

# Kyrgyz Open Data Cube of Satellite Images and Environmental Products as a Tool for Pasture Monitoring

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## Abstract

*From year to year, global climate change is observed, covering various areas, such as the state and access to natural resources, infrastructure of settlements, etc. Climate change has different consequences for agriculture and livestock herding, rainfall can affect crop yields and livestock feed. Kyrgyzstan is an agrarian country in which the main income of the population comes from agriculture and animal husbandry, adaptation to climate change and monitoring is needed. Satellite images are one of the sources for monitoring climate change in the world. Satellite imagery allows to analyze changes in temperature, vegetation cover, land cover, snow cover, etc. This article discusses the Kyrgyz Data Cube and its applications, including the visualization website that provides easy access to its satellite derived environmental information, regarding pasture, drought and snow and conclusions.*

## 1. Introduction

The Kyrgyz Republic has 90 400 sq. km. (85% of the area of agricultural land) of pastures, which include summer pasture regions in the high mountain areas (DPLB, 2020). From year to year in the country, there is an increasing degradation of pastures due to severe overgrazing around settlements (LMDP2, IFAD), soil erosion and the effects of climate change, which leads to the need for monitoring and adoption of adaptation measures.

Resolution of the Government of the Kyrgyz Republic No. 386 dated June 19, 2009, a national law “On pastures” was adopted. The law on pastures states that the state authorized body in the field of land monitoring must annually assess the state of pasture lands and provide the results for regulation of pastures and, based on the results, monitor the preservation of the natural state of pastures. This work requires financial and human resources. The last time monitoring work was carried out in 2015, but there are no cartographic materials to study the state of rangelands in the localities, for effective management. Pasture monitoring tabular data were used to calculate the capacity of rangelands and grazing planning.

In Kyrgyzstan, in January 2020, the SIBELIUs project funded by the United Kingdom Space Agency began to be implemented (Sibelius, 2021).

The SIBELIUs project is being implemented by the representative office of the international humanitarian organization Mercy Corps in Kyrgyzstan, eOsphere Limited and the University of Leicester (Mercy Corps, 2021). Within the framework of this project, a memorandum of understanding and cooperation was drawn up with the Department of pastures and livestock breeding under the Ministry of agriculture, forestry and water resources of the Kyrgyz Republic, Kyrgyzhydromet under the Ministry of emergency situations and the Central-Asian Institute for Applied Geosciences, also partners are WUA and Kompanion Bank. The following tasks are considered within the framework of the project:

- a baseline study that aims to better understand the problems faced by livestock breeders and assist the project in developing solutions to these problems. The pilot regions were selected Zhayilskiy (Ak-Bashat and Zhayil PC) and At-Bashinskiy region (Ak-Muz and Kazybek PC) (Figure 1).
- development of the Kyrgyz Open Data Cube (KDC) and the web map.
- training in the application of the KDC for carrying out various analyses of satellite images.

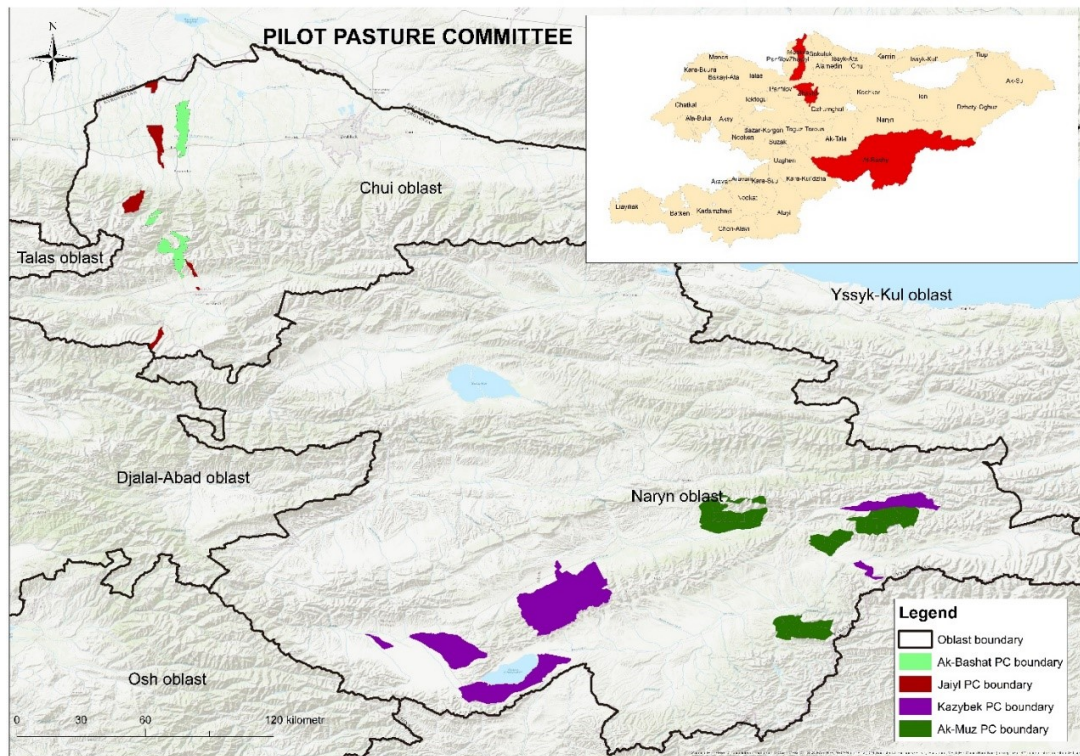


Figure 1: Pilot pasture committees

## 2. Data and Methods

### 2.1 Study Area

Zhaiylskiy region is located in the western part of the Chui oblast and bordered: the north - by the state border with the Republic of Kazakhstan; the west - the Panfilovskiy region; the south - by the watershed of the Kyrgyz Range; the east - the Moscow region. The territory includes a part of the Suusamyr valley. At-Bashynskiy region is located in the southern part of the territory of the Naryn oblast and bordered from the north by the Baibiche-Too, Naryn-Too, Jaman-Too ridges, from the south by Torugart-Too, Kokshaal-Too, from the west by the Fergana ridge.

### 2.2 Data

The Open Data Cube (ODC) is an open-source geospatial data management and analysis software project that helps harness the power of satellite data (ODC, 2021). The KDC has been developed based on ODC technology, this is an open-source geospatial data management and analysis software project that helps harness the power of satellite data. The KDC is populated with images from different satellites: Sentinel 2 fleet (2a, 2b and 2c), Landsat 8, Aqua, Terra, and Suomi-NPP (Table 1). For Landsat 8 and Sentinel 2, ATCOR is used to convert the Level 1 data to Level 2 atmospherically corrected data. The Level 1 data are being

downloaded from Amazon Web Services for Landsat 8 and from Copernicus Hub for Sentinel 2. ATCOR is an atmospheric/topographic correction is the elimination of atmospheric and illumination effects to retrieve physical parameters of the earth's surface i.e., the retrieval of surface spectral reflectance, emissivity and temperature (ATCOR, 2021). Satellite images in the KDC can be accessed in two ways, depending on the users' level of expertise and depending on the type of data and information they require.

1. The easiest way to access information in the KDC is a specially designed website. SIBELIUS web map is available <https://kyrgyzstan.sibelius-datacube.org/map/EN>. Information on the visualization map can be viewed at the level of the country, region and district. Informative satellite images and products in the form of cartographic materials can be exported in .pdf format. In this way, pasture committee officials or other interested persons can access the satellite imagery through the website, upload the map, make decisions and use it in the communities' annual pasture management plan. The website has information on biomass, anomalies, Normalized difference vegetation index (NDVI) on grazing land, snow cover, land surface temperature (LST), etc.

Table 1: List of the satellite data available in the KDC

Satellite/Sensor	Dates	Product	Resolution (meters)
Landsat 8	March 2013 to present	18_15m (panchromatic, mask)	15
		18_30m (coastal aerosol, blue, green, red, near infrared, short wave infrared 1, short wave infrared 2, cirrus, land surface temperature, mask)	30
Sentinel 2	November 2015 to present	s2_10m (blue, green, red, near infrared, mask)	10
		s2_20m (coastal aerosol, vegetation red edge 1, vegetation red edge 2, vegetation red edge 3, narrow nir, water vapour, short wave infrared cirrus, short wave infrared 1, short wave infrared 2, mask)	20
MODIS	January 2003 to present	MOD09GQ, MYD09GQ, MOD09GA, MYD09GA, MOD10A1, MYD10A1, MOD11A1, MYD11A1, MCD43A4	250, 500, 1000
VIIRS	January 2012 to present	VNP09GA, VNP10A1, VNP21A1D, VNP21A1N, VNP43IA4, VNP43MA4	375, 500, 1000

2. The data cube can also be accessed directly by more advanced users who work with geographic information systems. Information from the KDC can be accessed as web map services and web coverage services (WMS and WCS). GIS and Remote Sensing specialist can access the KDC via JupyterHub, a portal that will allow the user to make full use of the KDC data. A web map helps to navigate and see the context in which information about the environment is located, reflection of the pasture conditions, navigate by location and time, and also independently download finished products in the form of maps. The satellite imagery used to obtain environmental information falls into high and low-resolutions. The high-resolution imagery is based on 10m x 10m pixels from the ESA Sentinel-2 satellites and 30m x 30m pixels from NASA's Landsat-8 satellites. Low-resolution images have pixels of 250m x 250m and are acquired more frequently than the higher resolution data, with NASA's MODIS instruments aboard the Terra and Aqua satellites. For pilot pasture committees and district agrarian development departments, trainings were conducted on the use of web map and material was developed with the analysis of NDVI, anomaly and snow cover. The Pasture Anomaly product compares the pasture biomass values from a given time period to the historic time-averaged values from the same time period.

It produces a product as a percentage of the pasture biomass currently compared to the long-term historical values (KDC, 2021). The training was attended by deputies and employees of local municipality, pasture users and employees of the agrarian development department of the pilot districts.

For training, the guide of the visualization map was developed. The participants were given recommendations, to add the pasture borders, the import of maps in jpeg format for use in pasture management, add base map with high resolution to distinguish land use categories. The staff of the project conducted training for potential users of government agencies and non-governmental organizations (Kyrgyzhydromed, Department of pasture and livestock breeding, ARIS, LMDP2 and Camp Alattoo etc.), how to use KDC and satellite imagery processing using the Python programming language on the JupyterHub interface (Figure 2).

Trainings were divided into 2 sections:

- 1) Introduction to Python and Data Cubes.
- 2) More Advanced Data Cube Usage – Import data files, using .shp files, farming a crop, NDVI, anomaly map, time series analysis, MODIS products, interactive crop health and others (Figure 3).

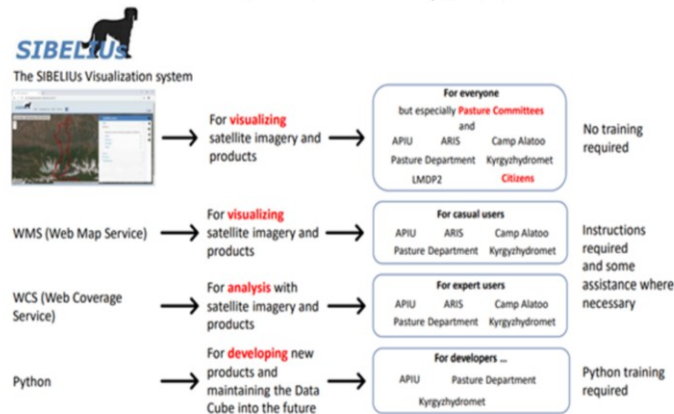


Figure 2: Data Access and Training: tailored for each user group (Sibelius, 2020)

```
[5]: # Find the nodata value to remove it from our DEM data
nodata = ds_dem.nodatavals[0]
print(nodata)
print()

# Remove the nodata value
ds_dem = ds_dem.where(ds_dem!=nodata)
print(ds_dem)

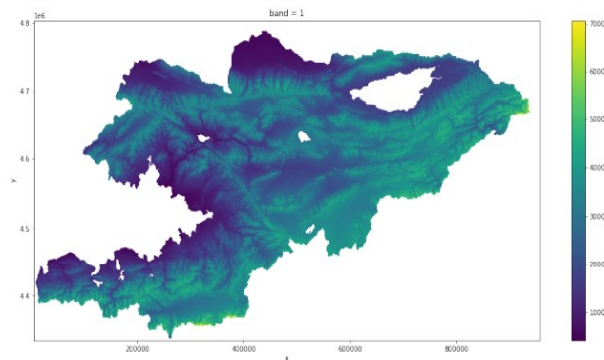
-32768.0

<xarray.DataArray (band: 1, y: 1281, x: 2607)>
array([[nan, nan, nan, ..., nan, nan, nan],
       [nan, nan, nan, ..., nan, nan, nan],
       [nan, nan, nan, ..., nan, nan, nan],
       ...,
       [nan, nan, nan, ..., nan, nan, nan],
       [nan, nan, nan, ..., nan, nan, nan],
       [nan, nan, nan, ..., nan, nan, nan]])

Coordinates:
  * band      (band) int64 1
  * y         (y) float64 4.803e+06 4.803e+06 4.802e+06 ... 4.337e+06 4.336e+06
  * x         (x) float64 5.896e+03 6.26e+03 6.625e+03 ... 9.56e+05 9.563e+05
Attributes:
  transform:    (364.7129570256314, 0.0, 5713.144114925002, 0.0, -364.712...
  crs:          +init=epsg:32643
  res:          (364.7129570256314, 364.7129570256314)
  is_tiled:     0
  nodatavals:   (-32768.0,)
  scales:       (1.0,)
  offsets:      (0.0,)
  AREA_OR_POINT: Area

[6]: # Plotting DEM
ds_dem.plot(figsize=(18,8))

[6]: <matplotlib.collections.QuadMesh at 0x7f1826482460>
```



Now you can treat the DEM like a data layer, so for example you could find the maximum and minimum elevation point for Kyrgyzstan

Figure 3: DEM codes (Sibelius, 2021)



In Figure 3 presented codes how to manipulate Digital Elevation Models (DEMs) using python. The following coding is carried out load all the packages, loaded DEM from the data folder and reprojected, plot the data and to mask the nodata value and remove it and plotting DEM.

### 3. Results and Discussion

The web map makes it possible to achieve the following results:

- to improve the visual definition the extent and area of distribution of droughts, assessing vegetation cover and land temperature and the tendency of the impact of climate change;
- associations of pasture users rational and affective use of pasture lands in accordance with the legislation;
- taking into account climate change in the Community Plans for Pasture Management and Improvement. In the chapter conditional pasture assessment and environmental protection taking into account climate change of the plan contain environmental elements, impact, mitigation and adaptation of climate change;
- identifying plants that are becoming widespread in many rangelands (such as caragana) which livestock are unable to eat. In 2020, within the framework of the project, work was carried out to determine the area of distribution of caragana in the Suusamyrgyz valley. Sentinel 2 of the Kyrgyz Data Cube were used for the analysis. Overall, the two maps show a net increase in Karagany from 6.3% of the area to 7.1% between 2014 and 2020 (Sibeliush, 2021).
- information provision of scientific research information for pasture users, employees of the Ministry of agriculture, forestry and water resources of the Kyrgyz Republic and other interested parties will be improved.

The Department of pastures and livestock breeding of the Ministry of agriculture, forestry and water resources of the Kyrgyz Republic is a key institution in grazing and pasture management in accordance with the legislation. The use of the Kyrgyz Data Cube makes it possible to receive information in a timely manner and carry out monitoring work based on satellite images and carry out regulatory measures for the management of rangelands.

Also, all satellite data are available for all stakeholders, from government agencies to pasture users.

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