5989	0.8277	0.2127	0.1553
SFF_43	SFF_43_Toguz-Toro	4043.33	63.62	1.57%	2016	3798	2883	2847	1.288	68.22	0.4401	0.6662	0.2136	0.1239
SFF_31_AK	SFF_31_Ak-Talaa	3772.54	215.15	5.70%	2305	3990	2912	2814	1.498	60.04	0.3706	0.5637	0.2047	0.0903
SFF_11	SFF_11_Salam-Alik	3137.10	788.61	25.14%	1509	2718	2020	1988	1.542	113.56	0.5884	0.8452	0.2052	0.1789
SFF_14	SFF_14_Zerger	2957.38	1674.54	56.62%	1288	2160	1734	1838	1.776	124.03	0.5906	0.8556	0.2056	0.1709
SFF_8	SFF_8_Altyn Bulak	5515.16	1095.93	19.87%	1599	3102	2257	2281	2.567	100.74	0.5724	0.8126	0.2050	0.1681
SFF_1	SFF_1_Kara-Almin	10868.93	4853.27	44.65%	1234	2566	1903	1839	2.870	114.25	0.5920	0.8407	0.2004	0.1716
SFF_18	SFF_18_Zerger	1365.19	202.67	14.85%	1383	2012	1638	1549	4.481	120.74	0.5564	0.8188	0.2072	0.1500

SFF_28	SFF_28_Ak-tal	5039.14	35.35	0.70%	1561	1859	1633	1640	5.039	23.55	0.2265	0.2682	0.2007	0.0159
SFF_9	SFF_9_Kyz-kol	1725.21	18.72	1.09%	991	1658	1185	1173	7.187	68.52	0.3263	0.7670	0.2000	0.0991
SFF_2	SFF_2_Kara-Almin	10255.71	5334.68	52.02%	1276	2910	1845	1821	7.722	127.25	0.6299	0.8579	0.2290	0.1688
SFF_37	SFF_37_Kosh-dobo	190.01	30.91	16.27%	2567	3005	2779	2831	9.236	71.93	0.4467	0.6793	0.2023	0.1218
SFF_7	SFF_7_Atabekov	1485.29	483.83	32.57%	1218	2153	1694	1572	10.591	109.78	0.5203	0.8158	0.2081	0.1617
SFF_40	SFF_40_Togolok-Moldovan	2265.20	0.74	0.03%	2995	3031	3006	3005	14.220	55.16	0.3727	0.5819	0.2070	0.0919
SFF_42	SFF_42_Atay	1128.24	112.82	10.00%	1397	2560	1823	1562	16.823	77.28	0.3770	0.5896	0.2022	0.1133
SFF_23	SFF_23_Jazy	3051.54	133.00	4.36%	883	1296	1029	959	25.714	83.67	0.3530	0.6709	0.2005	0.0901

Table 16: Results of SFFs analysis and statistics

Here is an example of SFF territory analyzed for vegetation/climatic conditions:

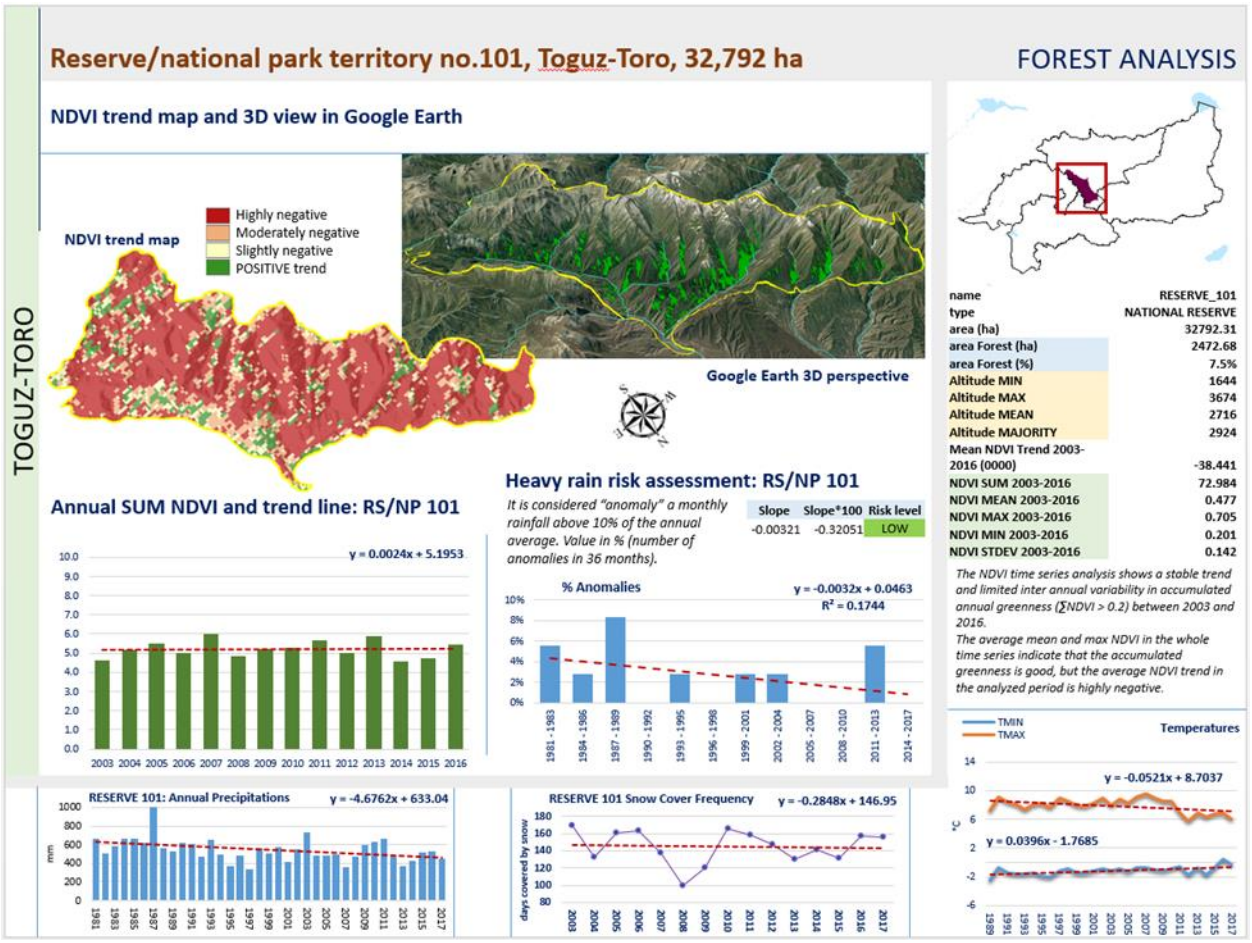


Figure 53: Sample descriptive form for one of the two national reserves

Looking at the data, the following may be summarized:

- The negative NDVI trends seems to be concentrated in area with low vegetation and steep slopes.
- Forests are mainly detected on slopes exposed to North.
- The NDVI mean and max in the area suggest that the greenness production averaged in the area is not high and is associated also with a substantial overall negative trend in NDVI.
- The NDVI time series analysis between 2003 and 2016, which is also the period on which the map is generated, shows a stable trend and limited inter annual variability in accumulated annual greenness (∑NDVI > 0.2).
- Precipitations are reducing and the NDVI trend seems not affected by rainfall inter annual variability.
- Because of the overall reduction in precipitations, also the heavy rain risk is assessed low.

6. HEAVY RAIN RISK ASSESSMENT

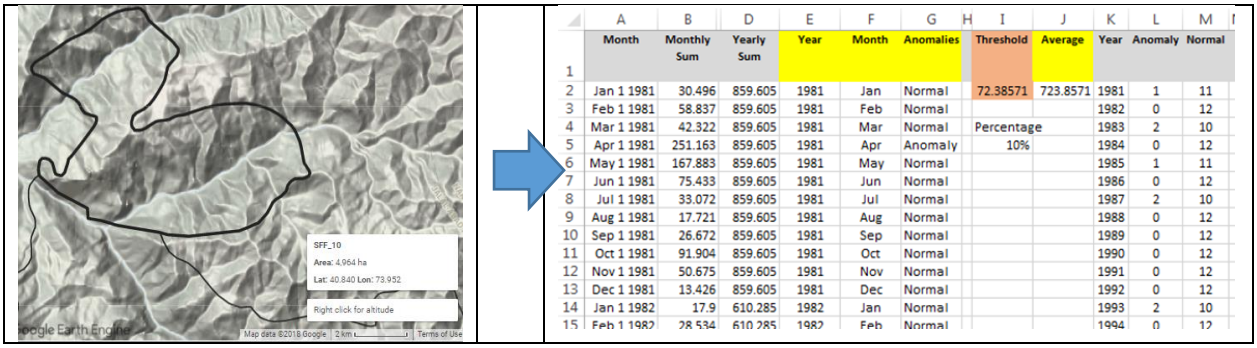
This assessment has been conducted applying an analysis approach based on available time series of spatially enabled precipitation data and knowledge of local indications of "normal" and "anomaly" rainfalls.

6.1 Methodology

This assessment has been conducted by using precipitations from the CHIRPS[40] database available through the Google Earth Engine computing platform, which provides spatialized monthly data from 1981 to current (36 years) with a cell resolution of about 25 km^2 and values in mm.

The analysis has been conducted at local scale by using boundaries of State Forest Fund (leshoz), national reserves and available Pasture-Users Union areas in the core four target rayons.

Through functionalities exposed by the FAO's tool Earth Map, monthly total precipitations for the period 1981-2017 have been extracted per each territory and processed in a simple Excel worksheet.



	A	B	D	E	F	G	H	I	J	K	L	M	I
1	Month	Monthly Sum	Yearly Sum	Year	Month	Anomalies		Threshold	Average	Year	Anomaly	Normal	
2	Jan 1 1981	30.496	859.605	1981	Jan	Normal		72.38571	723.8571	1981	1	11	
3	Feb 1 1981	58.837	859.605	1981	Feb	Normal				1982	0	12	
4	Mar 1 1981	42.322	859.605	1981	Mar	Normal		Percentage		1983	2	10	
5	Apr 1 1981	251.163	859.605	1981	Apr	Anomaly		10%		1984	0	12	
6	May 1 1981	167.883	859.605	1981	May	Normal				1985	1	11	
7	Jun 1 1981	75.433	859.605	1981	Jun	Normal				1986	0	12	
8	Jul 1 1981	33.072	859.605	1981	Jul	Normal				1987	2	10	
9	Aug 1 1981	17.721	859.605	1981	Aug	Normal				1988	0	12	
10	Sep 1 1981	26.672	859.605	1981	Sep	Normal				1989	0	12	
11	Oct 1 1981	91.904	859.605	1981	Oct	Normal				1990	0	12	
12	Nov 1 1981	50.675	859.605	1981	Nov	Normal				1991	0	12	
13	Dec 1 1981	13.426	859.605	1981	Dec	Normal				1992	0	12	
14	Jan 1 1982	17.9	610.285	1982	Jan	Normal				1993	2	10	
15	Feb 1 1982	28.534	610.285	1982	Feb	Normal				1994	0	12	

Figure 54: FAO's Earth Map

The approach adopted to perform this analysis is to calculate, on a monthly basis, the deviation from the "normal" conditions, which is identified as a percentage of the annual average. For Kyrgyzstan, based on local information extendible to the whole Country, this "threshold" was estimated as the 10% of the annual average.

[40] *Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), http://chg.geog.ucsb.edu/data/chirps/*

	A	B	D	E	F	G	H	I	J	K	L	M
1	Month	Monthly Sum	Yearly Sum	Year	Month	Anomalies		Threshold	Average	Year	Anomaly	Normal
2	Jan 1 1981	30.496	859.605	1981	Jan	Normal		72.38571	723.8571	1981	1	11
3	Feb 1 1981	58.837	859.605	1981	Feb	Normal				1982	0	12
4	Mar 1 1981	42.322	859.605	1981	Mar	Normal		Percentage		1983	2	10
5	Apr 1 1981	251.163	859.605	1981	Apr	Anomaly		10%		1984	0	12
6	May 1 1981	167.883	859.605	1981	May	Normal				1985	1	11
7	Jun 1 1981	75.433	859.605	1981	Jun	Normal				1986	0	12
8	Jul 1 1981	33.072	859.605	1981	Jul	Normal				1987	2	10
9	Aug 1 1981	17.721	859.605	1981	Aug	Normal				1988	0	12
10	Sep 1 1981	26.672	859.605	1981	Sep	Normal				1989	0	12
11	Oct 1 1981	91.904	859.605	1981	Oct	Normal				1990	0	12
12	Nov 1 1981	50.675	859.605	1981	Nov	Normal				1991	0	12
13	Dec 1 1981	13.426	859.605	1981	Dec	Normal				1992	0	12
14	Jan 1 1982	17.9	610.285	1982	Jan	Normal				1993	2	10
15	Feb 1 1982	28.534	610.285	1982	Feb	Normal				1994	0	12

Figure 55: Heavy Rain Risk Assessment processing: threshold

Each monthly total precipitations was compared with the threshold and classified as an "anomaly" or not. By counting all anomalies in groups of three years and calculating their ratio with the number of observations (thirty-six months), a time series has been developed and a linear regression calculated.

	O	P	Q	R	S	T	U	V
	Years	Anomalies	Normal	% Anomalies		Slope	Slope*100	Risk level
	1981 - 1983	3	33	8%		-0.00104	-0.10441	Low
	1984 - 1986	1	35	3%				
	1987 - 1989	2	34	6%				
	1990 - 1992	0	36	0%				
	1993 - 1995	2	34	6%				
	1996 - 1998	0	36	0%				
	1999 - 2001	1	35	3%				
	2002 - 2004	1	35	3%				
	2005 - 2007	0	36	0%				
	2008 - 2010	3	33	8%				
	2011 - 2013	2	34	6%				
	2014 - 2017	1	47	2%				

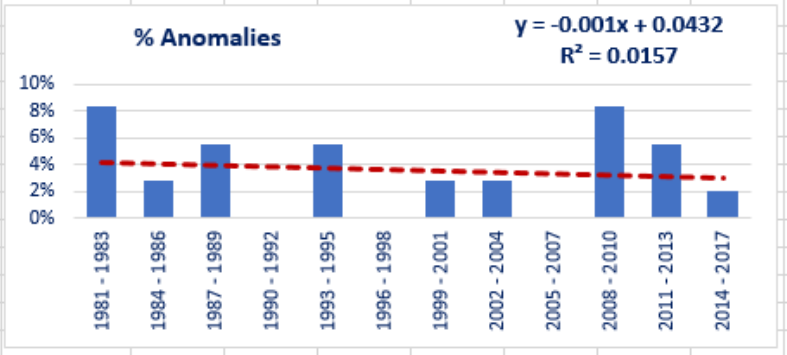


Figure 56: Heavy Rain Risk Assessment processing: linear regression

The slope of the linear regression represents the change rate, in percentage, of occurring anomalies expected each 36 months. All negative slopes indicate an increasing trend in the occurrence of such events, while the positives indicate that the events are reducing.

6.2 Results for SFF and National Reserve areas

name	area ha	type	rayon	ayil_aimak	rate of change (%)	CLASS
RESERVE_100	14946.55	RESERVES or NATIONAL PARK	Uzgen	Uzgen_reserve	0.03157	STABLE
RESERVE_101	32792.31	RESERVES or NATIONAL PARK	Toguz-Toro	Toguz-Toro_reserve	-0.32051	LOW
SFF_1	10868.93	Leshoz	Suzak	Kara-Almin	-0.34722	LOW
SFF_2	10255.71	Leshoz	Suzak	Kara-Almin	-0.43706	LOW
SFF_3	2664.40	Leshoz	Suzak	Kara-Almin	-0.48563	LOW
SFF_4	15148.99	Leshoz	Suzak	Kara-Almin	-0.31808	LOW
SFF_5	7781.34	Leshoz	Suzak	Kara-Almin	-0.40550	LOW
SFF_6	2734.42	Leshoz	Suzak	Kara-Almin	-0.39821	LOW
SFF_7	1485.29	Leshoz	Suzak	Atabekov	-0.32051	LOW
SFF_8	5515.16	Leshoz	Uzgen	Altyn Bulak	0.17725	HIGH
SFF_9	1725.21	Leshoz	Suzak	Kyz-kol	-0.47348	LOW
SFF_10	4966.95	Leshoz	Uzgen	Karool	-0.10441	LOW
SFF_11	3137.10	Leshoz	Uzgen	Salam-Alik	0.17725	HIGH
SFF_12	12011.53	Leshoz	Uzgen	Salam-Alik	-0.42492	LOW
SFF_13	13870.07	Leshoz	Uzgen	Kyzyl-Too	-0.19182	LOW
SFF_14	2957.38	Leshoz	Uzgen	Zerger	-0.46377	LOW
SFF_15	259.96	Leshoz	Suzak	Tash-Bulak	-0.33751	LOW
SFF_16	2048.24	Leshoz	Suzak	Kara-Almin	-0.23067	LOW
SFF_17	2250.63	Leshoz	Suzak	Kara-Almin	-0.34722	LOW
SFF_18	1365.19	Leshoz	Uzgen	Zerger	-0.68716	VERY LOW
SFF_19	2210.04	Leshoz	Uzgen	Changet	-0.86441	VERY LOW
SFF_20	3557.24	Leshoz	Suzak	Kara-Almin	-0.26952	LOW
SFF_21	3021.18	Leshoz	Suzak	Kyz-kol	-0.59246	VERY LOW
SFF_22	19675.92	Leshoz	Toguz-Toro	Kara-Suu	-0.37879	LOW
SFF_23	3051.54	Leshoz	Uzgen	Jazy	-0.36908	LOW
SFF_24_KA	1870.38	Leshoz	Toguz-Toro	Kargalyk	0.14812	HIGH
SFF_24_KO	623.11	Leshoz	Ak-Talaa	Kosh-dobo	0.11898	HIGH
SFF_25	7139.56	Leshoz	Toguz-Toro	Kargalyk	0.15783	HIGH
SFF_26	3919.71	Leshoz	Toguz-Toro	Sary-Bulun	0.28409	HIGH
SFF_27	5350.85	Leshoz	Toguz-Toro	Toguz-Toro	0.35208	HIGH
SFF_28	5039.14	Leshoz	Ak-Talaa	Ak-tal	0.18454	HIGH
SFF_29	10319.23	Leshoz	Toguz-Toro	Toguz-Toro	0.39578	HIGH
SFF_30	1305.89	Leshoz	Ak-Talaa	Kek-jar	0.44920	HIGH
SFF_31_AK	3772.54	Leshoz	Ak-Talaa	Toguz-Toro	0.54876	VERY HIGH
SFF_31_TT	2051.50	Leshoz	Toguz-Toro	Toguz-Toro	0.54876	VERY HIGH
SFF_32	45227.09	Leshoz	Ak-Talaa	Kek-jar	0.42007	HIGH
SFF_33	7613.48	Leshoz	Ak-Talaa	Baetov	0.38850	HIGH
SFF_34	1806.02	Leshoz	Ak-Talaa	Jerge-tal	0.15540	HIGH
SFF_35	4330.60	Leshoz	Ak-Talaa	Kosh-dobo	0.42007	HIGH
SFF_36	6719.83	Leshoz	Ak-Talaa	Kosh-dobo	0.17725	HIGH

SFF_37	190.01	Leshoz	Ak-Talaa	Kosh-dobo	0.35208	HIGH
SFF_38	235.17	Leshoz	Toguz-Toro	Sary-Bulun	0.43949	HIGH
SFF_39	6404.94	Leshoz	Toguz-Toro	Toguz-Toro	0.42007	HIGH
SFF_40	2265.20	Leshoz	Ak-Talaa	Togolok-Moldovan	0.39578	HIGH
SFF_41	671.44	Leshoz	Toguz-Toro	Kargalyk	0.20639	HIGH
SFF_42	1128.24	Leshoz	Toguz-Toro	Atay	-0.47591	LOW
SFF_43	4043.33	Leshoz	Toguz-Toro	Toguz-Toro	0.35208	HIGH

Table 17: Heavy Rain Risk Assessment results, SFF

47 units were analyzed, 2 of which in the category of national reserves. The area overall area is 302,329 ha (18.2% of 4 rayons land), of which 55,096 ha is forest (Hansen database). According to this assessment, low and high risks combined make almost 91% of the total area, with the low risk at almost exactly 50% of the total area.

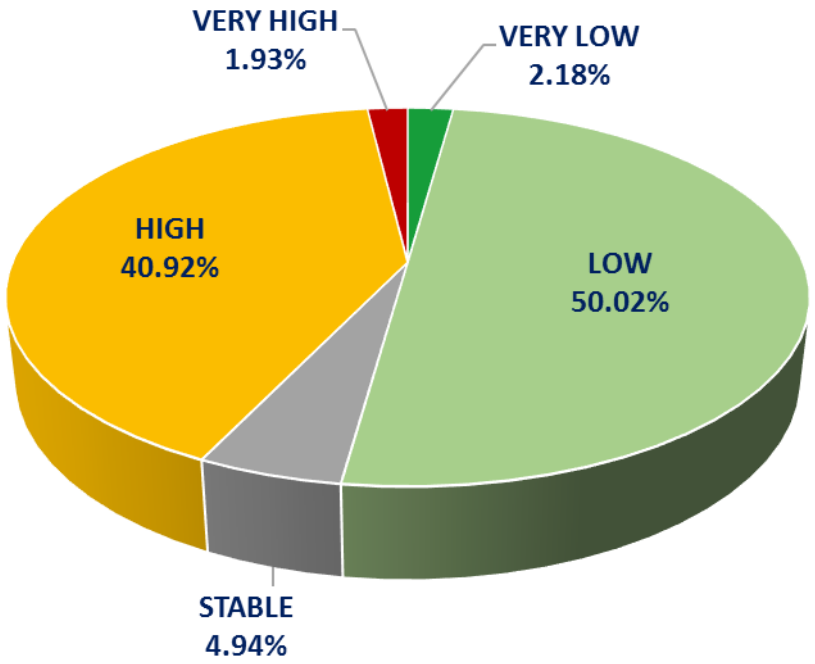


Figure 57: Chart of distribution of Heavy Rain Risk levels in SFF and National Reserve areas

The map below shows a clear difference between areas at West and areas at East of the target rayons, which reflect the trends in precipitations that shows the areas with increases in rainfall all concentrated at East (greens).

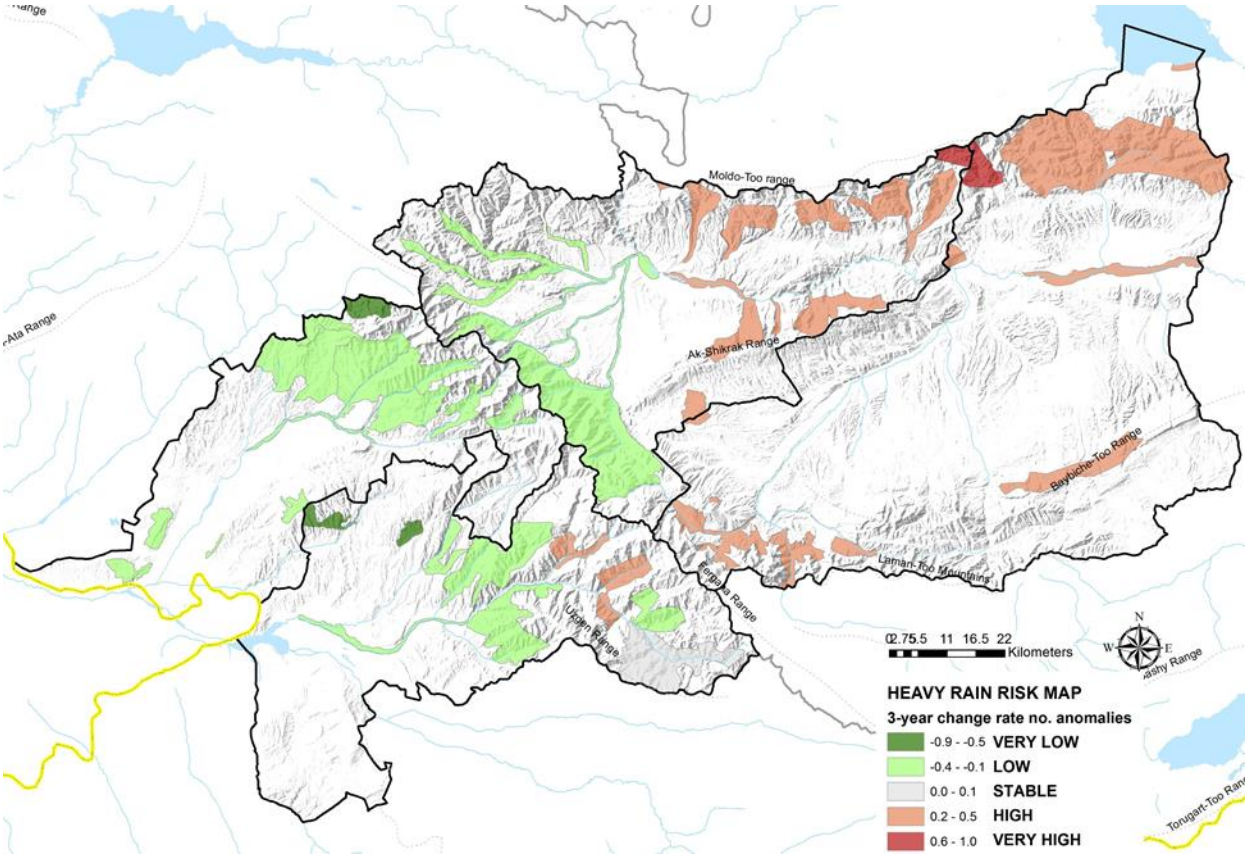


Figure 58: Map of Heavy Rain Risk Assessment in SFF and National Reserve areas

6.3 Results for Pasture Users Union areas

name	rayon	type	PUU ha	Pasture ha	rate of change (%)	CLASS
Ak-chiy	Ak-Talaa	Pasture Users Union	32,841	18,232	0.310800	HIGH
Ak-Jar	Uzgen	Pasture Users Union	15,692	3,662	0.157828	HIGH
Ak-tal	Ak-Talaa	Pasture Users Union	46,601	40,074	0.155400	HIGH
Altyn Bulak	Uzgen	Pasture Users Union	13,480	4,909	0.089841	STABLE
Atabekov	Suzak	Pasture Users Union	14,149	6,105	-0.133547	LOW
Atay	Toguz-Toro	Pasture Users Union	24,785	14,566	-0.378788	LOW
Baetov	Ak-Talaa	Pasture Users Union	35,577	24,035	0.320513	HIGH
Bash-Dobo	Uzgen	Pasture Users Union	11,015	2,782	-0.114122	LOW
Changet	Uzgen	Pasture Users Union	16,062	8,720	-0.738151	VERY LOW
Don-Bulak	Uzgen	Pasture Users Union	13,980	2,381	0.012141	STABLE
Iri-Suu	Uzgen	Pasture Users Union	20,989	10,665	-0.415210	LOW
Jalpak-Tash	Uzgen	Pasture Users Union	17,702	9,225	-0.194250	LOW
Jany-talap	Ak-Talaa	Pasture Users Union	17,341	0	0.174825	HIGH
Jazy	Uzgen	Pasture Users Union	8,885	10,885	-0.318085	LOW
Jerge-tal	Ak-Talaa	Pasture Users Union	66,647	34,583	0.223388	HIGH

Jylandy	Uzgen	Pasture Users Union	10,951	2,590	0.060703	STABLE
Kara-Byrgon	Ak-Talaa	Pasture Users Union	68,009	29,861	0.310800	HIGH
Kara-Darya	Suzak	Pasture Users Union	15,231	8,496	-0.143260	LOW
Kara-Tash	Uzgen	Pasture Users Union	5,740	3,071	-0.038850	STABLE
Kargalyk	Toguz-Toro	Pasture Users Union	79,863	51,963	0.060703	STABLE
Karool	Uzgen	Pasture Users Union	13,560	4,178	-0.055847	STABLE
Kek-jar	Ak-Talaa	Pasture Users Union	37,282	20,155	0.500194	VERY HIGH
Keldyuk	Uzgen	Pasture Users Union	19,669	6,054	-0.143260	LOW
Kok-irim	Toguz-Toro	Pasture Users Union	118,387	31,761	-0.359363	LOW
Kongorchok	Ak-Talaa	Pasture Users Union	25,355	14,451	0.485625	HIGH
Kosh-dobo	Ak-Talaa	Pasture Users Union	93,252	41,012	0.322941	HIGH
Kurshab	Uzgen	Pasture Users Union	17,645	7,937	-0.055847	STABLE
Kuzul-Beles	Ak-Talaa	Pasture Users Union	17,927	13,822	0.235528	HIGH
Kyz-kol	Suzak	Pasture Users Union	33,306	11,244	-0.386072	LOW
Kyzyl-Oktyabr	Uzgen	Pasture Users Union	18,837	8,307	0.031566	STABLE
Kyzyl-Too	Uzgen	Pasture Users Union	16,780	3,890	-0.104409	LOW
Lenin	Suzak	Pasture Users Union	5,170	663	-0.424922	LOW
Myrza-Ake	Uzgen	Pasture Users Union	11,899	3,014	0.157828	HIGH
Salam-Alik	Uzgen	Pasture Users Union	44,600	12,055	-0.279235	LOW
Sary-Bulun	Toguz-Toro	Pasture Users Union	30,604	14,940	-0.094697	STABLE
Togolok-moldo	Ak-Talaa	Pasture Users Union	25,791	19,323	0.235528	HIGH
Toguz-Toro	Toguz-Toro	Pasture Users Union	85,971	47,734	0.420066	HIGH
Tort-Kol	Uzgen	Pasture Users Union	20,899	9,170	-0.007284	STABLE
Ugyt	Ak-Talaa	Pasture Users Union	39,165	21,738	0.310800	HIGH
Zerger	Uzgen	Pasture Users Union	27,603	13,493	-0.220960	LOW
		TOTAL	**1,239,242**	**591,746**		
		Target Rayons ha	**1,662,712**			

Table 18: Heavy Rain Risk Assessment results, PUUs

40 PPUs were analyzed. The overall area is 1,239,242 ha (74.5% of 4 rayons land), of which 591,746 ha is pasture (local data).

According to this assessment, low and high risks combined make more than 77% of the total area, with the high risk at almost exactly 47% of the total area. Around 18% of the total area is resulted stable in the risk of heavy rains.

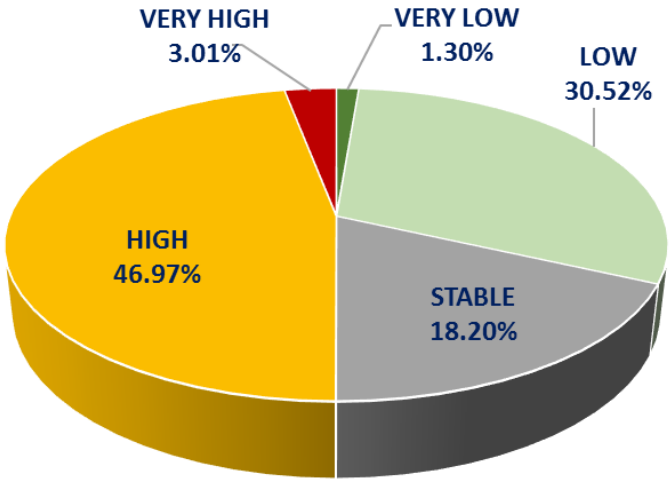


Table 19: Chart of distribution of Heavy Rain Risk levels in PUU areas

The map below shows a clear difference between areas at West and areas at East, which reflect the trends in precipitations showing that areas with increases in rainfall all concentrated at East.

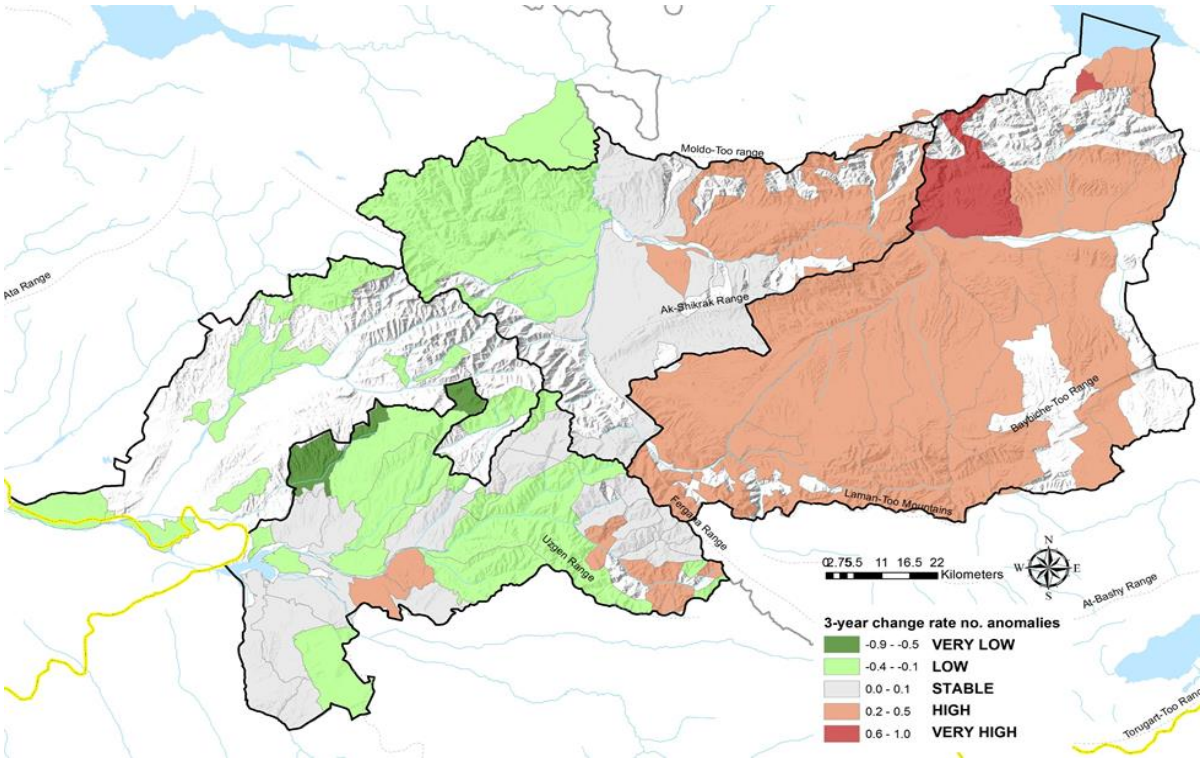


Figure 59: Map of Heavy Rain Risk Assessment in PUU areas

7. PRIORITY EXPANSION AREA

This area of 26,891 km^2 has been identified in 6 rayons at North-West of the Country: Jaiyl, Panfilov, Toktogul, Bakai-Ata, Kara-Buura and Talas (Panfilov and Kara-Buura, however, are considered second priority expansion area compared to the other four); it represents a territory of potential expansion of activities proposed by this project following the results of a study commissioned by IFAD predicting the effects of climate change on the major climate related hazards affecting Kyrgyzstan.

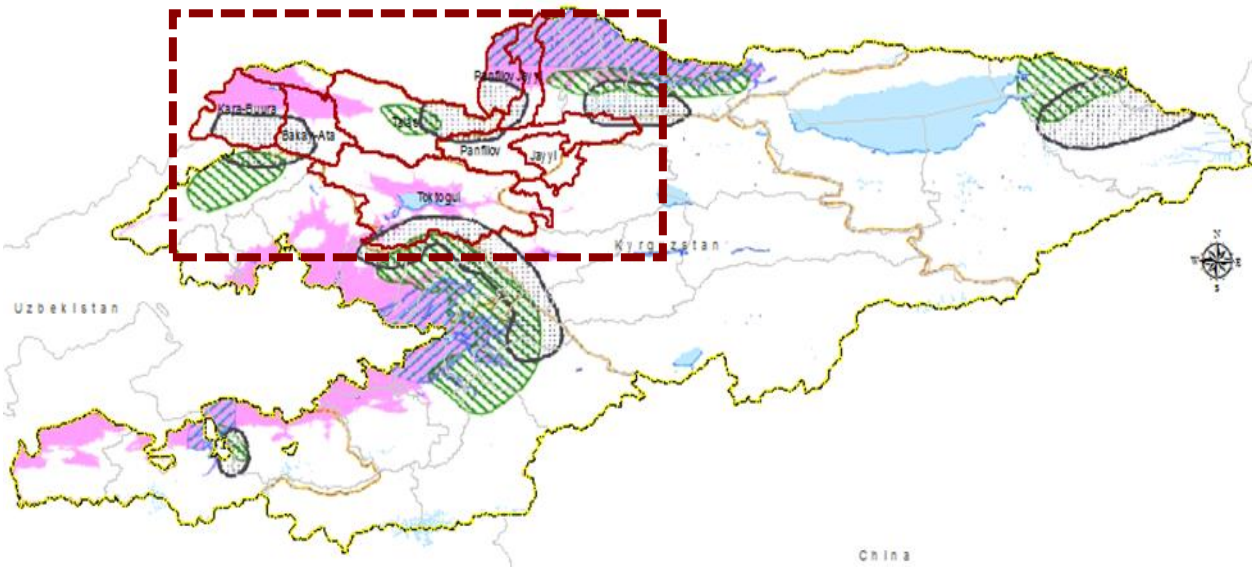


Figure 60: Map of main hazards due to climate change

7.1 Demography

The priority expansion area covers 26,891 km^2, which is about 13.5% of the national extent, with a population of 345,700 people, which is around 5.7% of the national population. The expansion area is made by six rayons located in three oblasts: Chui, Jalal-Abad and Talas. Almost 80% of the population of these six rayons lives in rural areas.

			Projected population[41]		
Rayon	Oblast	Area (km^2)	Total 2016	Urban 2016	Rural 2016
Jaiyl	Chui	2,994	102,600	44,200	58,400
Panfilov	Chui	4,869	44,400	8,800	35,600
Toktogul	Jalal-Abad	8,646	19,000	19,000	0
Bakai-Ata	Talas	2,672	49,500	0	49,500
Kara-Buura	Talas	2,618	63,700	0	63,700
Talas	Talas	5,092	66,500	0	66,500
TOTAL 6 RAYONS		26,891	345,700	72,000	273,700

[41] *Source: https://data.humdata.org/dataset/kyrgyzstan-population-statistics*

TOTAL KYRGYZSTAN		199,263	6,034,000	

Table 20: Population projection 2016, expansion area

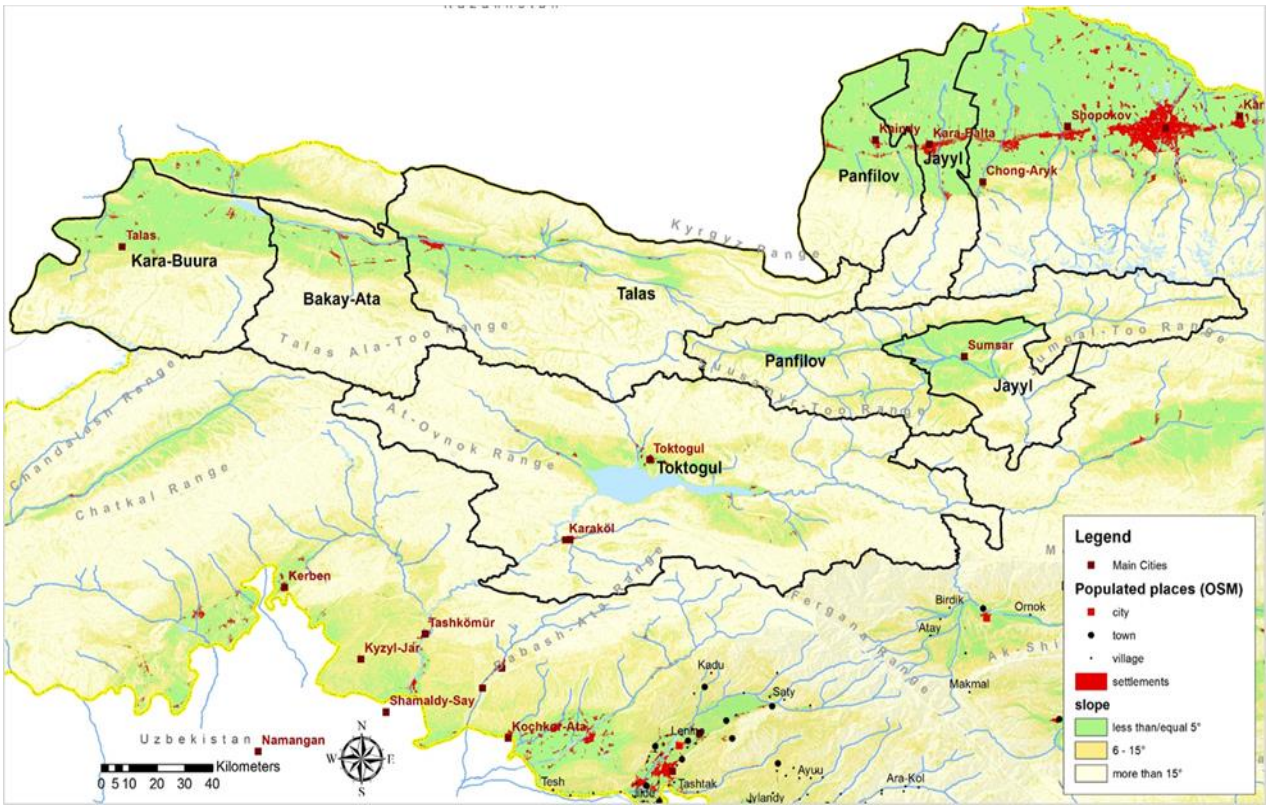


Figure 61: Map of settlements in expansion area

7.2 Topography

The area includes tall mountains and flat low altitude valleys. The elevation stretches from less than 500m m to almost 4,500 m. The major mountain ranges are Talas Ala-Too and Suusamyr-Too (middle), Kyrgyz at North, and At-Ovnok at South West. Here is a stratification of altitude in 4 significant classes of elevation:

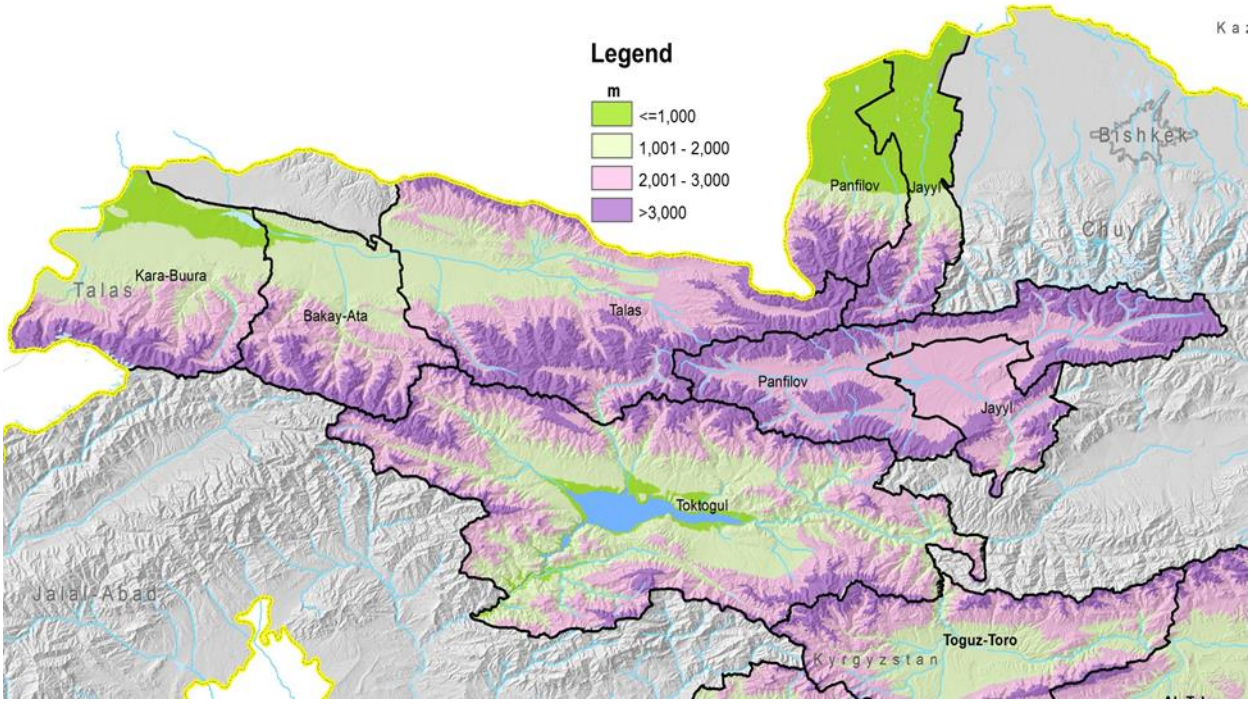


Figure 62: Elevation map of expansion area with four classes of altitude. GCF/FAO

The chart and table below show the area distribution by Rayon and by different ranges of altitude:

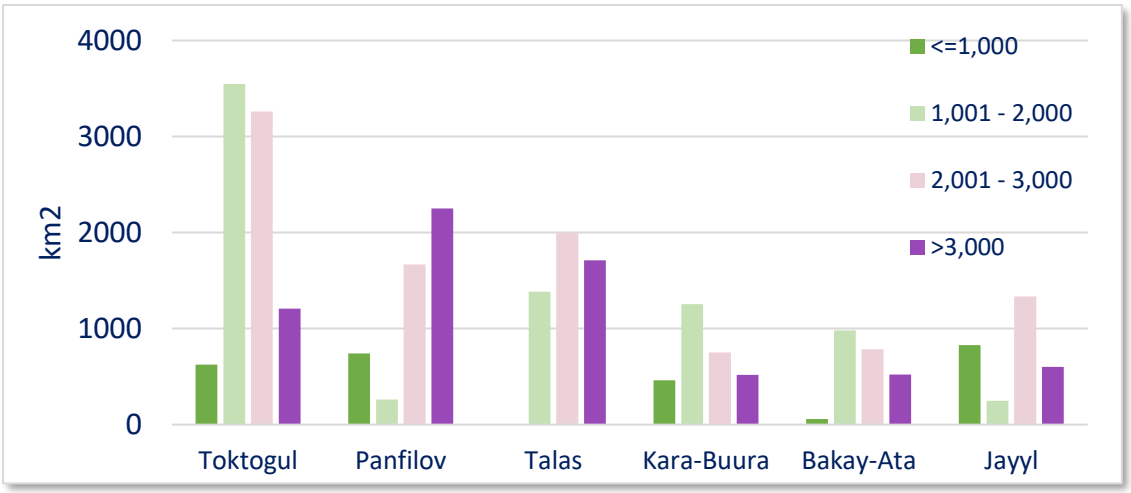


Figure 63: Chart of distribution of elevation ranges, expansion area

From the table below, Toktogul, Kara-Buura and Bakay-Ata have the highest percentage of area between 1000 and 2000 m, while Panifilov is highly mountains compared to the other rayons.

Altitude classes (m)	Toktogul	Panfilov	Talas	Kara-Buura	Bakay-Ata	Jayyl
<=1,000	7.2%	15.0%	0.0%	15.5%	2.4%	27.5%
1,001 - 2,000	41.1%	5.3%	27.2%	42.0%	41.9%	8.2%
2,001 - 3,000	37.7%	33.9%	39.2%	25.1%	33.5%	44.3%

>3,000	14.0%	45.7%	33.6%	17.3%	22.2%	20.0%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 21: Distribution of elevation ranges by rayon, expansion area

7.3 Climate

The expansion area is part of two climatic zones: the **Northern- north-western**, which includes the Chui, Talas and Kemin valleys. They are surrounded by the Talas, Kyrgyz and Cho-Kemin mountain ranges. It has a relatively humid climate with mean annual temperature between 5 – 10 ◦C, minimum -10 to -5 ◦C and maximum around 35 ◦C. Precipitation in the northern part of the Chui valley averages around 370 mm a year, whereas in the upper part of the valley precipitation increases to 425 – 500 mm, up to 1,000 mm/year; and the **Inner Tien-Shan**, which is a closed climatic zone bounded by adjacent mountain ranges. It is characterized by low precipitation, and a marked continental climate with distinctive local contrasts.

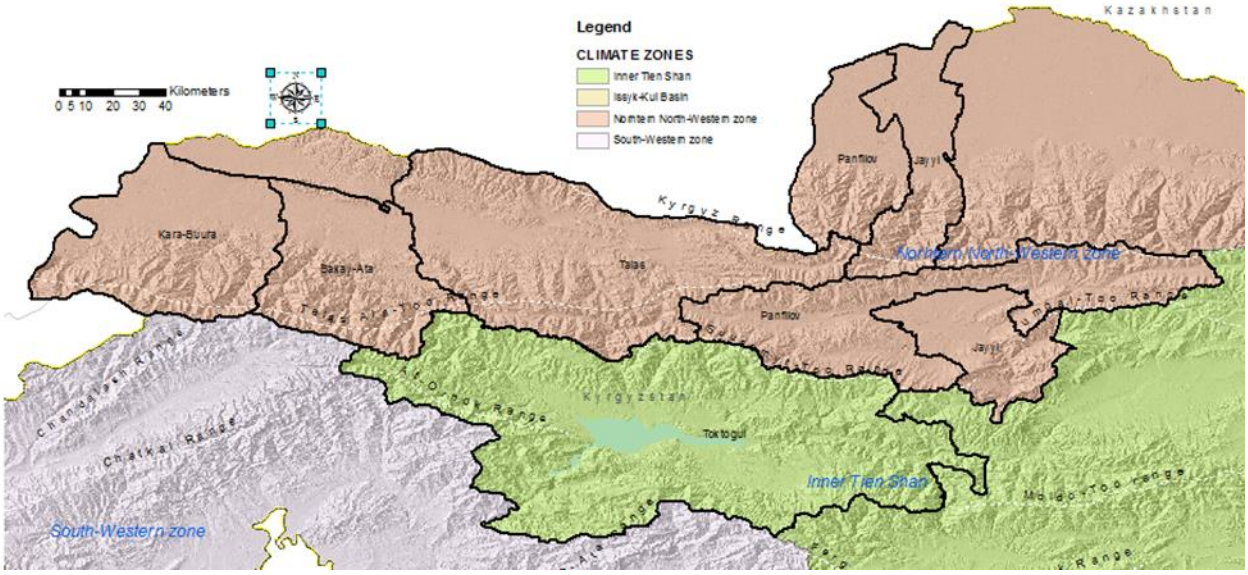


Figure 64: Map of climatic zones in expansion area

The table below shows combined data on long term averages[42] of **temperatures and precipitation** in each of the six priority exansion rayons:

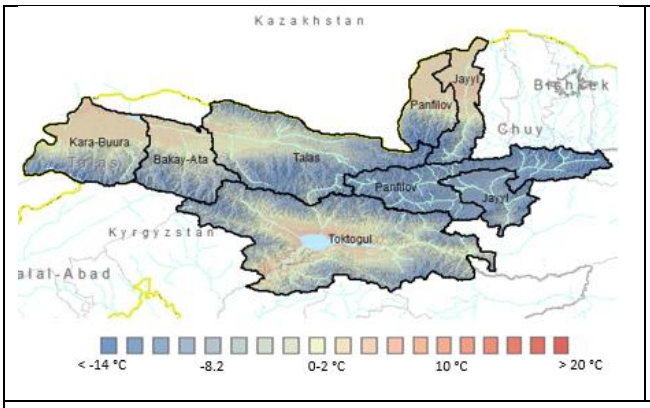
Name	PRECIPITATIONS (mm)	MAX TEMPERATURE (°C)	MIN TEMPERATURE (°C)
Toktogul	568	10.4	-2.3
Panfilov	553	5.9	-6.9
Talas	560	7.7	-4.8
Kara-Buura	488	11.5	-1.0
Bakay-Ata	493	10.2	-2.4
Jayyl	468	9.0	-4.2

[42] *WorldClim Version2 - http://worldclim.org/version2*

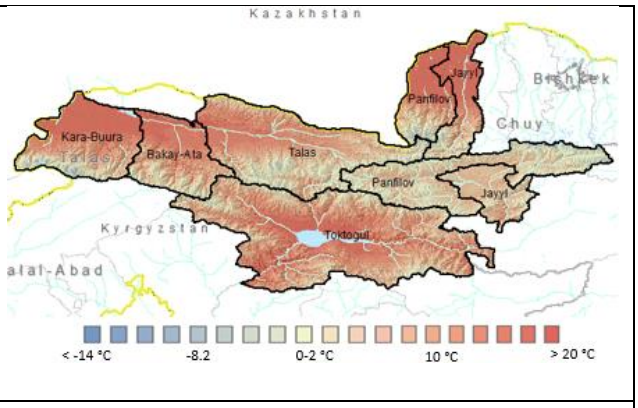
Figure 65: Chart precipitation-temperature averages 1970-2000, expansion area

Below are maps of spatialized temperature and precipitations resulting of long (1970-2000) time series averages:

Annual mean of MIN Temperature



Annual mean of MAX Temperature



Annual Total Precipitations

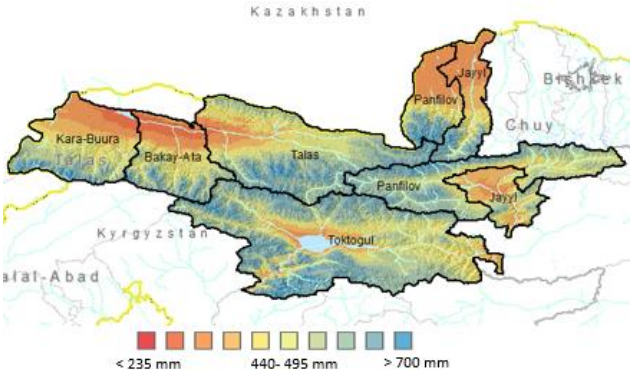


Figure 66: Distribution maps of precipitation/temperature, expansion area

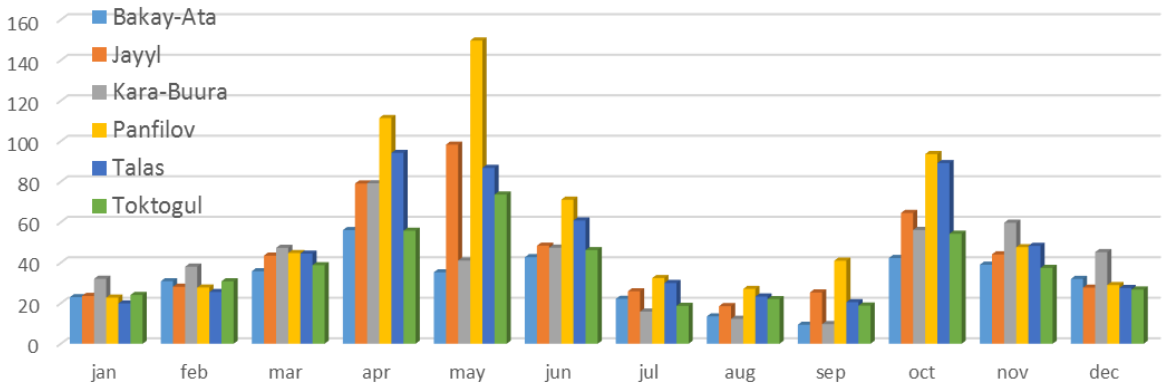


Figure 67: Chart of monthly average precipitations (mm) 1981-2016, expansion area

Time series of precipitations[43] and temperatures[44] have also been used to run pixel based linear regressions and extract annual (trend) and total change according to historical observations.

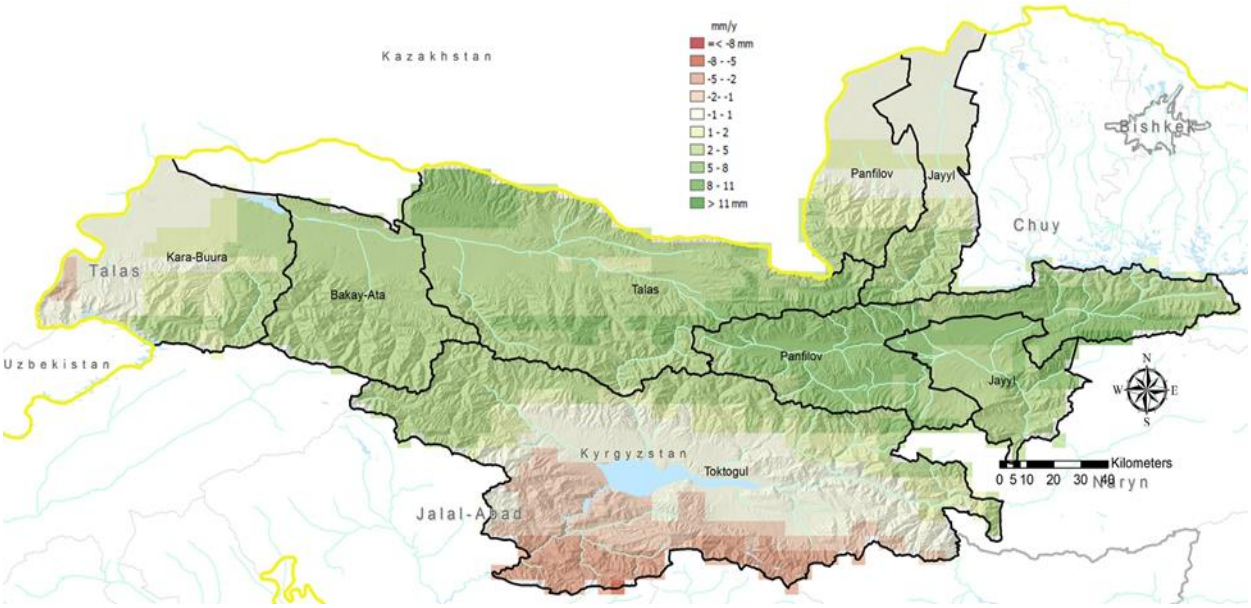


Figure 68: Map of precipitation linear trend 1981-2016, expansion area

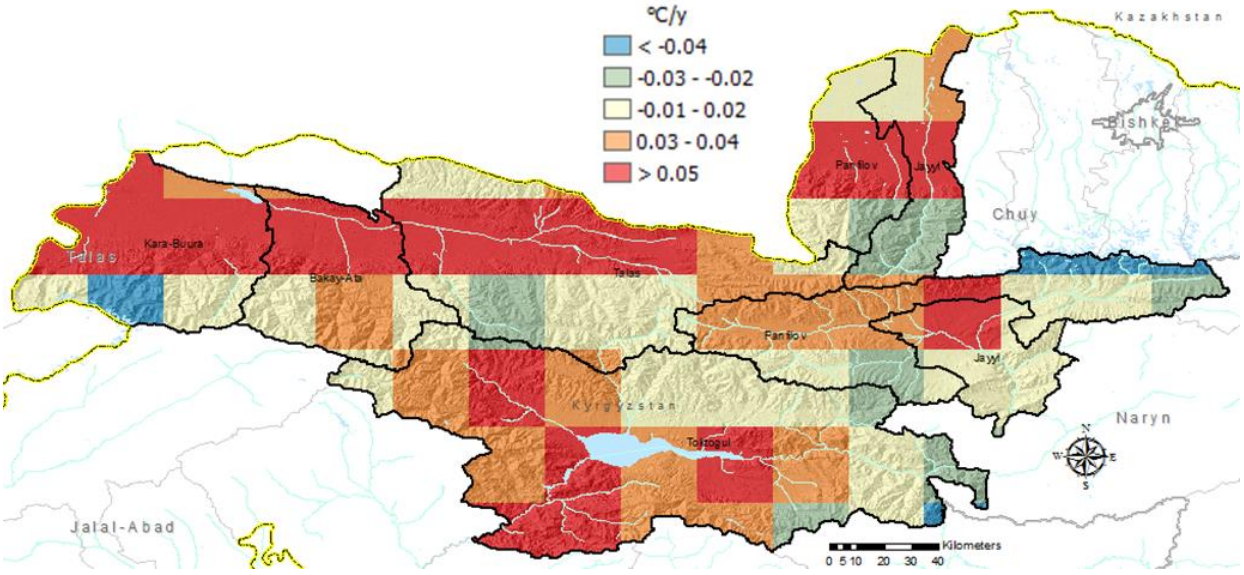


Figure 69: Map of MAX temperature linear trend 1989-2016, expansion area

[43] *Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)*
[44] *Source: European Centre for Medium-Range Weather Forecast (ECMWF)*

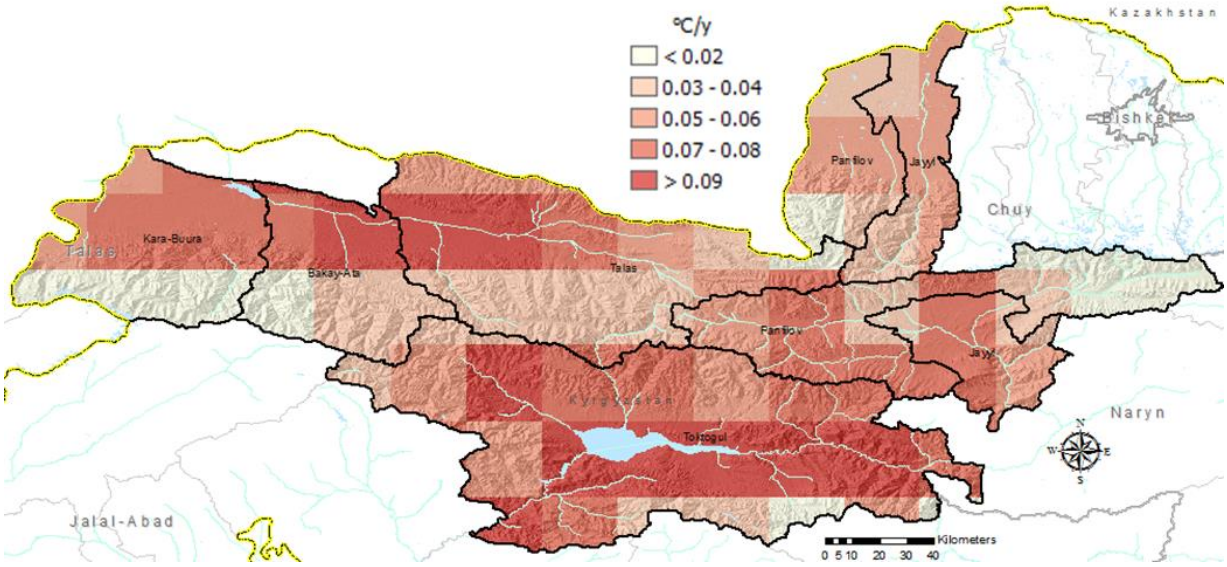


Figure 70: Map of MIN temperature linear trend 1989-2016, expansion area

The trends based on historical observations shows mostly increases in annual precipitations, even though in limited values, with reductions concentrated above all in Toktogul rayon. Temperature variations are very small; however, almost everywhere trends are for an increase of fractions of degree per year.

An additional climatic variables analyzed for the priority expansion area is the **Potential Evapotranspiration (PET).** PET is the amount of evaporation, expressed in mm that would occur if a sufficient water source were available. It is a measure of the demand for moisture from a surface, and it is affected by temperature, insolation and wind. PET is higher in the summer, on less cloudy days, and closer to the equator, because of the higher levels of solar radiation that provides the energy for evaporation. PET is also higher on windy days because the evaporated moisture can be quickly moved from the ground of plants, allowing more evaporation to fill its place.

Hotter temperatures result in greater PET which requires more precipitations just to meet the greater demand. Climates where PET is always greater than P are termed arid climates.

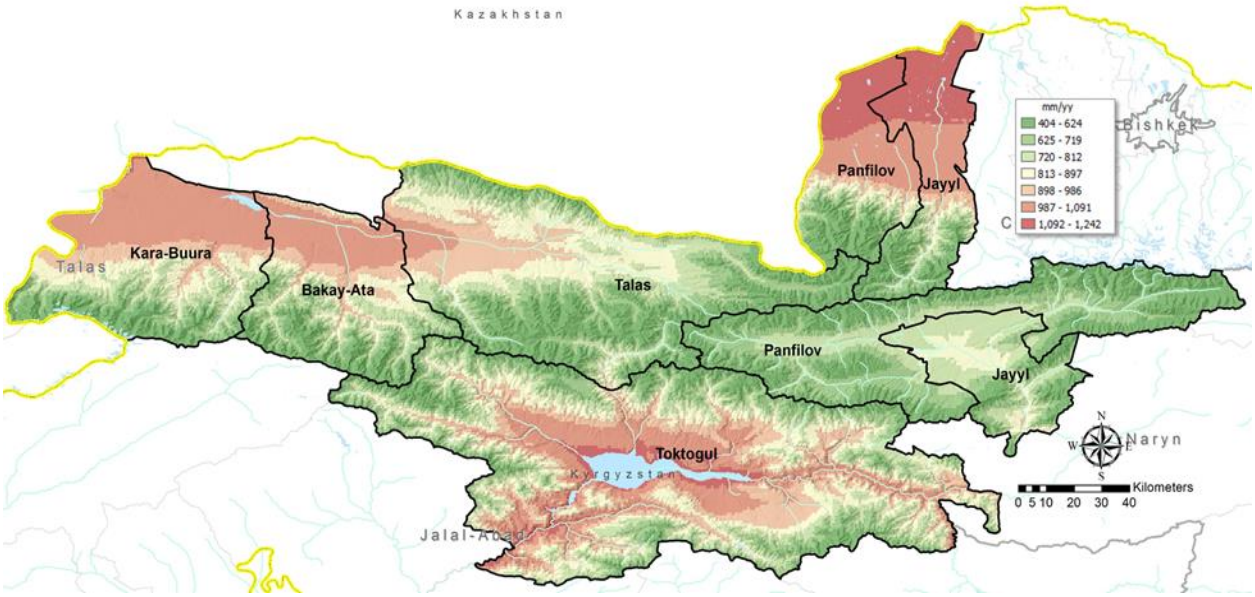


Figure 71: Map of potential evapotranspiration (Global-PET) 1950-2000, expansion area

The map above shows the potential evapotranspiration derived from the global database produced by CGIAR-CSI[45], in which source climatic data FAOCLIM2 was used in the PET equation (FAO application of the Penman-Monteith). The areas with higher values exceeding the annual precipitations are the low lands/valleys of the northern rayons, and the central valley of Toktogul.

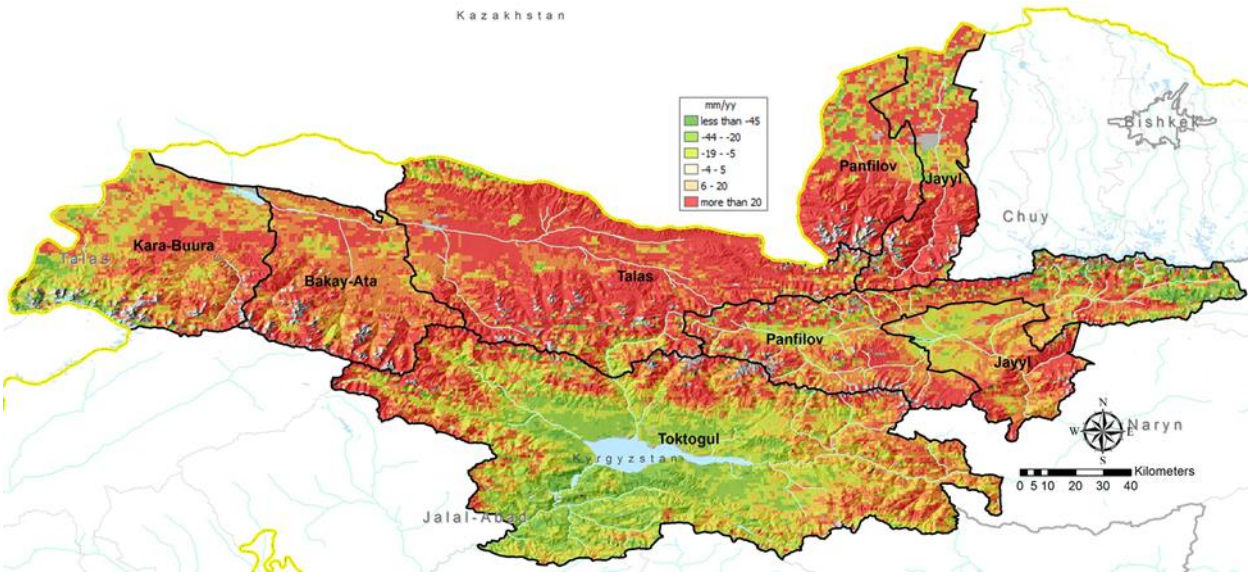


Figure 72: Map of potential evapotranspiration, linear trend 2000-2014, expansion area

The map above shows the trend in mm (absolute increase or decrease per year) of annual potential evaporation from ground, and transpiration from plant surfaces where there is sufficient soil moisture. It

[45] *Source: CGIAR-CSI Global Potential Evapotranspiration (Global-PET), http://www.cgiar-csi.org/?s=global-pet&submit.x=0&submit.y=0*

is based on 2000-2014 satellite data[46] and shows a general reduction of PET in lowland and valleys, with a tendency to increase in the mountain ranges in the middle of the area running East-West.

Because prevalently mountain area, Kyrgyzstan is particularly sensitive to a changing climate, through increases in temperature coupled with changes in precipitation regimes. These driving factors strongly influence the variability of the mountain snow-pack through a decrease in seasonal reserves and earlier melting. Snow monitoring from remote sensing provides a unique opportunity to address the question of **snow cover regime** changes.

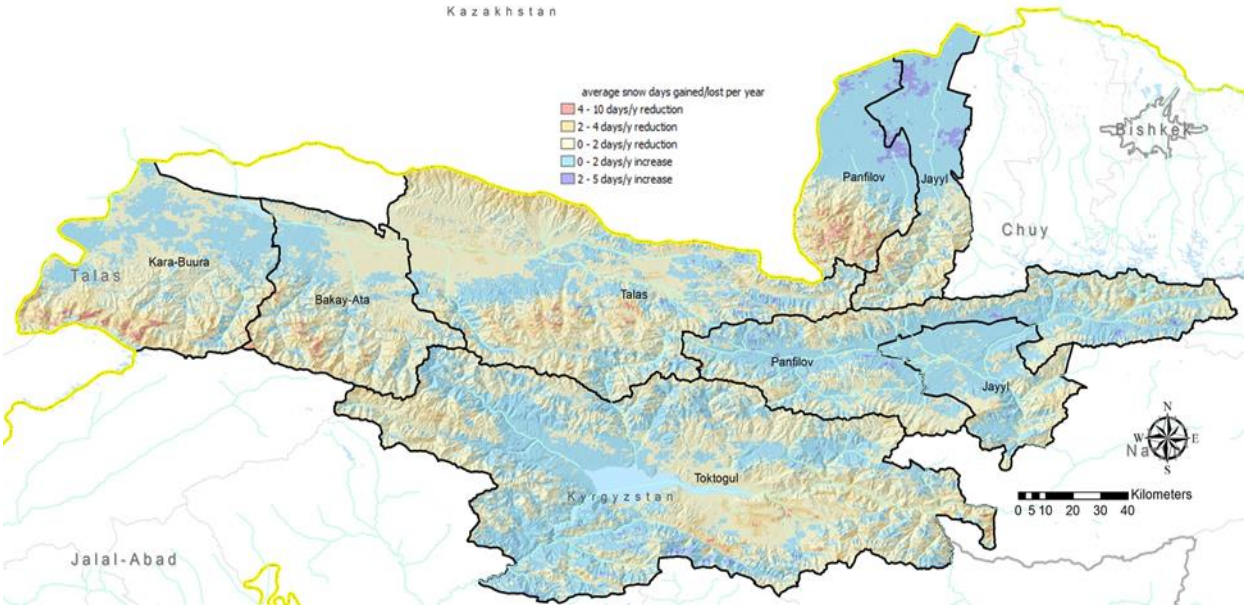


Figure 73: Map of Snow Cover Frequency (MODIS), trend 2002-2016, expansion area

The map above shows trends in number of days of snow covered areas per year, lost or gained, according to a time series of satellite based images[47] between 2002 and 2016. Brown areas are where the number of "snowy" days are higher (mostly high mountains), but the trend is actually negative, while bluish areas are those where it is stable or increasing, even though mostly by only up to two days per year.

7.4 Vegetation

One of the most used proxy to detect status and trend of vegetation using remote sensing is the Normalized Difference Vegetation Index (NDVI). NDVI determines the density of green on a patch of land by observing and comparing visible and near-infrared sunlight reflected by the plants. Healthy vegetation absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light, resulting in higher values of NDVI. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light, resulting in lower values of NDVI. This index ranges from -1 to 1. However, no green leaves gives a

[46] *Source: Global MOD16A2 MODIS/Terra Net Evapotranspiration 8-Day L4*
[47] *Source: MOD10A1.005 MODIS/Terra Snow Cover Daily L3 Global 500m*

value close to zero. A zero means no vegetation and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves.

The map below shows a satellite[48] based annual mean NDVI, averaged in the years 2014-2016. Valleys and foothills are greener, while high mountain peaks show no vegetation (permanent snow).

Figure 74: Map of annual mean NDVI (MODIS), average 2014-2016, expansion area

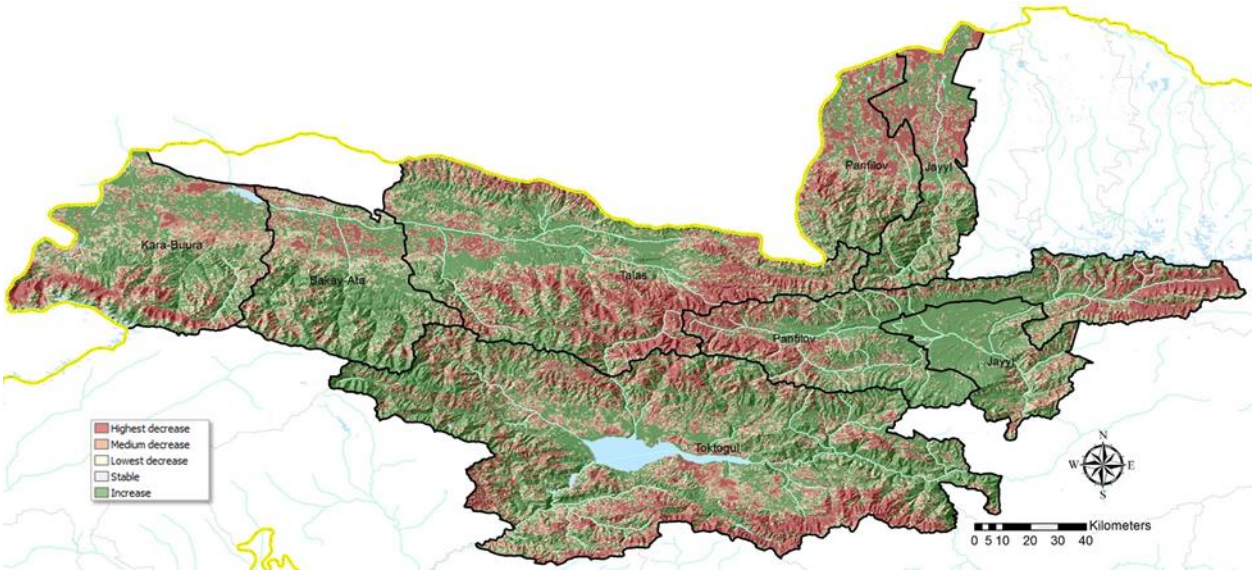


Figure 75: Map of NDVI trend (MODIS) 2003-2016, expansion area

[48] *Source: MOD13Q1.005 Vegetation Indices 16-Day Global 250m*

Using MODIS based NDVI data, this map depicts annual trend in NDVI index based on 16 days composite time series from 2003 to 2016. Shades of red show different degrees of vegetation loss. Green shows areas where the trend is positive (increase vegetation).

7.5 Protected areas

The 6 Rayons in the expansion area are covered by 5 national designated **protected areas (WDPA)**[49] for an overall surface of about 43,000 ha:

- Beshtash (Nature Park)
- Chychkan (Wildlife Refuge)
- Dzhardy-Kaindin (Wildlife Refuge)
- Manass (Wildlife Refuge)
- Western Tien-shan (World Heritage Site)

The map below shows the location of these 5 protected areas:

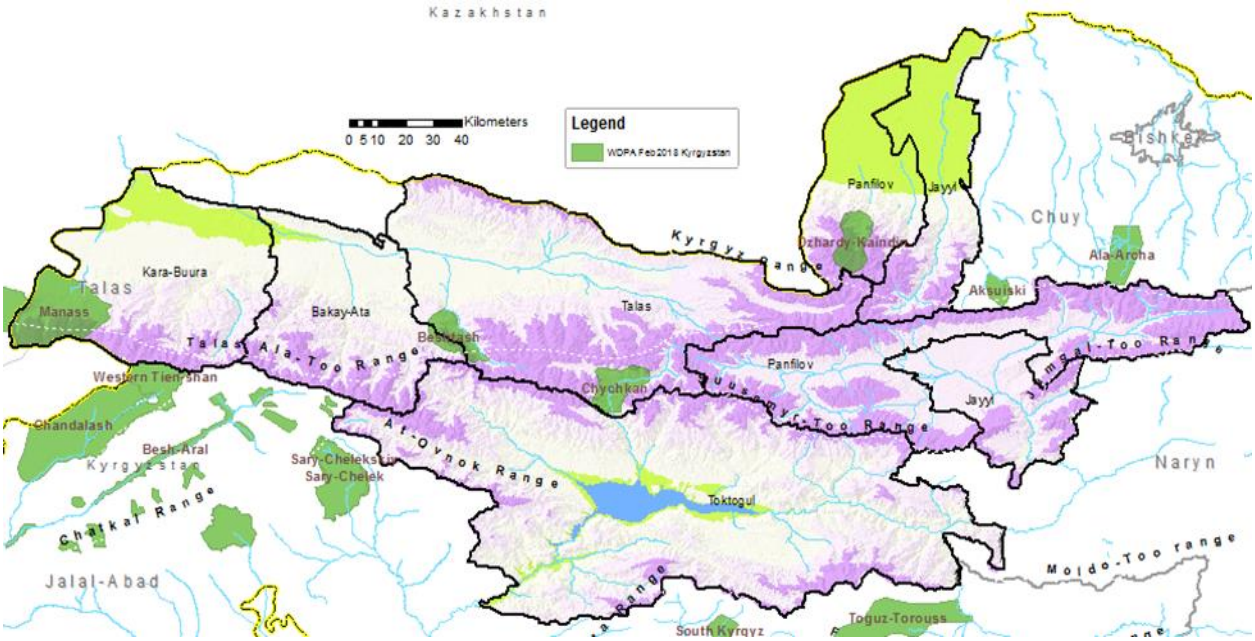


Figure 76: Map of World Designated Protected Areas Feb2018, expansion area

7.6 Land Cover

The two land cover / land use classes of major interest for this project are **Forests and Pastures**.

[49] *UNEP-WCMC (2018). Protected Area Profile for Kyrgyzstan from the World Database of Protected Areas, February 2018. www.protectedplanet.net/country/KGZ*

One of the most used satellite based forest database worldwide is the Global Forest Change 2016[50]. It provides the % of tree cover in each pixel, considering "tree cover" as any vegetation type taller than 5 meters in height. It was produced by using data of Landsat missions from 2000 to 2016 at 30m resolution. Actually, the available datasets are the reference tree cover map dated 2010, and gains/losses on yearly basis. By combining these layers, the tree cover of 2016 can be mapped.

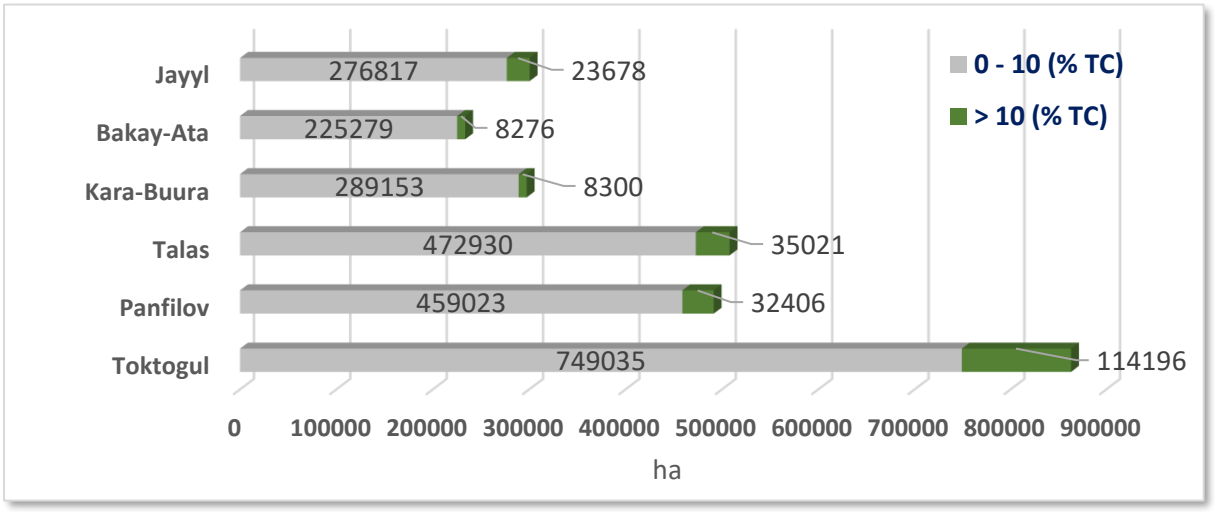


Figure 77: Chart of Forest / non Forest 2016, expansion area

The chart above shows the distribution of "forest" (land with a tree cover percentage higher than 10) versus what is lower in TC% or zero. Here is the correspondent summary table:

Class	Toktogul (ha)	Panfilov (ha)	Talas (ha)	Kara-Buura (ha)	Bakay-Ata (ha)	Jayyl (ha)	TOTAL (ha)
0 - 10 (%TC)	749035	459023	472930	289153	225279	276817	2472237
10.1 - 100 (%TC)	114196	32406	35021	8300	8276	23678	221877
Rayon (ha)	**863231**	**491429**	**507951**	**297453**	**233555**	**300495**	**2694114**

The map below displays the geographic distribution.

[50] *Source: https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.4.html*

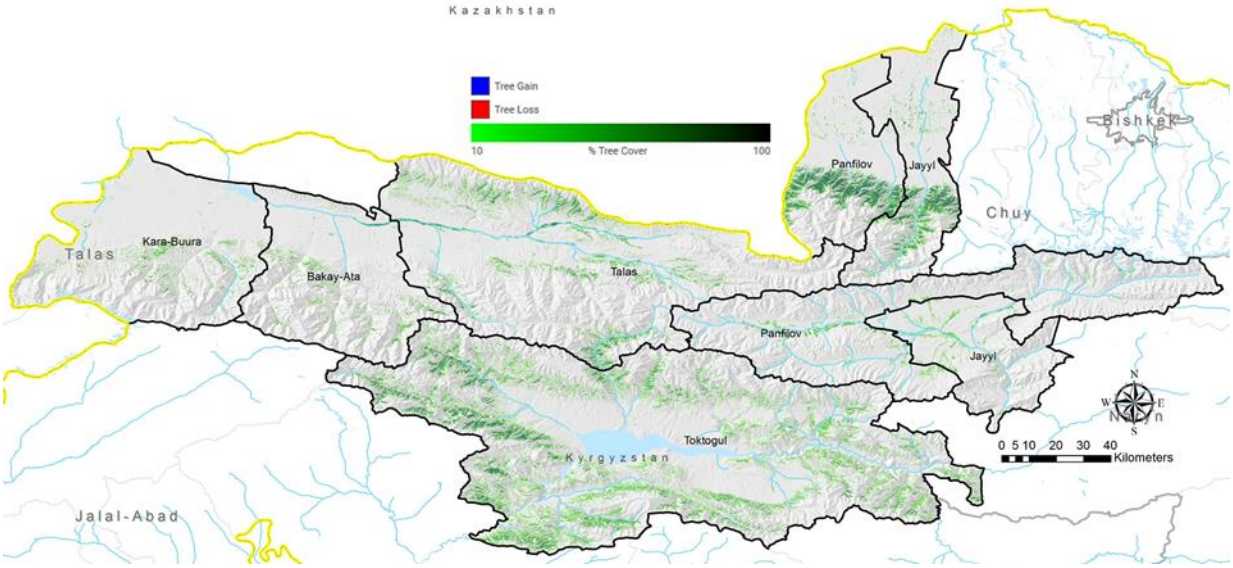


Figure 78: Map of Forest Cover (2016 Hansen's Tree Cover >10%), expansion area

No pasture coverage from local databases is available at this moment.

Other land covers were estimated in the area using the 2010 global database GlobeLand30[51]. It was generated from 30m Landsat satellite imagery around the year 2010, and includes 10 main classes. Here below are table and map showing the area distribution by land cover class in each Rayon.

km²	Toktogul	Panfilov	Talas	Kara-Buura	Bakay-Ata	Jayyl	TOT	TOT%
10-cultivated land	314.5	716.7	460.8	658.6	367.5	988.5	**3506.6**	**13.0%**
20-forest	1437.5	239.2	339.2	497.1	395.6	195.6	**3104.2**	**11.5%**
30-grassland	4860.1	2735.2	3309.2	921.5	529.8	1259.6	**13615.4**	**50.5%**
40-shrubland	518	204.8	251.4	93	112.9	54.5	**1234.6**	**4.6%**
50-wetland	0.5	0	0	2.3	0.1	0	**2.9**	**0.0%**
60-water bodies	324.6	9.4	6.7	18.4	2.6	15.1	**376.8**	**1.4%**
80-artificial surface	43.8	58.6	61.2	62.9	42.8	79.8	**349.1**	**1.3%**
90-bareland	1074.7	637.4	529.1	661.8	846.4	357.2	**4106.5**	**15.2%**
100-permanent snow	70.7	318.3	130.7	68	43.5	57.7	**688.8**	**2.6%**
Tot	**8644.4**	**4919.6**	**5088.2**	**2983.6**	**2341.1**	**3008**	26984.9	**100.0%**

Table 22: 2010 land cover distribution (GlobeLand30), expansion area

[51] *Source: GlobeLand30, http://www.globallandcover.com/home/Enbackground.aspx*

Figure 79: Map 2010 land cover distribution (GlobeLand30), expansion area

By using this land cover dataset, forest and grassland have been extracted to compare them with all other classes. The chart below shows the distribution of grasslands and forest in the whole expansion area.

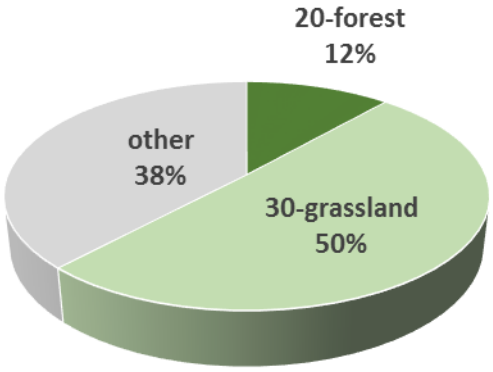


Figure 80: Chart Forest/Grassland (GlobeLand30), expansion area

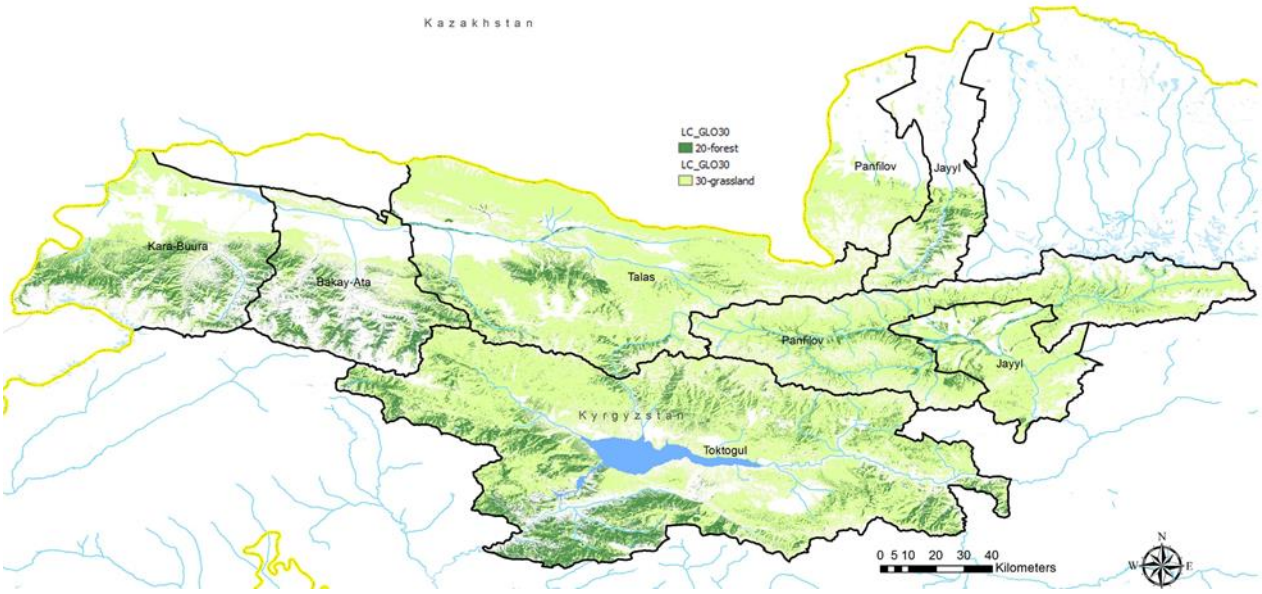
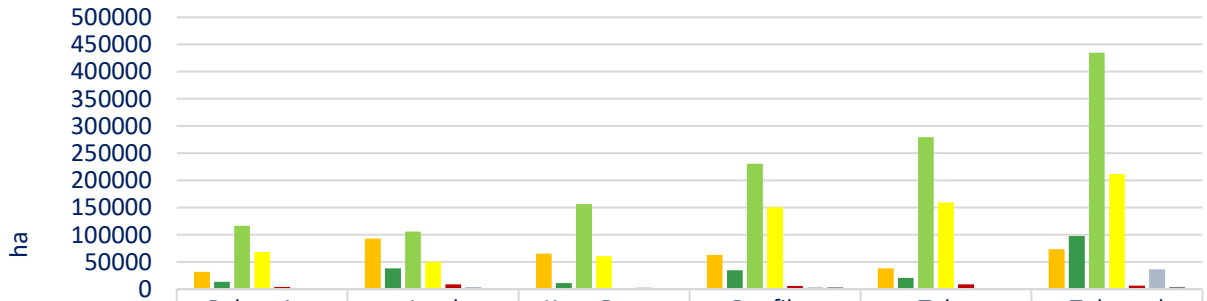


Figure 81: Map Forest/Grassland (GlobeLand30), expansion area

In 2016, a sample based survey by using the FORIS Collect Earth tool[52] was conducted in Kyrgyzstan by local experts. 13,200 sample points were characterized for a number of variables, including the land use, in order to estimate distribution and conditions based on what could be detected by analyzing high resolution imageries and other indicators available through the Google platform.

In the expansion area, the estimate from the samples falling in the six Rayons of interest has given the following results:



	Bakay-Ata	Jayyl	Kara-Buura	Panfilov	Talas	Toktogul
Cropland	31569	93223	65641	63002	38575	73511
Forest	13560	38120	11062	34626	20561	97599
Grassland	116428	105767	156866	230790	279648	434671
Other Land	68164	50419	60414	150627	159363	211985
Settlement	4385	8621	1462	5960	8770	6439
Wet Land	0	3930	2919	3299	1465	36263
No data	2	720	0	3656	435	3975

Table 23: Distribution main land uses out of sample based survey 2016 (Collect Earth), expansion area

[52] *Collect Earth: http://www.openforis.org/tools/collect-earth.html*

The following map gives an indication of hot spots for the presence of land covers such as croplands, forests or grasslands.

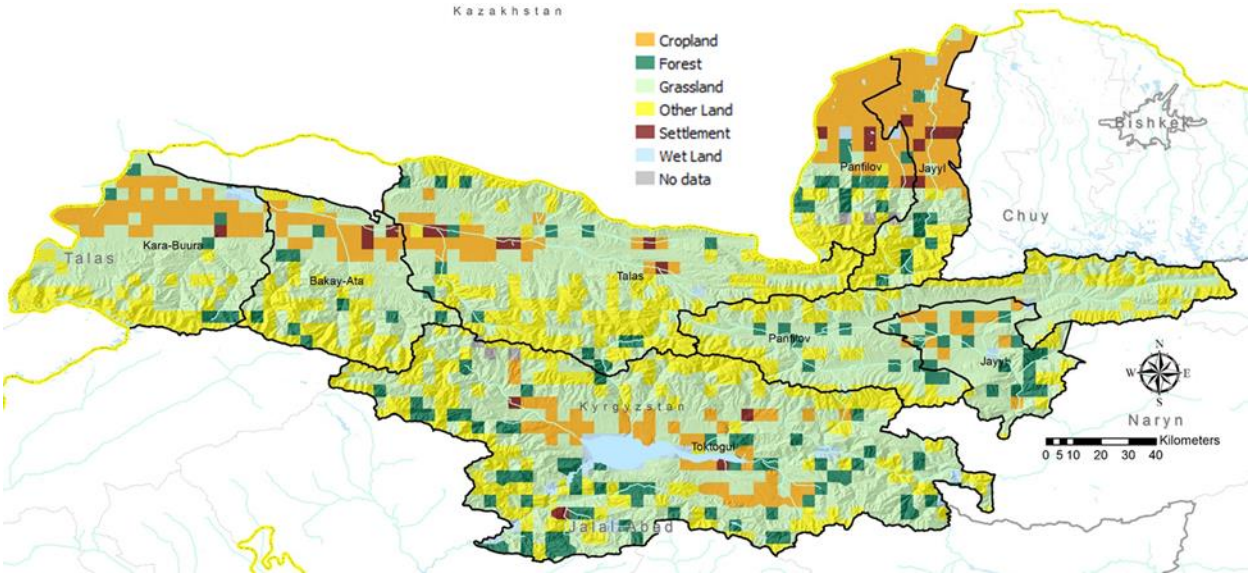


Figure 82: Map Land Use 2016 out of sample based survey (Collect Earth), expansion area

8. ANNEX: FIGURES

9. ANNEX: TABLES