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Landscape Restoration Opportunities in the Naryn River Basin, the Kyrgyz Republic

Restoration Opportunities Assessment Methodology (ROAM) Report

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Acknowledgments

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Abbreviations and Acronyms

BAU	Business As Usual
BCR	Benefit-Cost Ratio
CAIAG	Central Asian Institute for Applied Geosciences
CAMP	Central Asian Mountain Partnership
CBA	Cost-Benefit Analysis
CBD	Convention on Biological Diversity
CDO	Climate Data Operator
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station
CNBL	Channel Network Base Level
ELD	Economics of Land Degradation
EX-ACT	EX-Ante Carbon Balance Tool
FAO	Food and Agricultural Organization of the United Nations
FDI	Foreign Direct Investment
FLR	Forest Landscape Restoration
FTE	Full-Time Equivalent
GCF	Green Climate Fund
GCM	Global Circulation Model
GHG	Greenhouse Gas
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
HAC	High Activity Clay
HPP	Hydropower Plant
IFAD	International Fund for Agricultural Development
InVEST	Integrated Valuation of Ecosystem Services and Trade-offs
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
IUCN	International Union for Conservation of Nature
LU	Livestock Unit
MODIS	Moderate resolution Imaging Spectrometer
NDC	Nationally Determined Contribution
NDVI	Normalized Difference Vegetation Index

Abbreviations and Acronyms

NEX-GDDP	NASA Earth Exchange Global Daily Downscaled Projections
NPV	Net Present Value
NTFP	Non-Timber Forest Product
ODA	Official Development Assistance
PC	Pasture Committee
PES	Payment for Ecosystem Services
PESTLE	Political, Economic, Sociological, Technological, Legal, and Environmental
RCP	Representative Concentration Pathway
RESILAND	Resilient Landscape Restoration
RKDF	Russian-Kyrgyz Development Fund
ROAM	Restoration Opportunities Assessment Methodology
SAEPF	State Agency for Environmental Protection and Forestry (now SFS)
SDC	Swiss Development Cooperation
SDGs	Sustainable Development Goals
SDR	Sediment Delivery Ratio
SFS	State Forest Service (former SAEPF, State Agency for Environmental Protection and Forestry)
SFF	State Forest Fund
SOC	Soil Organic Carbon
SRTM	Shutter Radar Topography Mission
UNDP	United Nations Development Programme
USLE	Universal Soil Loss Equation
WRI	World Resources Institute

Abstract

This report outlines the main results of the study based on the Restoration Opportunities Assessment Methodology (ROAM) conducted in the Naryn River Basin, the Kyrgyz Republic. This assessment identifies degraded forest and pasture areas, considers the potential correlation between land degradation and sedimentation in hydropower reservoirs, and proposes feasible and effective landscape restoration measures for the Naryn River Basin. The study also presents several recommendations to fast-track the implementation of proposed interventions for the Naryn River Basin and scale up to other degraded areas throughout the country.

Executive Summary

Context

The Kyrgyz Republic is one of the countries in Central Asia most vulnerable to land degradation and climate change impacts. Climate-related disasters and land degradation due to unsustainable land use practices already affect the rural and urban population, which depends on natural resources and critical infrastructure.

Land degradation hotspots are observed throughout the country, particularly along the northern and western borders, including in the Naryn River Basin. The Naryn River Basin was selected for this study to assess potential opportunities for landscape restoration because of its transboundary importance for energy generation and provision of irrigation water. The Toktogul hydropower plant (HPP), fed by the Naryn River and the single largest HPP in the Kyrgyz Republic, provides up to 50 percent of the total national electricity production (1,200 MW) and plays a vital role in the country's energy security.[2]

The loss of active storage capacity due to reservoir sedimentation, as a result of land degradation, is significant in Central Asia and many other regions worldwide.[3] Soil erosion and sediment concentration also affect the performance of dams, hydropower generation plants, and irrigation infrastructure.[4]

The current rate of sedimentation in the Toktogul hydropower reservoir does not appear to put the plant at imminent risk of storage capacity loss. There are no recent and comprehensive data to verify this assumption by assessing the correlations between land degradation in the Naryn River Basin and sedimentation in the reservoir.

Landscape restoration refers to a wide variety of nature-based interventions that fall under the umbrella of investment in 'green infrastructure'. Typical landscape restoration interventions include slope correction using terracing, gulley stabilization, contour trenching and bunding; planting hedgerows and cover crops; implementing reforestation and afforestation; establishing orchards, woodlots, and silvopastures; and revising grazing practices.

Landscape restoration provides many ecosystem services and has a positive impact on many sectors of the economy, including energy, irrigation, agriculture, water supply, and transport. Reduced soil erosion and downstream impacts of sediment movement and accumulation are among the most visible and immediate results.

Other key ecosystem services include improved water holding capacity, water harvesting, flow stabilization, flood regulation, groundwater recharge, water provision, water quality, biodiversity, soil fertility, pasture health, and land productivity. Landscape restoration interventions can also be targeted

2 Other important HPPs in the Naryn River Basin include Kurpsay (800 MW), Tash-Komur (450 MW), Kambar-Ata-2 (production: 90 MW – full capacity: 360 MW), Shamaldy-Say (240 MW), Uch-Korgon (180 MW), and At-Bashy (40 MW). http://www.cawater-info.net/analysis/register/pdf/hps_kg_r.pdf

3 A 2023 study undertaken by the United Nations University's Institute for Water, Environment and Health (UNU-INWEH) reveals that the original global storage capacity lost to sediment by 2050 will amount to 1.65 trillion m3, equal to the combined annual water use of India, China, Indonesia, France, and Canada, significantly undermining water security, irrigation, and power generation. https://inweh.unu.edu/trapped-sediment-robbing-worlds-large-dams-of-vital-water-storage-capacity-26-loss-by-2050-foreseen/

4 https://www.sciencedirect.com/science/article/abs/pii/S1364032115004517.

to increase climate adaptation and resilience and to reduce the risk associated with natural disasters exacerbated by climate change like floods, droughts, and mass movements such as erosion, transport, and accumulation of material on slopes due to gravitational forces. At the same time, landscape interventions provide a means for climate mitigation through improved carbon storage and sequestration.

Landscape restoration interventions generate on-site socioeconomic benefits to communities. These include new jobs in construction and maintenance of green infrastructure; provision of non-timber forest products (NTFPs, that is, nuts), fuelwood, and fodder for livestock production; and improvement of livelihoods from woodlots, agroforestry, and silvopasture practices. Business cases concerning land restoration are typically built around several such benefits.[5]

Purpose and Methodology

The purpose of this study is to identify degraded areas and propose feasible and effective landscape restoration measures for the Naryn River Basin, using the Restoration Opportunities Assessment Methodology (ROAM),[6] with an outlook for similar applications to other areas in the country. ROAM is a framework developed by the International Union for Conservation of Nature (IUCN) and the World Resources Institute (WRI) to conduct forest and landscape restoration opportunity assessments and identify specific priority areas at national or subnational level.

Degradation hotspots, areas that are vulnerable to degradation and restoration opportunities, were identified (Section 2 and Annex 6). For this, various parameters such as Normalized Difference Vegetation Index (NDVI), soil organic carbon (SOC), elevation, rainfall intensity, soil erodibility, slope, and others were analyzed in a remote sensing software. The resulting maps were validated by ground truthing.

The study also assessed the correlation between land degradation and sedimentation of the Toktogul hydropower reservoir. For this, the Sediment Delivery module of the Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) model was used.[7] The results from InVEST were embedded in the remote sensing analysis. Climate change risk screening was performed to identify the potential implications of climate change on land degradation in the Naryn River Basin and indirectly on sediment transport to the Toktogul hydropower reservoir (Section 2 and Annex 6).

The methodology applied included a prioritization process of restoration measures based on socioeconomic analysis, policy review, stakeholders' consultation, and readiness assessment (Section 1.2, Figure 2). The socioeconomic benefits assessed include on-site benefits to communities and the potential benefits for hydropower and irrigation facilities, which are the most prevalent in the Naryn River Basin as well as global benefits such as carbon sequestration.

A cost-benefit analysis (CBA) was conducted for each proposed restoration measure in and outside the Naryn River Basin (Section 3.3). This analysis was based on a per hectare model for all measures, except for green and grey infrastructure measures which were calculated for 100 linear meters of infrastructure.

A final refinement of priority areas that were suitable for restoration was undertaken. Using the results of the CBA, the list of priority areas in and outside the Naryn River Basin was tailored to the maximum cost of a realistic restoration investment, which was assumed to be US$50 million.

[5] UNCCD Global Land Outlook.

[6] https://www.wri.org/research/restoration-opportunities-assessment-methodology-roam

[7] https://invest.readthedocs.io/en/latest/

Main Results and Recommendations

The land degradation assessment has identified highly degraded and vulnerable areas in the entire country first and then in the Naryn River Basin, which was the focus of the study. At the national level, degraded pastures and forests represent an area of more than 1.5 million ha (8 percent of the total country area), while for the Naryn River Basin degraded areas amount to 511,985 ha (10 percent of the total Naryn River Basin area). Within the Naryn River Basin, the Kokomeren River watershed shows the highest level of land degradation, with 15.5 percent of its area distributed in the most significant degradation classes[8] (Figure 3 and Table 1 in Section 2.2).

The restoration opportunity assessment has identified that all highly degraded and vulnerable areas, both at the national level and in the Naryn River Basin, offered high restoration opportunities (Table 2 in Section 2.2). This is because areas classified as highly degraded overlap with areas where human activity is present, which means they are productive lands and are accessible.

In the Naryn River Basin, the areas with high restoration opportunities (classes 3–6) were further refined to take account of the capacity of land managers and users, which is key to the success of restoration programs. This was done at a stakeholder workshop where participants identified a final list of four experienced state forest enterprises and 14 pasture committees (PCs), all located in the Naryn River Basin, where restoration measures should take place. As a result, 92,815 ha of pastures (Table 9 in Section 3.2) and 420 ha of forests (Table 5 in Section 3.2) were identified as priority areas for restoration in the Naryn River Basin. No agricultural land for restoration was identified, as the methodology used in the degradation assessment did not make it possible to clearly define degraded croplands. The limited size of priority forest areas is related to the basin's low forest cover, due to harsh climate, poor soil conditions, and widespread grazing.

At the same workshop, a final list of 12 restoration measures was elaborated in forest, pasture, agricultural, and protective lands (Table 4 in Section 3.1.2).

The CBA for each of these 12 restoration measures demonstrates that nine of them generate economic benefits over the 20-year reference period (Table 13, Table 15, Table 18, and Table 20 in Section 3.3). Riverbank protection offers the greatest benefits from avoided damage to infrastructure and settlements. In forest lands, afforestation with nut-bearing trees (walnuts or pistachio) also provides multiple direct benefits, including nuts and hay production. Similar activities in spruce forests, which is the most common species in the Naryn River Basin, do not provide immediate economic benefits due to slow tree growth under harsh mountain conditions. All agricultural and pastureland restoration measures generate economic benefits among which improved irrigation and no tillage produce the greatest benefits.

The proposed restoration measures also provide important environmental services. Ecosystem services were described for each restoration measure (Table 27) and include carbon sequestration and a flat value of US$6.8 per ha[9], which were included in the CBA.

The up-front investment based on the CBA, which is required to restore all of priority lands identified in the Naryn River Basin and in other parts of the country, is too high to be realistically financed. Hence, a final refinement of the priority areas for restoration was conducted. It only considered the most degraded areas (degradation classes 4–6 or 5–6 depending on the

[8] The six degradation classes are defined as follows: (1) No Degradation, Minor Vulnerability, (2) No Degradation, Major Vulnerability, (3) Minor Degradation, Minor Vulnerability, (4) Minor Degradation, Major Vulnerability, (5) Major Degradation, Minor Vulnerability, (6) Major Degradation, Major Vulnerability. The most significant degradation classes correspond to classes 3–6.

[9] Economics of Land Degradation (ELD) study in the Kyrgyz Republic.

type of land) within and outside the Naryn River Basin.

The areas prioritized in this final selection amount to 50,027 ha. This includes 39,818 ha of pastures, 8,909 ha of forests, and 1,300 ha of cropland. All of the 39,818 ha of pastures are included in the Naryn River Basin, as grazing is the main land use in the area. Most of the 8,909 ha of forests areas are located directly outside the basin (Figure 9, Figure 10, and Figure 11), and only 420 ha are located in the basin. The 1,300 ha of cropland have been determined by national experts because the land degradation analysis could not capture degraded agricultural land. These 1,300 ha are located in the Naryn River Basin (column 'target area description' in Table 25).

Based on the results of the CBA and the final prioritization of areas that are most suitable for restoration (50,027 ha), the total up-front cost for restoration (total investment costs in the first year of implementation) was estimated at US$45.36 million. This includes US$43.07 million for direct restoration costs and US$2.28 million for capacity building, consultancies, and investment management (Table 25).

Blended financing is recommended to cover this up-front cost of restoration to scale landscape restoration in the Kyrgyz Republic. It combines funds from the state budget, taxes and incentives, private investments from landowners or land lease holders, and investments from international cooperation organizations and development banks, as well as loans through local banks or specific funds.

Additional financial resources in sustainable land management can be streamlined toward landscape restoration interventions. Carbon financing available from the emerging voluntary carbon market can also be considered. Leveraging finance for restoration through a payment for ecosystem services (PES) mechanism is also an effective option in the Kyrgyz Republic although it first requires upgrades in legislation and in the public finance management system.

It is assumed that the direct restoration costs would be almost equally shared between international cooperation organizations and development banks and third parties, including government funds and investments from the private sector and local stakeholders. According to the assessment, this would amount to US$22.51 million to be financed from third parties and US$22,85 million from international cooperation organizations and development banks.

The overall net present value (NPV) of the proposed restoration program amounts to US$93.33 million at a 8 percent discount rate and over a 20-year time horizon. The discounted cost-benefit ratio of the investment is 2.4, that is, US$2.4 is generated from the investment of US$1. The return on investment was calculated at 138 percent. There are also nonmonetary benefits which would contribute to improved livelihoods through environmental and socioeconomic benefits such as employment, access to wood and non-wood forest products, and increase of income, among others.

The assessment of the correlation between continued land degradation and potential land restoration and sedimentation in the Toktogul hydropower reservoir was not conclusive. InVEST-based modeling found a linear relation between soil loss and sediment deposition, which was characterized by a 26 percent Sediment Delivery Ratio (SDR) on average. However, this assessment was based on the limited data that were available. For this reason, it was also not possible to determine a more precise impact of restoration (Section 2 and Annex 6).

Nevertheless, it is assumed that the prioritized restoration measures can contribute to reduced sedimentation overall in existing and commissioned hydropower and irrigation reservoirs within the Naryn River Basin. Moreover, the benefits of landscape restoration for these reservoirs are likely to increase with the escalating impacts of climate change on sediment and water regimes, as the Naryn

River will turn increasingly into a rain-fed river due to the melting of glaciers and reduction of snow cover.

Local land users and managers have good knowledge of pasture degradation and restoration. Local capacity is increasing through training provided by government institutions and under various international cooperation projects. There are successful examples of local land managers cooperating to combine resources and implement restoration interventions in pasture and forest lands.

There are opportunities to improve strategies and multilateral processes connected with landscape restoration and the coordination of restoration efforts between the pasture, agriculture, forest, and energy sectors. Based on the assessment, there are limited capacity-building mechanisms in place in the forest and pasture sectors and there are few successful examples of restoration of degraded agricultural land. Knowledge sharing on land restoration remains highly dependent on initiatives from international cooperation organizations or development banks. Permanent educational structures such as training facilities for the continuous capacity building of land users and managers would be beneficial.

Limitations and further studies

Further studies are recommended to confirm the potential correlation between land degradation, sedimentation, and storage loss for reservoirs in the Naryn River Basin, considering the implications of climate change. In-depth studies, integrating climate modelling approaches with field observations, will require new bathymetric surveys and revision of the dead storage capacity of existing and proposed reservoirs in the Naryn River Basin. This information would allow to identify the reservoirs at higher risk of siltation in the short term and medium term along the Naryn River and to prioritize landscape restoration measures, targeting the reservoirs that are more prone to future siltation.

The proposed interventions can also contribute to disaster alleviation and natural hazard risk reduction although this was not directly assessed. Improved soil structure and vegetation cover, in combination with other disaster alleviation activities, can improve ground stabilization, thereby increasing the basin's resilience to mudflows, landslides, rockfalls, and slumping. Landscape restoration can also help reduce flooding hazards and increase watershed drought tolerance and water retention. These benefits, which will become more significant as the impacts of climate change escalate, were not estimated, and further investigations are required to assess the full potential in natural hazards reduction.

Some of the proposed financing options require institutional and legal preconditions which need to be further researched. The issuance of carbon credits is not yet regulated in the Kyrgyz Republic, although there are ongoing efforts to establish a supportive legislative framework. Further studies are needed to explore realistic options for leveraging voluntary carbon market financing and to assess their time horizon.

1. Introduction

1.1. Context

The Kyrgyz Republic ranks second within the Central Asian region in terms of vulnerability to climate change during the period 2000–2019, after Tajikistan (Eckstein, Kunzel, and Schafer 2021). Climate-related disasters already affect the rural population, which is highly dependent on natural resources. To address these challenges, the Government of the Kyrgyz Republic has expressed interest in forest landscape restoration (FLR). The Kyrgyz Republic pledged to restore 23,200 ha of forests and 300,000 ha of pastures until 2030 in the Astana Resolution (2019) under the Bonn Challenge. The Kyrgyz Republic also joined the Europe, Caucasus, and Central Asia 30 (ECCA 30) initiative[10], which will support countries from this region to achieve their land restoration objectives. The Regional Program on Resilient Landscape Restoration (RESILAND) aims to reverse land degradation and increase the contribution of natural capital to economic recovery and development, with a particular focus on cross-border landscapes and collective efforts.

The Toktogul hydropower plant (HPP), fed by the Naryn River, provides up to 50 percent of the total electricity production in the country and plays a vital role in the country's energy security. In addition, the Toktogul Reservoir is also used to provide irrigation water. The loss of active storage capacity due to reservoir sedimentation, as a result of land degradation, is significant in many regions of the world and the Kyrgyz Republic is no exception. Soil erosion and sediment concentration also affect the performance of dams and hydropower generation plants in different ways: (a) efficiency loss and increased maintenance costs related to passage and accumulation of sediments; (b) more variable inflows into the reservoirs due to more frequent and severe peak inflows, which also increase reservoirs' vulnerabilities; and (c) reduced dam safety and increased operational risks due to upstream sediment build-up.

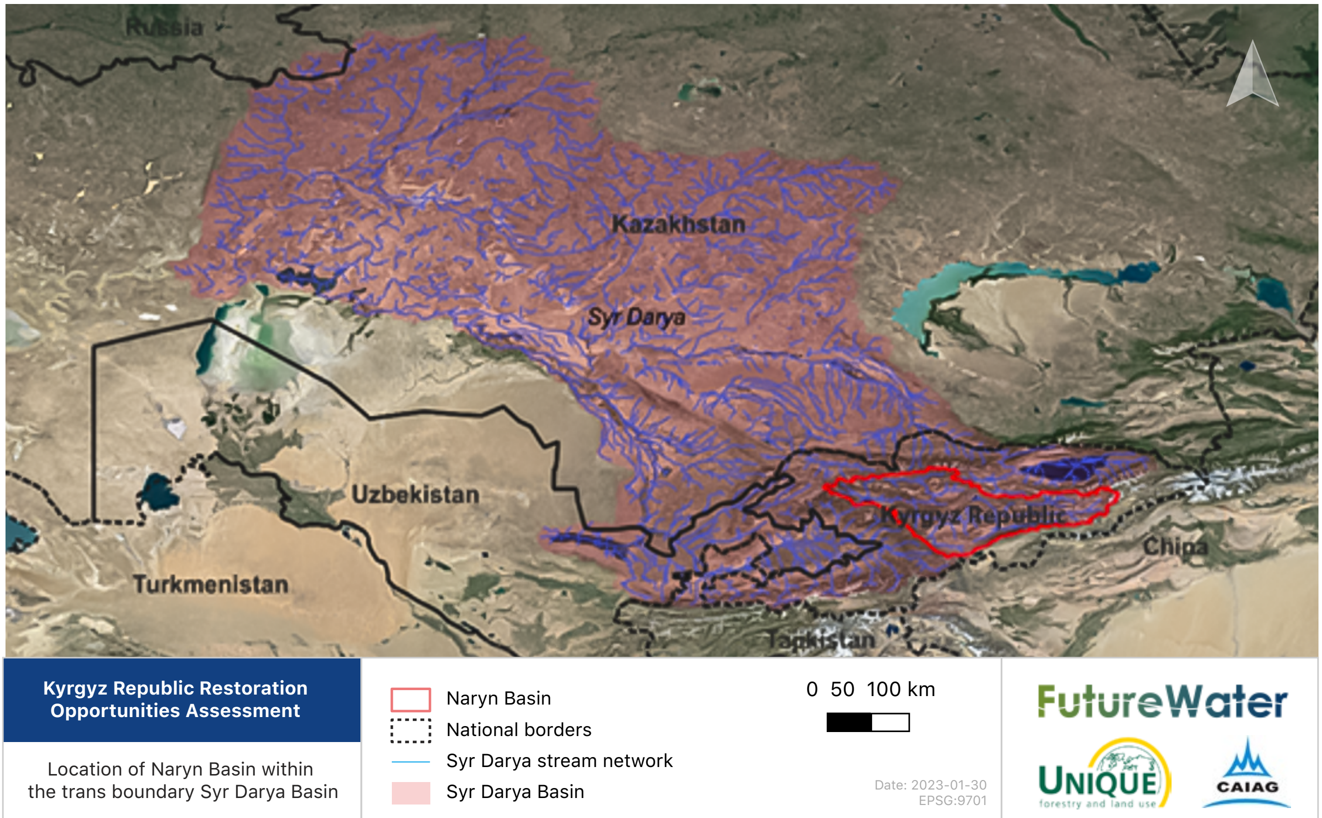
According to the available knowledge and data, the current rate of sedimentation in the Toktogul hydropower reservoir does not appear to put the plant at imminent risk of storage capacity loss. There are, however, no recent and comprehensive data to assess the correlation between land degradation in the Naryn River Basin and sedimentation in the reservoir. Downstream of the Toktogul dam, the Naryn River flows into Uzbekistan and later into Kazakhstan, forming the Syr-Darya River, which feeds the northern part of the Aral Sea (Figure 1). The Naryn River Basin water management is, therefore, of paramount transboundary importance.

Landscape restoration includes various nature-based interventions that fall under the umbrella of investment in 'green infrastructure', such as soil stabilization, tree plantations in various designs, and low-impact grazing practices.

These interventions may provide economic benefits and various ecosystem services to key sectors of the economy, including energy, irrigation, agriculture, water supply, and transport. They also provide other ecosystem services such as improved water holding capacity, water harvesting, flow stabilization, flood regulation, groundwater recharge, water provision, water quality, biodiversity, soil fertility, pasture health, and land productivity.

10 Initiative for bringing Europe, the Caucasus, and Central Asia into restoration by 2030

Figure 1: Location of the Naryn River Basin within the transboundary Syr-Darya Basin



Source: Original elaboration for this publication.

Finally, landscape restoration interventions generate on-site socioeconomic benefits to communities such as new jobs in construction and maintenance of green infrastructure; provision of non-timber forest products (NTFPs, i.e., nuts), fuelwood, and fodder for livestock production; and improvement of livelihoods from woodlots, agroforestry, and silvopasture practices.

1.2. Purpose and overall methodology

The purpose of this study is to identify degraded areas and propose feasible and effective landscape restoration measures for the Naryn River Basin and the Kyrgyz Republic, using the Restoration Opportunities Assessment Methodology (ROAM).[11] ROAM is a framework developed by the International Union for Conservation of Nature (IUCN) and the World Resources Institute (WRI) to conduct forest and landscape restoration opportunity assessments and identify specific priority areas at national or subnational level.

The methodology includes a prioritization process of restoration measures based on socioeconomic analysis, policy review, stakeholders' consultation, and a readiness assessment. For each of the proposed restoration measures, a cost-benefit analysis (CBA) was conducted to assess their potential to generate long-term economic benefits. The report also analyzes how land restoration in the Naryn River Basin could potentially decrease the amount of sediment flowing into the Toktogul hydropower reservoir. The detailed methodology used to perform the above steps is described in the appropriate sections of the report (2.1, 3.1.1, 3.2.1, 3.3.1, and 3.4.1).

[11] https://www.wri.org/research/restoration-opportunities-assessment-methodology-roam

Figure 2 gives an overview of the overall study workflow and logic.

Figure 2: Study workflow

- **Step 1.** Identification of degradation hotspots and sediment sourcing, including validation
- **Step 2.** Mapping feasibility of interventions and validation
- **Step 3.** Prioritization restoration options (CBA, GHG) and restoration areas
- **Step 4.** Restoration areas mapping
- **Step 5.** Readiness assessment
- **Step 6.** Analysis of finance and investment options

Source: Original elaboration for this publication.
Note: GHG = Greenhouse gas.

The results of the study are expected to help the Government of the Kyrgyz Republic make informed decisions for the restoration of degraded lands in the country and to define the most suitable financing mechanisms to restore degraded lands. Land restoration is expected to prevent long-term losses in hydropower production and generate additional monetary and nonmonetary benefits at local, national, and global levels.

2. Mapping of Land Degradation and Restoration Opportunities

2.1. Methodology

The detailed methodology for mapping baseline land degradation, vulnerability to degradation, and feasibility of interventions is described in the Data Collection and Baseline Report. In addition, the results of this satellite remote sensing-based assessment were validated in discussions with local experts and stakeholders and through the observations made and meetings held during the September 2021 field visits.

A crucial point of feedback from the field visits, as presented in the previously submitted Data Collection and Baseline Report, was the observation that unproductive lands ('badland' areas) in several regions were assigned a degradation class in the mapping. However, these lands are naturally unproductive, for example, saline soils, and should not be considered degraded or potential targets for restoration measures. As a result, the degradation maps were updated by removing these badlands from the degradation classification. Discussions with Central Asian Institute for Applied Geosciences (CAIAG) experts resulted in a most appropriate approach to 'masking' these areas, using Normalized Difference Vegetation Index (NDVI) and soil organic carbon (SOC) data. The most accurate badland mask was created using an upper NDVI threshold of 0.2 (the mean value for 2000–2020), and this layer was used to extract unproductive lands from the maps. An NDVI value typically ranges between –1 and 1. Low positive values, that is, 0.2, represent shrub and grassland and thus exclude the unproductive lands. Hence, all the negative values, and values below 0.2, were left out during this operation. This updated 'badland' (naturally non-productive areas) mask is presented in Annex 2.

The topographic and geographic situation of individual sites influences their potential impact on sedimentation. Factors such as upslope and downslope land cover, slope gradient, size of the upstream area, and distance to a stream can be used to quantify an 'index of connectivity'. This index represents the likelihood that material eroded from a certain site will reach a stream sink and thereby contribute to siltation. To take account of this connectivity dimension, the Sediment Delivery Ratio (SDR) module of the Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) model was applied. This assessment was based on the limited data that were available. For this reason, the default InVEST values are used in this study, resulting in limited accuracy.

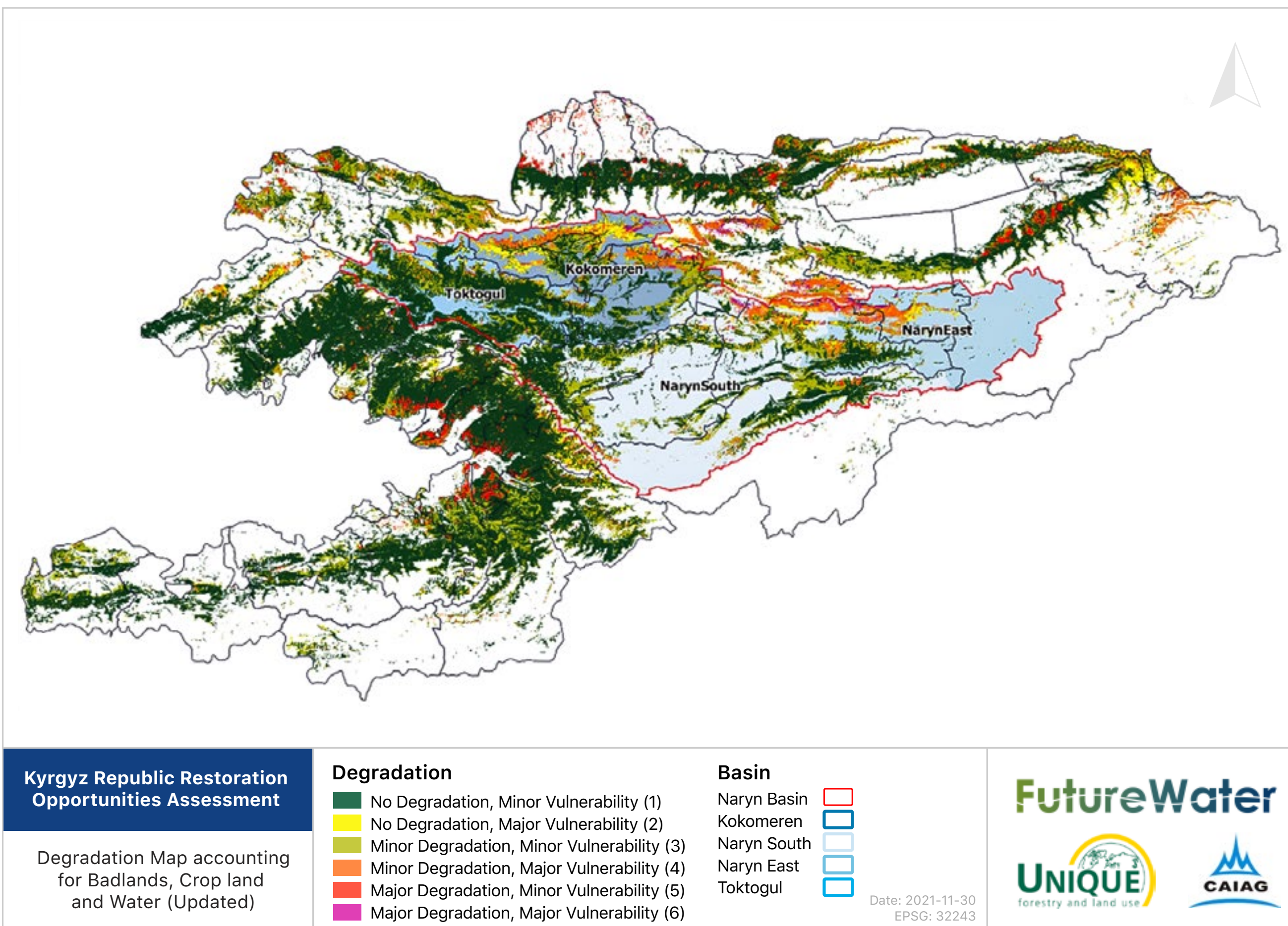
Differences in degraded extents between this study and other studies, like the recent Nationally Determined Contribution (NDC) update, occur since there were differences in methodologies, definitions, and assumptions used. In general, based on discussions with local experts, choices in the identification of degradation were more on the conservative side. Among other differences, the assessment included a more rigorous exclusion of 'badlands', considered as degraded summer pastures in the NDC update and other studies.

2.2. Results

Figure 3 shows the updated map resulting from the overall degradation assessment, composed of both the baseline degradation and vulnerability mapping as described in Annex 6 (previously included in the Data Collection and Baseline Report). Six classes were defined based on the combinations of the three qualitative classes indicating baseline degradation and the two showing vulnerability to soil erosion. The resulting classes are as follows: (1) No Degradation, Minor Vulnerability, (2) No Degradation, Major Vulnerability, (3) Minor Degradation, Minor Vulnerability, (4) Minor Degradation, Major Vulnerability, (5) Major Degradation, Minor Vulnerability, and (6) Major Degradation, Major Vulnerability.

Hotspots of significant degradation and/or vulnerability can be observed in the western part of the Kyrgyz Republic and directly to the southeast of Issyk Kul Lake. Within the Naryn River Basin, stretches along the basin's northern edge are considered degraded. Compared to the map presented in the Data Collection and Baseline Report, large parts of the Naryn South sub-basin are now regarded as unproductive lands and excluded from the classification. This is in line with field observations and was validated by national partners at the subsequent workshop on December 3, 2021.

Figure 3: Map of overall land degradation



Source: Original elaboration for this publication.

Note: White areas contain non-forest or pastureland use classes (for example, high mountain areas, croplands, water bodies) and include the badlands extracted through the mask presented in Annex 2.

Table 1 presents for each class of degradation and vulnerability the extent to which it occurs at the national, basin, and sub-basin levels. According to this assessment, including classes 3–6, **over 1.5 million ha (8 percent of the total area) at the national level consists of pastures and forests that are degraded to a certain extent**. The extent of degradation is more significant in the Naryn River Basin (511,985 ha or 10 percent of area) and highest within the Kokomeren Watershed, at 15.5 percent of the total sub-basin area.

Table 1: Overall land degradation statistics for each sub-basin

Class[12]	Kyrgyz Republic		Naryn Basin		Naryn Basin South		Naryn Basin East		Toktogul Watershed		Kokomeren Watershed	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
1	3,771,563	18.9	943,867	18.3	369,721	15.6	79,949	7.8	341,948	40.8	152,207	16.6
2	505,130	2.5	212,416	4.1	64,139	2.7	36,437	3.5	33,074	3.9	78,752	8.6
3	909,624	4.6	290,933	5.6	155,431	6.6	17,659	1.7	53,099	6.3	64,737	7.1
4	389,417	2.0	179,998	3.5	56,668	2.4	44,210	4.3	14,653	1.7	64,452	7.0
5	212,256	1.1	11,186	0.2	6,601	0.3	613	0.1	2,006	0.2	1,963	0.2
6	59,910	0.3	29,868	0.6	10,474	0.4	7,032	0.7	1,667	0.2	10,680	1.2
Total classes 3–6	1,571,207	-	511,985	-	229,174	-	69,514	-	71,425	-	141,832	-
Total	**5,847,900**	**-**	**1,668,268**	**-**	**663,034**	**-**	**185,900**	**-**	**446,447**	**-**	**372,791**	**-**

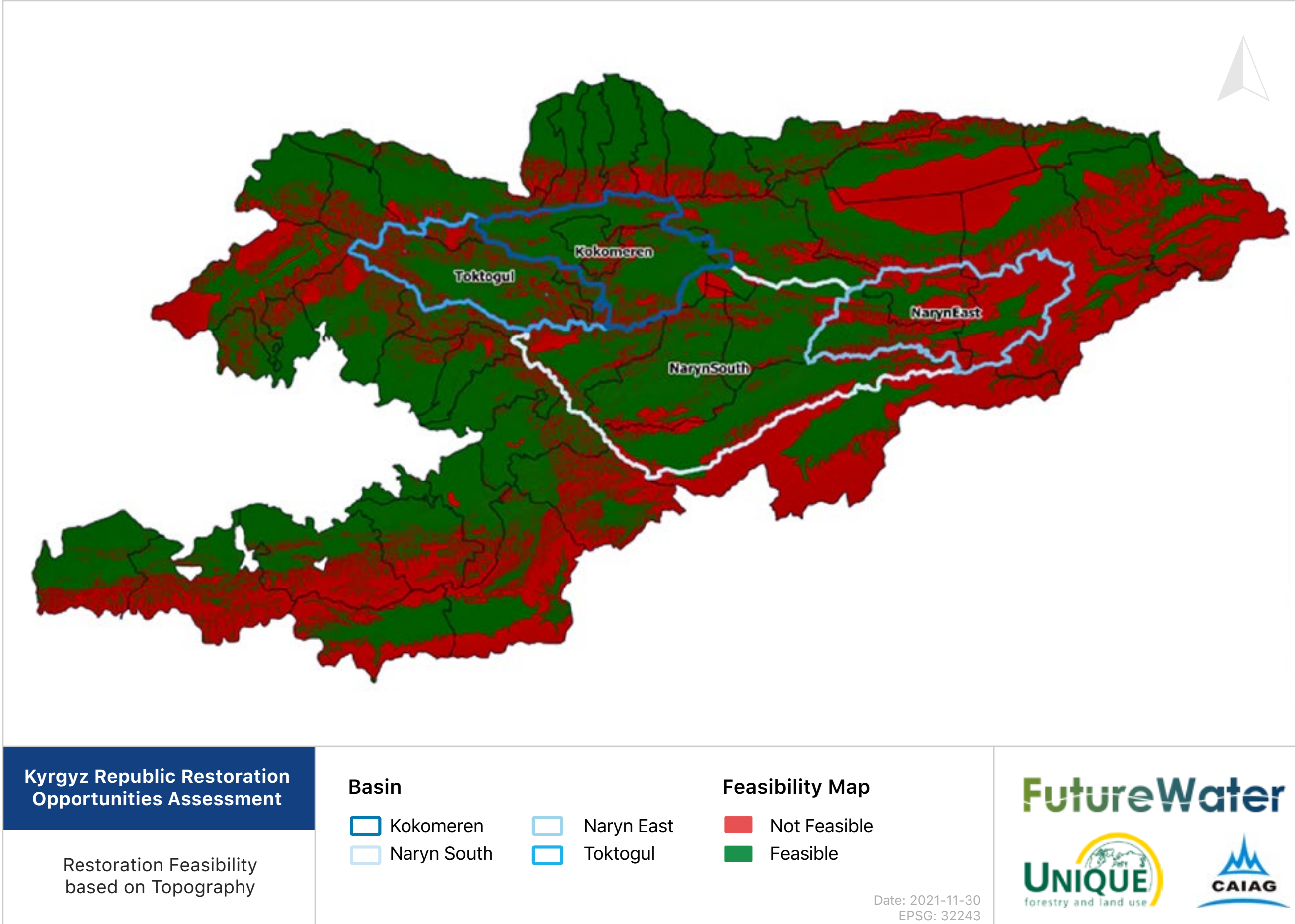
Source: Original elaboration for this publication.

Note: Class IDs correspond with those listed in the legend of Figure 6. Percentage total not equal to 100 due to non-applicable areas in the region.

To inform the planning of restoration activities, it is essential to combine the overall degradation map of Figure 3 with an assessment of practical feasibility of implementing restoration measures by excluding high altitude areas, steep slopes, and protected areas. As described in the Data Collection and Baseline Report, this mapping of restoration feasibility was performed by combining threshold values of elevation (3,500 m above sea level) and slope (30 degrees) and by excluding protected areas. The result of the SDR/InVEST model, which indicates a linear relation between soil loss and sediment deposition (characterized by a 26 percent SDR on average), was also considered as an additional restoration suitability criteria.The resulting feasibility map is shown in Figure 4.

[12] The degradation classes are (1) No Degradation, Minor Vulnerability, (2) No Degradation, Major Vulnerability, (3) Minor Degradation, Minor Vulnerability, (4) Minor Degradation, Major Vulnerability, (5) Major Degradation, Minor Vulnerability, (6) Major Degradation, Major Vulnerability.

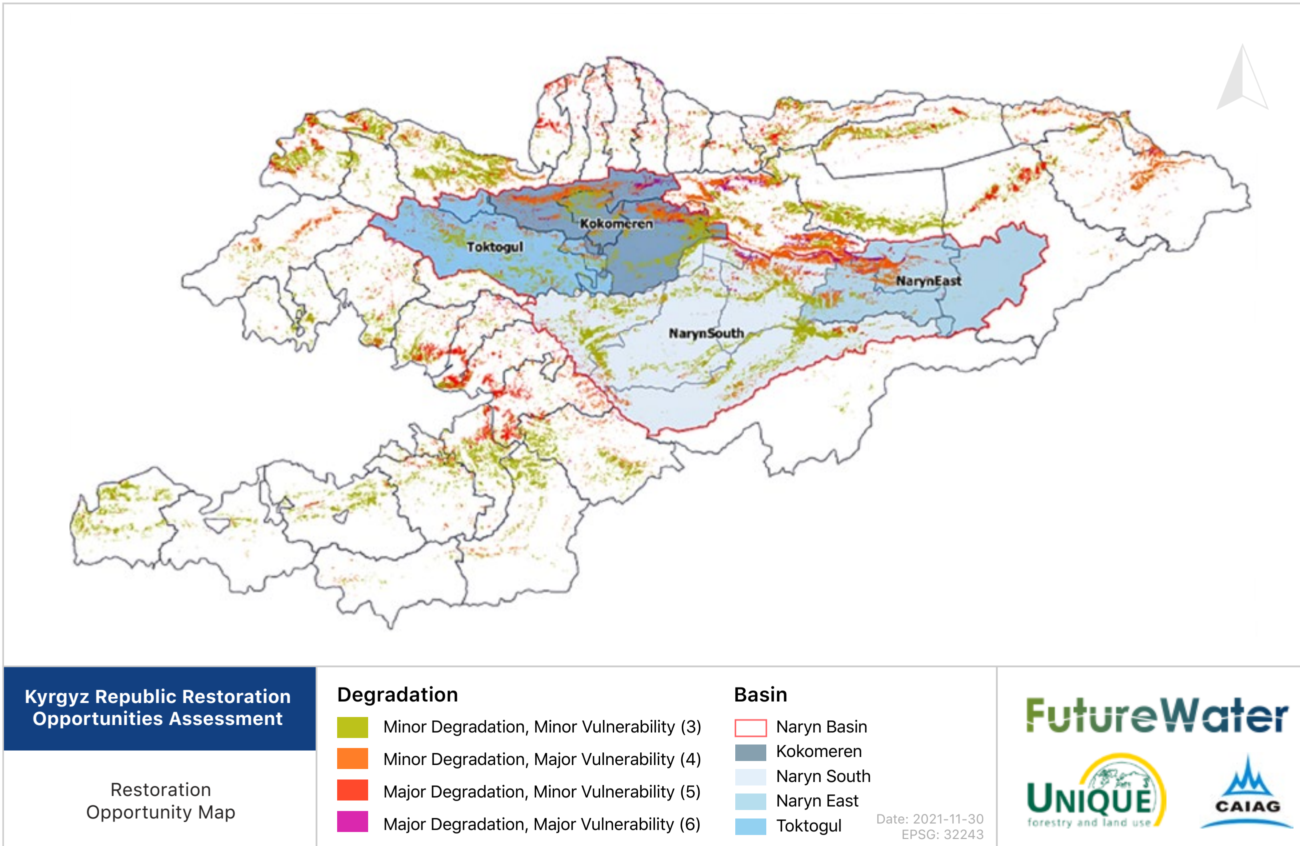
Figure 4: Restoration feasibility map



Source: Original elaboration for this publication.

Figure 5 then integrates the overall degradation map and the feasibility assessment to map restoration opportunities. Here, only classes 3–6 (where a certain extent of degradation was observed) were considered potentially relevant for implementing restoration activities. Table 2 lists the areas assigned to each degradation class after subtraction by the feasibility map. Areas are like those in Table 1, except for class 1. This is because areas classified as 'no degradation' overlap with terrain having high altitudes and steep slopes, where typically there is no temporal trend in NDVI and little human activity is present.

Figure 5: Final map of restoration opportunities



Source: Original elaboration for this publication.
Note: The map is constructed based on the overall land degradation map with non-feasible areas subtracted.

Table 2: Restoration opportunity statistics for each sub-basin

Class	Kyrgyz Republic		Naryn Basin		Naryn Basin South		Naryn Basin East		Toktogul Watershed		Kokomeren Watershed	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
1	2,427,577	12.2	583,697	11.3	242,548	10.3	41,756	4.0	197,949	23.6	101,438	11.1
2	505,130	2.5	212,416	4.1	64,139	2.7	36,437	3.5	33,074	3.9	78,752	8.6
3	909,624	4.6	290,933	5.6	155,431	6.6	17,659	1.7	53,099	6.3	64,737	7.1
4	389,417	2.0	179,998	3.5	56,668	2.4	44,210	4.3	14,652	1.7	64,452	7.0
5	212,256	1.1	11,186	0.2	6,601	0.3	613	0.1	2,006	0.2	1,963	0.2
6	59,910	0.3	29,868	0.6	10,474	0.4	7,032	0.7	1,667	0.2	10,680	1.2
Total	**4,503,915**	-	**1,308,098**	-	**535,861**	-	**147,707**	-	**302,447**	-	**322,022**	-

Source: Original elaboration for this publication.
Note: Percentage total not equal to 100 due to non-applicable areas in the region.

3. Results of restoration assessment

3.1. Identification of suitable restoration measures

3.1.1. Methodology

A long list of 33 restoration measures was first elaborated based on existing restoration experiences in government programs and development projects in the Kyrgyz Republic as well as on other experiences available worldwide. This long list was discussed at an online workshop on June 17, 2021, with representatives from the Ministry of Agriculture, the State Forestry Service, and the Kyrgyz National Agrarian University with the aim to delete the restoration measures which were not appropriate or feasible in the Kyrgyz Republic or in the Naryn River Basin, to add any other relevant restoration measures, and to select the most feasible and relevant ones. The participants were asked to assess the relevance of the proposed measures on a scale of 1 to 3 across a set of eight criteria presented in a PESTLE[13] framework (Table 3). The criteria related to political aspects were assessed by our team, since not all participants were familiar with SDGs and national and sector-specific strategies. All other criteria were assessed at the workshop. In addition, two 'killer' criteria were introduced to exclude measures that are not realistic or not relevant, either at the national level or at the Naryn River Basin level. The short-listed measures were further ranked according to their total scores, in each land use category (forest, pasture, agriculture, and protective lands).

Table 3: Evaluation criteria for the assessment of the restoration measures

Topics	Evaluation criteria
Political (level of alignment with national and sectoral policies and plans)	▪ Alignment with SDGs
	▪ Alignment with national and sector policies and strategies
Economic and financial (costs benefit, productivity)	▪ Direct costs and benefits (for example, investment, revenue flow, profitability)
	▪ Indirect costs and benefits (for example, lost and new economic opportunities, increased provision of ecosystem services)
Social (importance of livelihood, gender equality)	▪ Presence of well-functioning community-based land management bodies
	▪ Importance for rural livelihoods

[13] PESTLE stands for Political, Economic, Sociological, Technological, Legal, and Environmental criteria.

Table 3

Topics	Evaluation criteria
Legal and institutional (level of feasibility within existing legal system)	▪ Enabling land use rights to implement the measure
	▪ Feasibility within existing legal and regulatory frameworks
Environmental (level of alignment with reducing overall vulnerability - people and ecosystems)	▪ Ability to reduce vulnerability to environmental changes
	▪ Co-benefits (biodiversity, ecosystem services, and so on)
Killer criteria - national level	▪ Adoption rate by land users and managers
	▪ Technological feasibility (availability of needed technologies, human capacities)
Killer criteria - Naryn River Basin	▪ Adoption rate by land users and managers
	▪ Technological feasibility (availability of needed technologies, human capacities)

Source: Original elaboration for this report.

3.1.2. Results

From the initial list of 33 restoration measures, 21 were excluded. The main reasons for this were the expected low adoption rate and missing technologies and human capacities. The final list of restoration measures is presented in Table 4. The sequence of activities in each land use category corresponds to the ranking established by national partners during the online workshop.

Table 4: Prioritized restoration measures in and outside the Naryn River Basin

No.	Forest lands
1	Afforestation / reforestation with high-quality seedlings and polybags with protection measure (pistachio, walnut, juniper, and spruce)
2	Reforestation in riparian areas/forests
3	Assisted natural regeneration (pistachio, walnut, juniper, and spruce forests)
	Agricultural lands
4	Efficient use of water resources
5	No tillage/minimum tillage
6	Introduction of crop rotation and cover crops
7	Agroforestry models combining walnut trees, fruit trees, fast growing trees (hedgerows), native bushes, hay production, and agriculture in State Forest Funds (SFFs) and private lands

No.	Forest lands
	Pasturelands
8	Temporary grazing ban in degraded areas in all pasture types
9	Access to remote pastures through infrastructure improvement (for example, watering points, bridges, and roads)
10	Rotational grazing and grazing schedule in summer and winter pastures for increasing productivity and improving palatability
	Protective lands
11	Riverbank protection and gully stabilization through green infrastructure (plantation of adapted grass, bush, and tree species)
12	Riverbank protection and gully stabilization through grey infrastructure (gabions, check dams)

Source: Original elaboration for this publication.

3.2. Restoration area prioritization

3.2.1. Methodology

The data for the different forest types (that is, spruce, junipers, walnut, pistachio, and almond) were obtained from the 2008 Swiss Development Cooperation (SDC) dataset which was clipped onto the restoration opportunity map (224 × 224 m) to get an indication of restoration opportunities for each forest type. To capture sufficient detail, given that the available SDC data were composed of various small polygon features, the degradation map was resampled to a 10 × 10 m resolution. A similar methodology was applied to pastures. The restoration opportunities map was clipped with a grassland/pasture sample set from the 2019 Intergovernmental Panel on Climate Change (IPCC) Land Use dataset to obtain the pasture restoration opportunities map. This map of restoration opportunities was used to calculate the investments required to restore degraded lands (see Table 24). Priority was given to the most degraded areas (typically to areas classified within degradation classes 4–6, but also in some cases only classes 5–6 when class 4 was too large).

Further, the restoration opportunity map was overlaid with prioritized areas where the first investments should be channeled. For this, the map of restoration opportunities was combined with selected Leskhozes and pasture committees (PCs) (Figure 6 and Figure 7). This selection was done based on the following criteria:

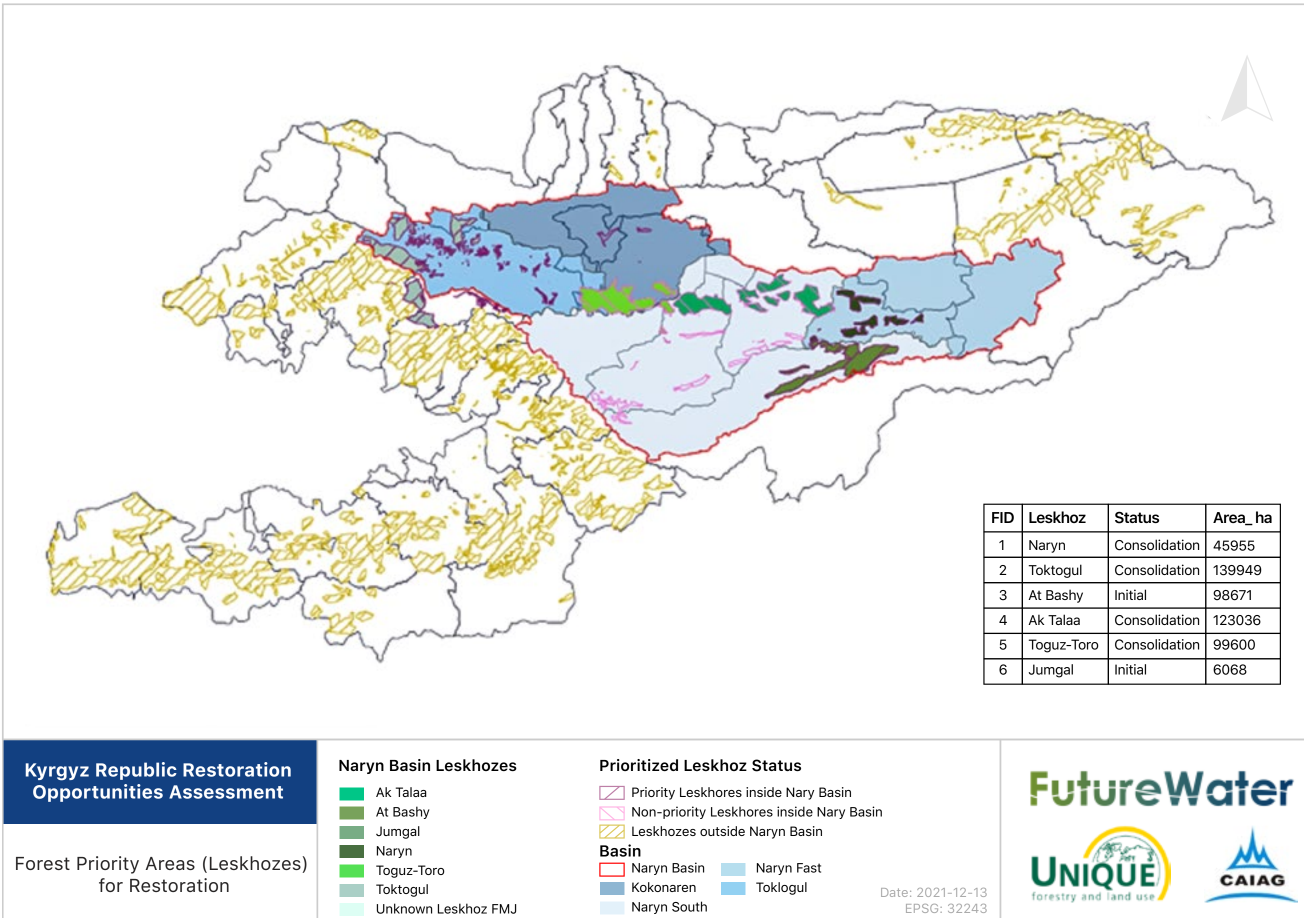
- **Leskhozes and PCs** which have **good track records in past restoration projects** and have demonstrated their willingness during field visits were identified as priority areas. They were further distributed into two classes:
  - Areas where **no project-funded restoration activities** were implemented in the past years were categorized as '**initial**'. It means any restoration initiative in these areas must start from zero.
  - Areas where **project-funded restoration activities were successfully** implemented in past years were categorized as '**consolidation**'. It means any new restoration initiative in these areas can easily build on the experience and practices already applied in the past.
- Leskhozes and PCs which will be target territories in the upcoming GCF-FAO[14] project **were excluded from priority** areas, as they will receive substantial financial support for restoration activities through this project.

[14] Green Climate Fund- Food and Agricultural Organization of the United Nations.

- Leskhozes and PCs which **performed poorly** in the implementation of past projects (information based on interviews with development partners) or which showed a passive attitude during field visits **were also excluded** from priority areas.

This prioritization was done by a team of experts and was confirmed at the validation workshop with national partners, who proposed to add one more PC and one Leskhoz which they consider as active and capable. Figure 6 and Figure 7 provide an overview of priority Leskhozes and PCs, respectively.

Figure 6: Priority Leskhozes for restoration activities

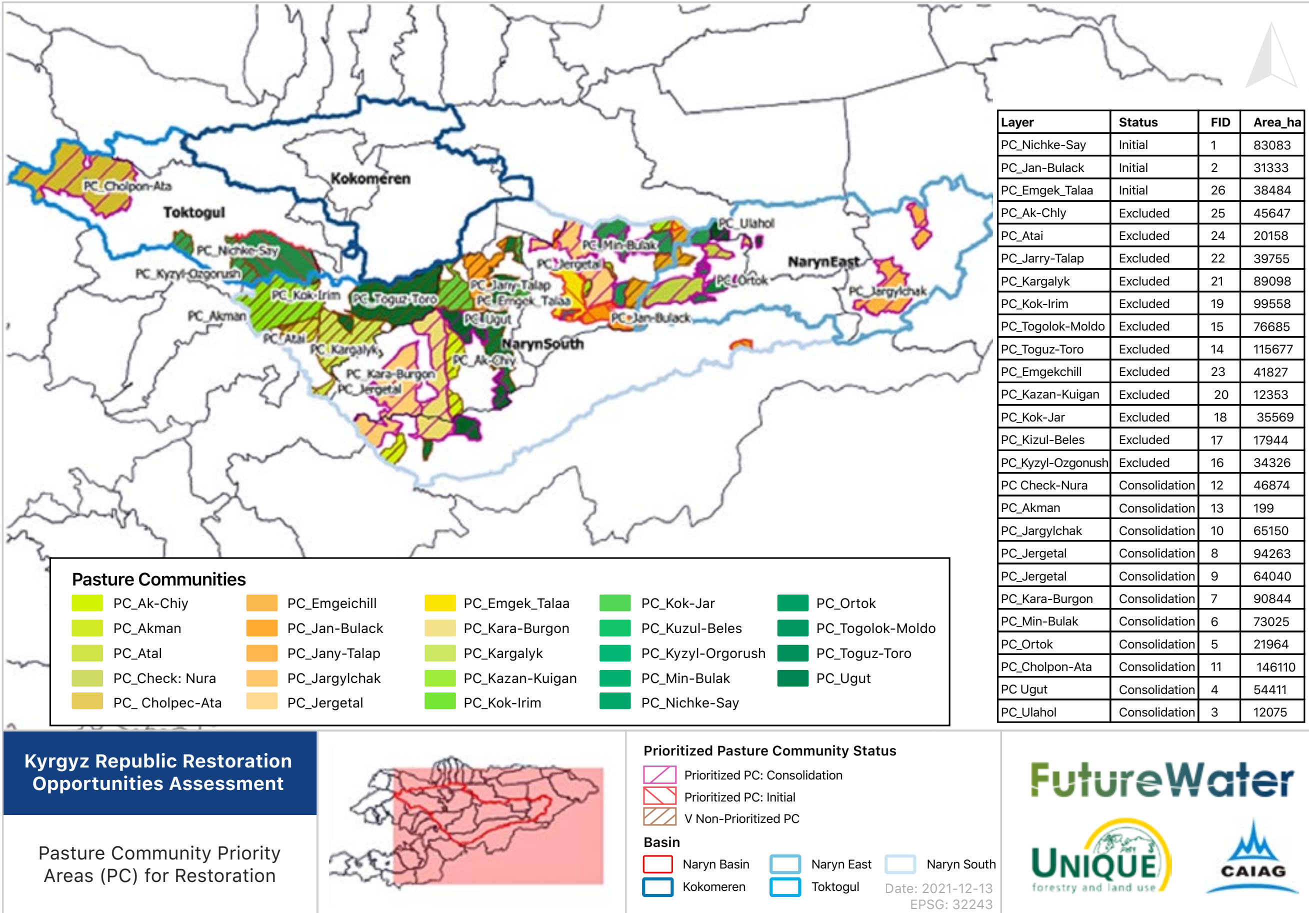


FID	Leskhoz	Status	Area_ha
1	Naryn	Consolidation	45955
2	Toktogul	Consolidation	139949
3	At Bashy	Initial	98671
4	Ak Talaa	Consolidation	123036
5	Toguz-Toro	Consolidation	99600
6	Jumgal	Initial	6068

Source: Original elaboration for this publication.

Note: Priority leskhozes are shown with purple outlines and hatched polygons, as indicated in the legend. Some leskhozes are so small that due to the scale of the map, the purple lines seem to be continuous planes.

Figure 7: Priority PCs for restoration activities



Source: Original elaboration for this publication.

3.2.2. Forest area prioritized for restoration

As outlined in the baseline report, forest resources are under high pressure due to excessive logging in the past and current unsustainable use as fuelwood as well as high pressure from uncontrolled grazing. The national survey results of SAEPF and FAO (2010) show that around 12.5 percent of forests suffer from degradation. This is a higher value than what was found in this study for Naryn River Basin forests, but it should be noted that both spatial domain and period differ between the two assessments. Degradation processes are also affected by climate change with more events of extreme climate and weather conditions. These processes, combined with the fragile mountain topography, have caused significant degradation of forest resources over the past decades (GIZ 2015; SAEPF 2015). Historically, forest cover was concentrated in the western part of the Kyrgyz Republic. Major parts of these forested areas have been cleared. However, the annual rate of tree cover loss has decreased over recent years, especially since 2013. This is due to an introduced logging ban (moratorium in 2017) for walnut and Juniperus forests and due to efforts of afforestation and reforestation. Deforestation is of minor importance in the Naryn River Basin according to WRI (2016)5F[15] and our study. Restoration efforts

[15] https://www.wri.org/data/atlas-forest-and-landscape-restoration-opportunities

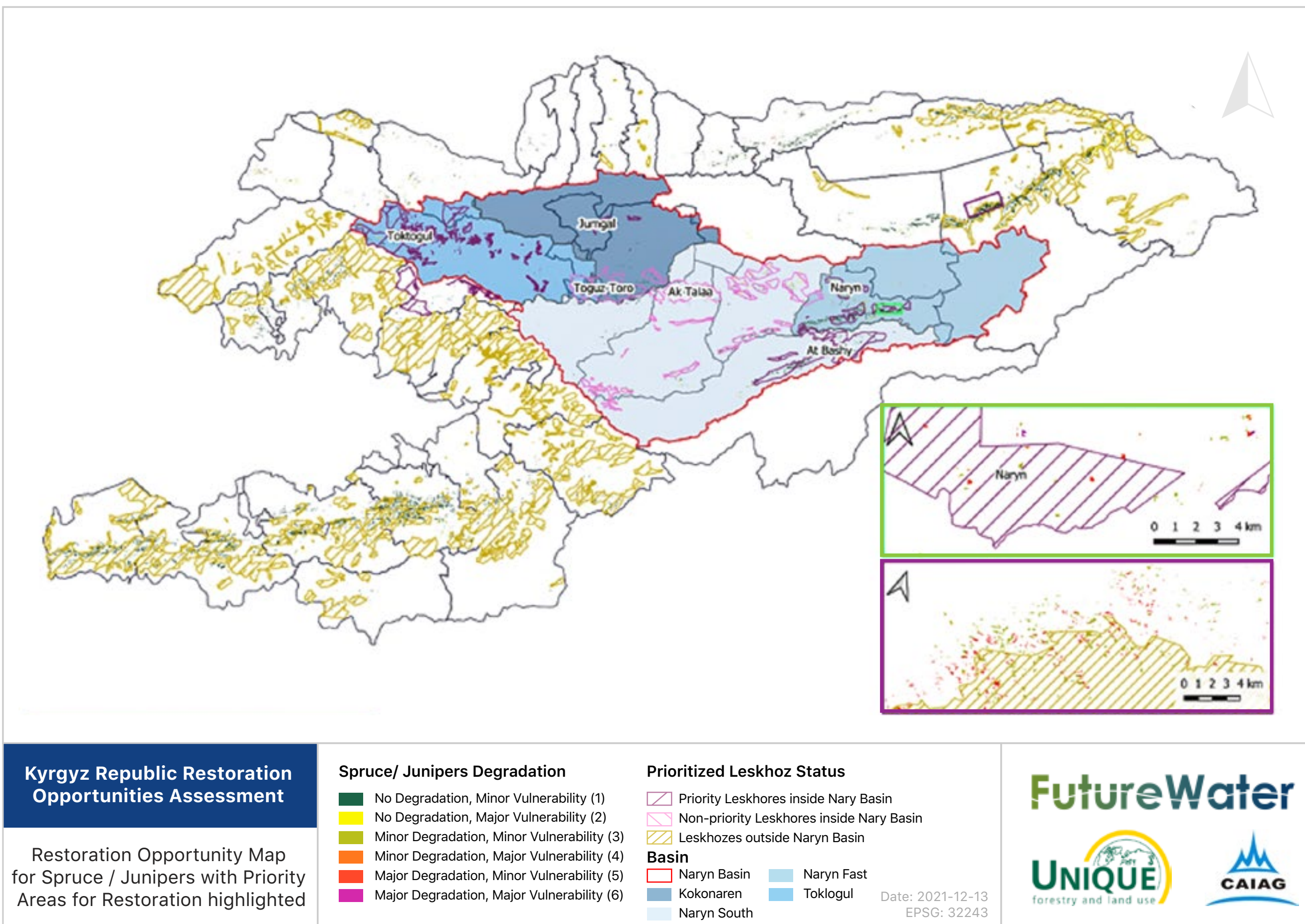
therefore should focus on areas where forests existed in the past and which are degraded instead of investing resources on afforestation under harsh climatic conditions in remote areas.

The forest areas are subdivided into three forest types: spruce and juniper forests, almond and pistachio forests, and walnut forests. For each of these forest types, separate restoration opportunity results are presented and the prioritized Leskhoz areas are highlighted. A full overview of the restoration opportunity areas for the different Leskhozes is provided in Annex 3.

Spruce and Juniperus degraded forests

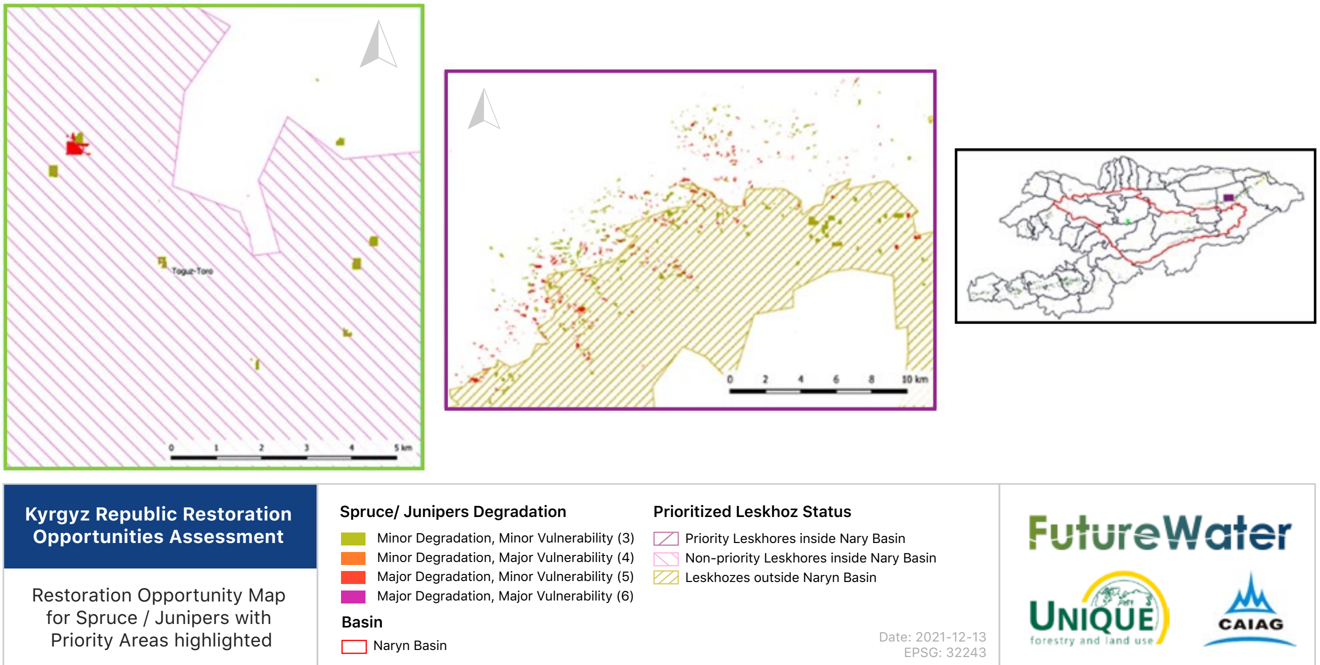
Figure 8 shows the map of restoration opportunities for spruce and juniper forests and indicates the priority Leskhozes in the Naryn River Basin. Figure 9 shows for two specific regions in the Naryn River Basin the occurrence of restoration opportunity locations in Toguz-Toro (left) and outside of the Naryn River Basin (right). Table 5 lists the total area of restoration opportunities for each of the priority areas for the different prioritized Leskhoz regions, with Naryn Leskhoz having the highest relative extent at 0.3 percent. Ak-Talaa and At-Bashy rank highest in terms of absolute extent for restoration opportunities (classes 3–6), with over 150 ha of the areas considered to offer opportunities for restoration activities.

Figure 8: Spruce and Juniperus restoration opportunity map with priority areas in and outside the Naryn River Basin



Source: Original elaboration for this publication.

Figure 9: Restoration opportunity map for spruce and juniper degraded areas with priority areas in two focus regions in and outside the Naryn River Basin



Source: Original elaboration for this publication.

Table 5 shows the area of degraded spruce and Juniperus forest types (degradation classes 3–6 and non-degraded areas classes 1–2) for each of the prioritized Leskhozes. In total, degradation classes 3–6 in the four prioritized Leskhozes amount to 420 ha. Although degradation has been detected in the Naryn River Basin, the degraded area is small — below 1 percent per class of the total area.

Table 5: Overall spruce and juniper restoration opportunity statistics for each Leskhoz

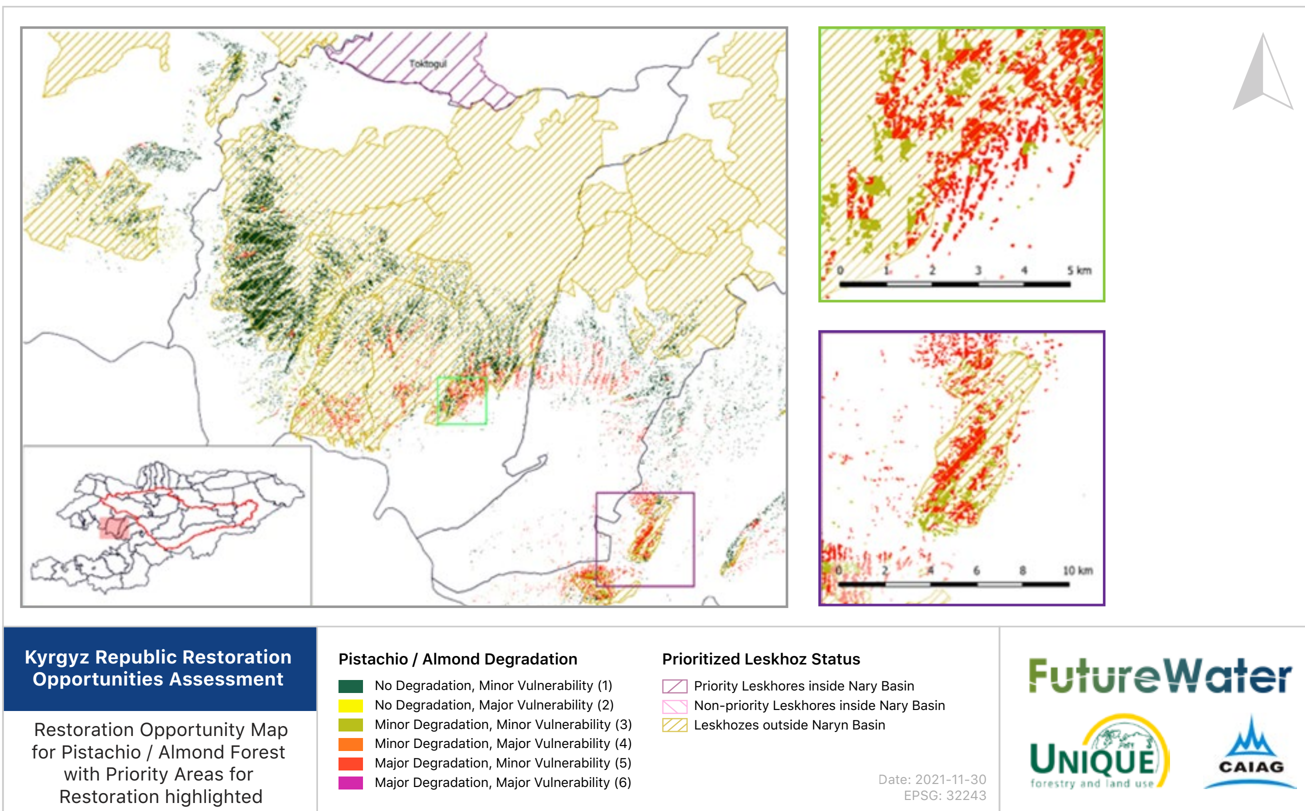
Class	Kyrgyz Republic		Naryn Basin		Toktogul Leskhoz		Naryn Leskhoz		At-Bashy Leskhoz		Jumgal Leskhoz	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
1	168,916	0.8	23,912	0.5	1,418	1.0	3,104	6.8	4,896	5.0	62	1.0
2	31,718	0.2	6,624	0.1	508	0.4	1,281	2.8	278	0.3	100	1.7
3	11,201	0.1	842	0.0	**35**	0.0	**62**	0.1	**154**	0.2	**0**	0.0
4	1,752	0.0	385	0.0	**9**	0.0	**28**	0.1	**4**	0.0	**0**	0.0
5	1,917	0.0	179	0.0	**66**	0.0	**27**	0.1	**7**	0.0	**0**	0.0
6	273	0.0	80	0.0	**21**	0.0	**6**	0.0	**1**	0.0	**0**	0.0
Total	**215,777**	-	**32,022**		**2,057**	-	**4,508**	-	**5,340**	-	**162**	-
Total classes 3–6 for the four priority leskhozes					**420 ha**							

Source: Original elaboration for this publication.
Note: Percentage total not equal to 100 due to non-applicable areas in region.

Pistachio / Almond degraded forests

Figure 10 shows the map of restoration opportunities for pistachio and almond forests (with degradation classes 3–6 and non-degradation classes 1–2) and indicates the priority Leskhozes. It is noticeable that most of the pistachio and almond forests are situated outside of the Naryn River Basin. Table 6 lists the total area of restoration opportunities for the different sub-basins. Toktogul is the only sub-basin that contains a few pistachio/almond restoration opportunities (0.1 percent). Annex 5 shows the table with restoration opportunity areas for each Leskhoz. However, as stated, none of the Leskhozes in the Naryn River Basin contain a key area of pistachio/almond forest type.

Figure 10: Pistachio and almond restoration opportunity map with priority areas outside the Naryn River Basin



Source: Original elaboration for this publication.

Table 6: Overall pistachio and almond restoration opportunity statistics for each sub-basin

Class	Kyrgyz Republic		Naryn Basin		Naryn Basin South		Naryn Basin East		Toktogul Watershed		Kokomeren Watershed	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
1	22,333.0	0.1	0.1	0.0	-	-	-	-	0.1	0.0	-	-
2	10.3	0.0	-	-	-	-	-	-	-	-	-	-

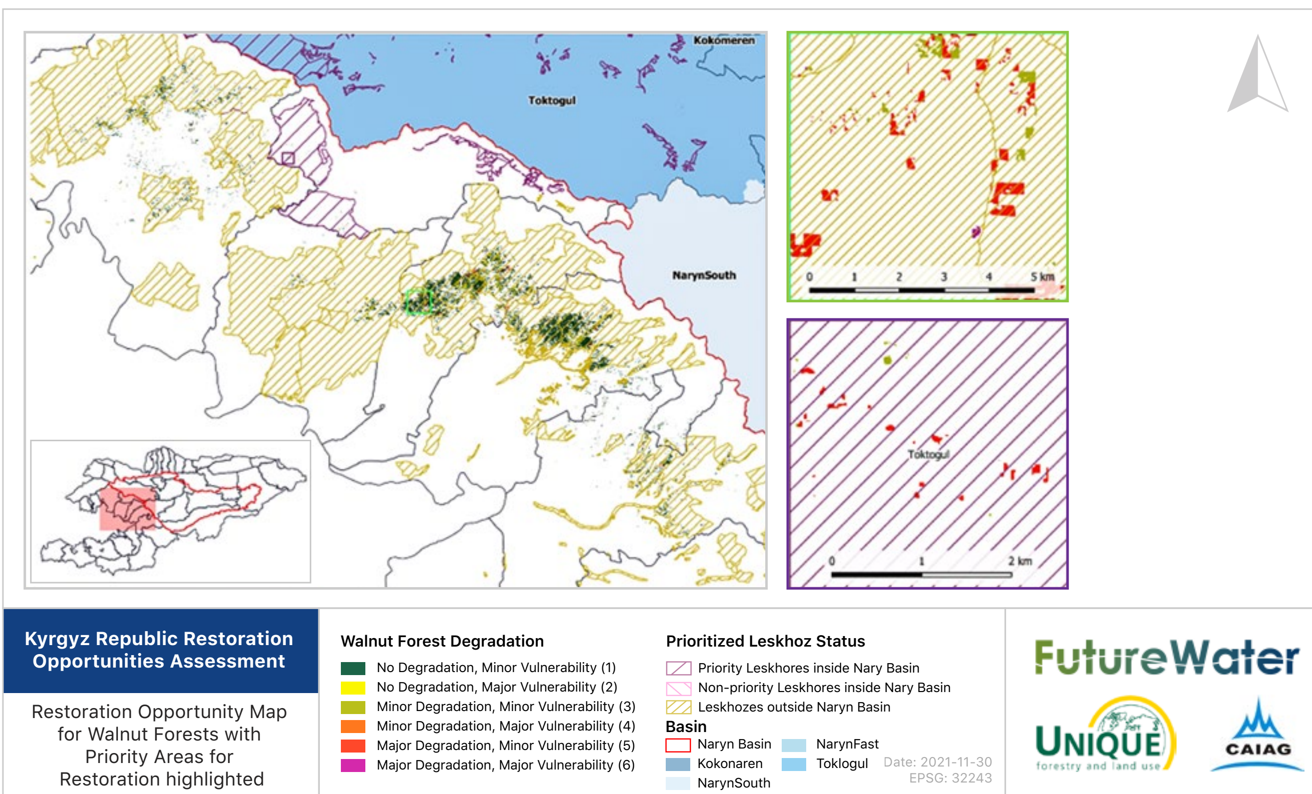
Class	Kyrgyz Republic		Naryn Basin		Naryn Basin South		Naryn Basin East		Toktogul Watershed		Kokomeren Watershed	
3	4,232.9	0.0	-	-	-	-	-	-	-	-	-	-
4	0.4	0.0	-	-	-	-	-	-	-	-	-	-
5	5,520.2	0.0	-	-	-	-	-	-	-	-	-	-
6	0.0	0.0	-	-	-	-	-	-	-	-	-	-
Total	**32,096.8**	**-**	**0.1**	**-**	**-**	**-**	**-**	**-**	**0.1**	**-**	**-**	**-**

Source: Original elaboration for this publication.
Note: Percentage total not equal to 100 due to non-applicable areas in region. There is no area with degradation class 6 for this forest type.

Walnut

Figure 11 shows the map of restoration opportunities for walnut forests (degradation classes 3–6 and non-degradation classes 1–2) and indicates the priority Leskhozes in the Naryn River Basin. It is noticeable that most of the walnut forests are outside of the Naryn River Basin. Only Toktogul Leskhoz contains some walnut forests (27.5 ha, 0.2 percent relative area) as shown in Table 32 (Annex 5). Table 7 lists the total area of restoration opportunities for the different sub-basins, of which Toktogul is the only sub-basin containing some opportunities for walnut forest restoration. The table per Leskhoz can be found in Annex 3.

Figure 11: Walnut restoration opportunity map with priority areas in and outside the Naryn River Basin



Source: Original elaboration for this publication.

Table 7: Overall walnut restoration opportunity statistics for each sub-basin

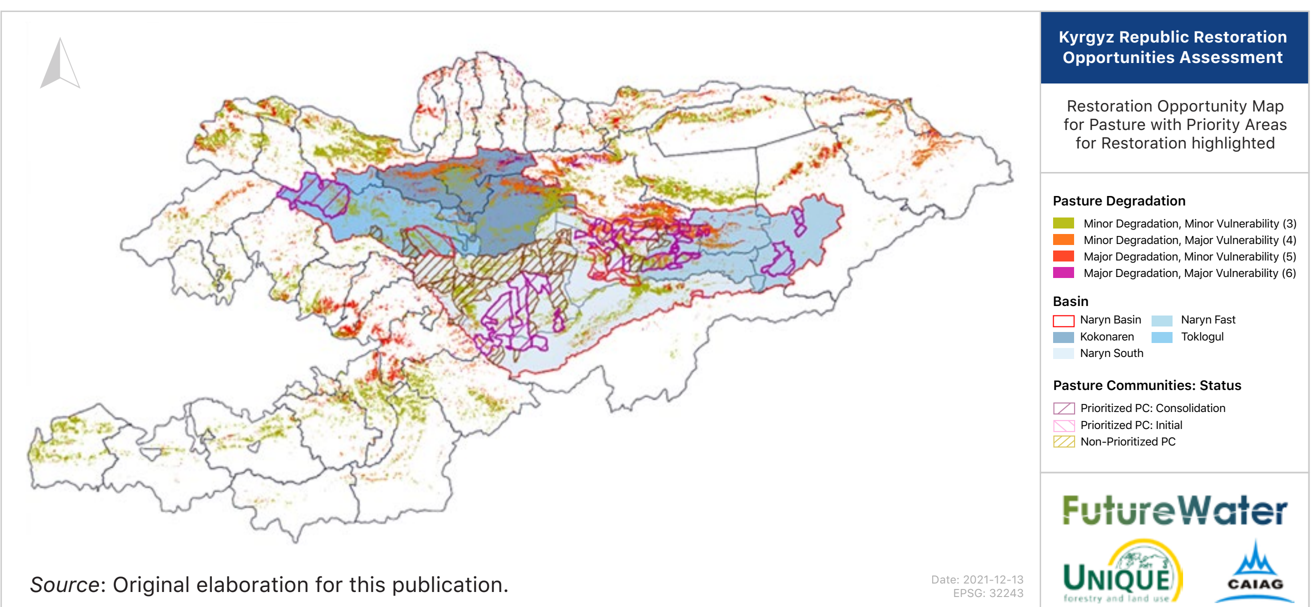
Class	Kyrgyz Republic		Naryn Basin		Naryn Basin South		Naryn Basin East		Toktogul Watershed		Kokomeren Watershed	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
1	32,700.9	0.2	6.3	0.0	-	-	-	-	6.3	0.0	-	-
2	152.3	0.0	0.1	0.0	-	-	-	-	0.1	0.0	-	-
3	4,890.7	0.0	0.2	0.0	-	-	-	-	0.2	0.0	-	-
4	10.7	0.0	-	-	-	-	-	-	-	-	-	-
5	1,313.2	0.0	0.4	0.0	-	-	-	-	0.4	0.0	-	-
6	14.0	0.0	-	-	-	-	-	-	-	-	-	-
Total	**39,081.8**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	**7**		**-**	**-**

Source: Original elaboration for this publication.
Note: Percentage total is not equal to 100 due to non-applicable areas in the region.

3.2.3. Pasture area prioritized for restoration

Figure 12 shows the map of restoration opportunities for degraded pastures (degradation classes 3–6) and indicates the priority PC in the Naryn River Basin (see PC in Figure 7). Table 9 lists the total area of restoration opportunities in degraded pastures for each of the prioritized PCs, with Ulahol PC (41.1 percent degradation of total area), Check Nura PC (33.1 percent), and Min Bulak PC (23.3 percent) showing high degradation percentage. The latter two also rank highest in terms of absolute degradation area for restoration opportunities, with more than 15,000 ha. A full overview, including a list of non-prioritized PCs, is provided in Annex 4.

Figure 12: Pasture restoration opportunity map with priority areas



Source: Original elaboration for this publication.

Table 8: Overall pasture restoration opportunity statistics for each sub-basin

Class	Kyrgyz Republic		Naryn Basin		Naryn Basin South		Naryn Basin East		Toktogul Watershed		Kokomeren Watershed	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
1	2,069,391	10.4	534,235.	10.4	224,770	9.5	34,727	3.4	182,534	21.8	92,196	10.1
2	464,012	2.3	201,222	3.9	58,731	2.5	33,929	3.3	30,722	3.7	77,825	8.5
3	897,818	4.5	290,569	5.6	155,256	6.6	17,637	1.7	52,981	6.3	64,687	7.1
4	389,282	2.0	179,937	3.5	56,611	2.4	44,206	4.3	14,652.5	1.7	64,452	7.0
5	204,414	1.0	10,227	0.2	6,220	0.3	591.4	0.1	1,474.9	0.2	1,938	0.2
6	58,827	0.3	29,589	0.6	10,406.0	0.4	7,003.8	0.7	1,499.8	0.2	10,666	1.2
Total	**4,083,744**	-	**1,245,779**	-	**511,994**	-	**138,094**	-	**283,864**	-	**311,764**	-

Source: Original elaboration for this publication.
Note: Percentage total is not equal to 100 due to non-applicable areas in the region.

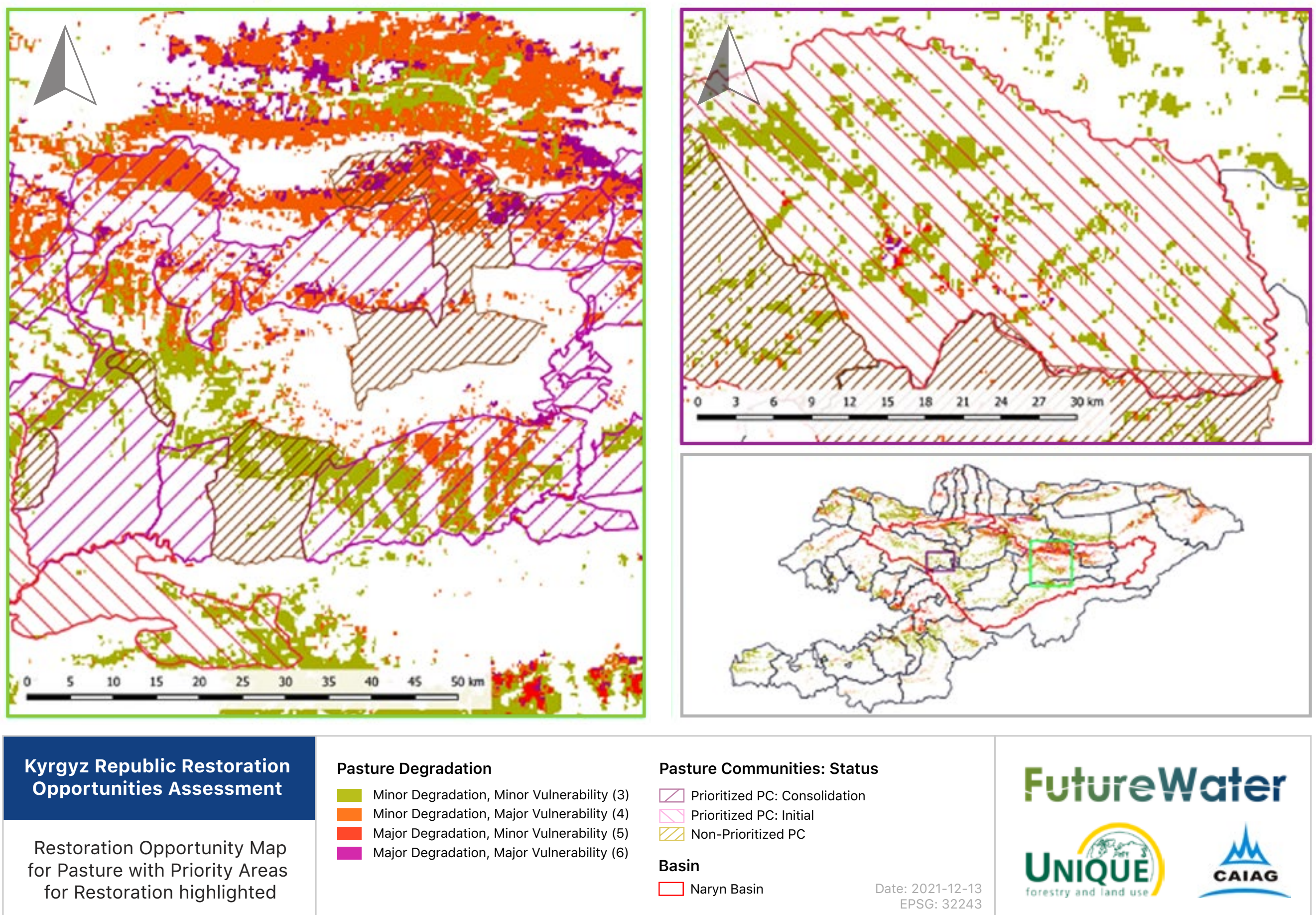
Table 9: Pasture restoration opportunity statistics (classes 3–6) for each prioritized PC

Pasture Committee	Priority status	ha	%
Nichke Say PC	Initial	9,993	10.8
Jan Bulack PC	Initial	3,972	4.3
Emgek Talaa PC	Initial	6,070	6.5
Check Nura PC	Consolidation	15,483	16.7
Akman PC	Consolidation	-	-
Jargylchak PC	Consolidation	53	0.1
Jergetal Ak-Talaa PC	Consolidation	4,581	4.9
Jergetal Naryn PC	Consolidation	12,255	13.2
Kara Burgon PC	Consolidation	1,660	1.8
Min Bulak PC	Consolidation	16,989	18.3
Ortok PC	Consolidation	2,490	2.7
Cholpon Ata PC	Consolidation	12,918	13.9
Ugut PC	Consolidation	1,396	1.5
Ulahol PC	Consolidation	4,955	5.3
Total		**92,815**	**100**

Source: Original elaboration for this publication.
Note: Consolidation and initial relate to the classification done in Section 3.1.1.

A visualization of the spatial patterns of restoration opportunities and degradation / vulnerability classes for the most affected priority PC is shown in Figure 13.

Figure 13: Pasture restoration opportunities with priority areas in two Naryn River Basin regions



Source: Original elaboration for this publication.

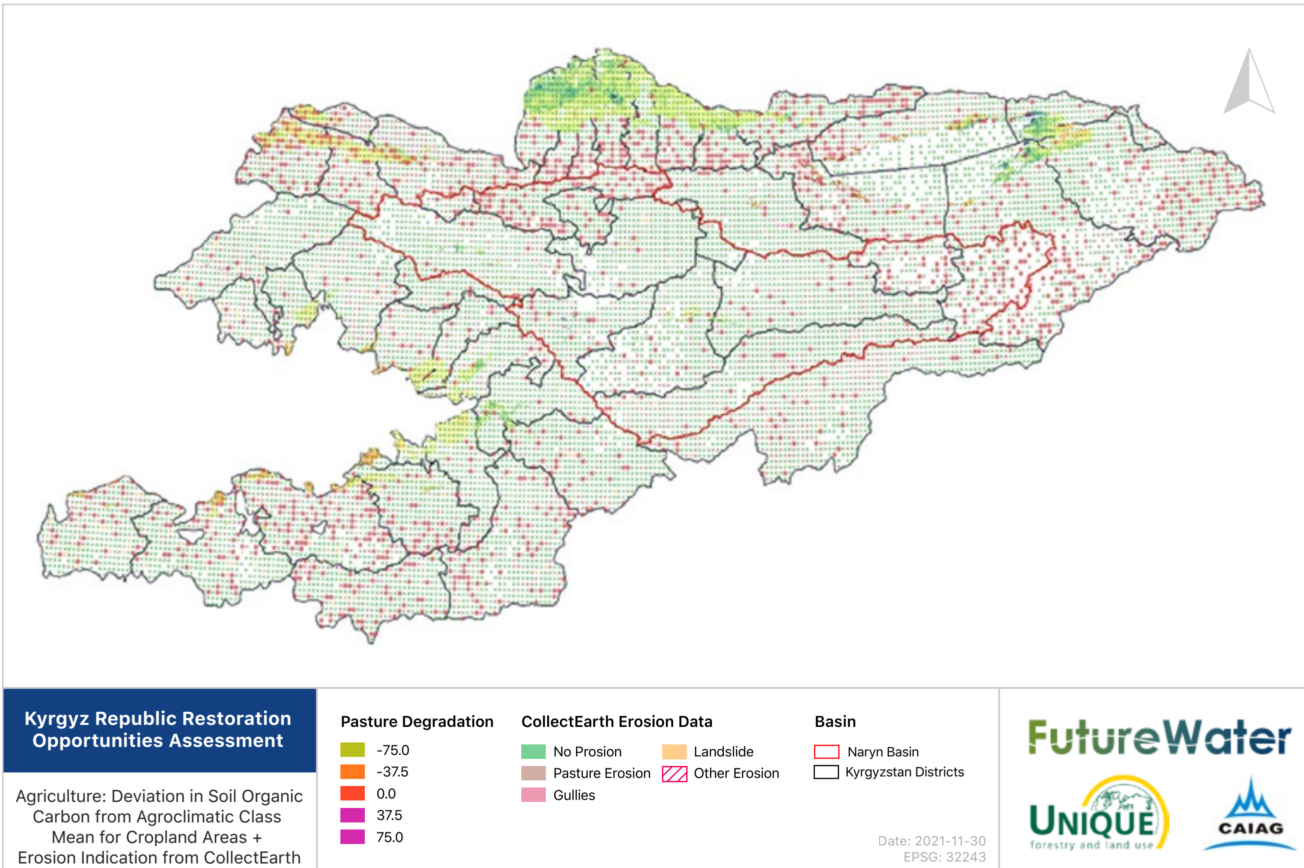
3.2.4. Agriculture area prioritized for restoration

As explained in the baseline report and Annex 6, the methodology applied for degradation mapping has limitations in agricultural cropland areas. Crop rotation schedules affect the extent to which trends and dynamics of vegetation indexes (NDVI) can be attributed to degradation. However, the spatial data of SOC, obtained from the SoilGrids v2.0 database,6F[16] can be analyzed to determine spatial patterns and identify areas with significantly lower SOC than other agricultural areas. This analysis is presented in Figure 14 where orange to red indicate areas where SOC is low. This phenomenon particularly occurs in the Ferghana Valley and to the east of Issyk Kul Lake. Also shown in the map are the erosion points contained by the CollectEarth Assessment performed by FAO. The colors of the dots indicate whether erosion features were observed in the landscape (on high-resolution imagery). Areas where erosive features overlie

16 https://soilgrids.org/

cropland (particularly in the northwest of the country) could be potential targets for cropland restoration efforts. However, both the assessment of SOC data and CollectEarth results should be considered as preliminary. Field investigation is required to take the next steps toward planning of restoration activities in agricultural areas. It should also be noted that agriculture in the Naryn River Basin spans a small area (14,217 ha or less than 1 percent of the total Naryn River Basin) and is therefore of minor importance for the sedimentation of the Toktogul water dam.

Figure 14: Agricultural cropland areas: Deviation in SOC with an erosion indication, CollectEarth dataset



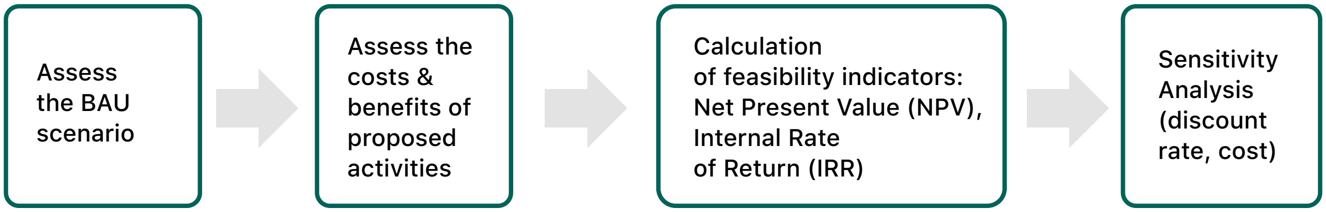
Source: Original elaboration for this publication.

3.3. Cost-benefit analysis of restoration measures

3.3.1. Methodology

A CBA was conducted for each proposed restoration intervention. The suggested restoration measures were presented in the baseline report, discussed with stakeholders in two workshops, and are summarized in Figure 16. The CBA followed the standard approach with four main steps (Figure 15). First, the current situation (business as usual or BAU) and related land use practices were assessed. Then, for each restoration measure a CBA was implemented to calculate the net present values (NPVs) and internal rates of return (IRRs). At the last step, a sensitivity analysis was conducted using changes in discount rate and cost increase.

Figure 15: Steps to conduct a CBA



Source: Original elaboration for this publication based on Robinson, Hammitt, and O'Keeffe (2019).

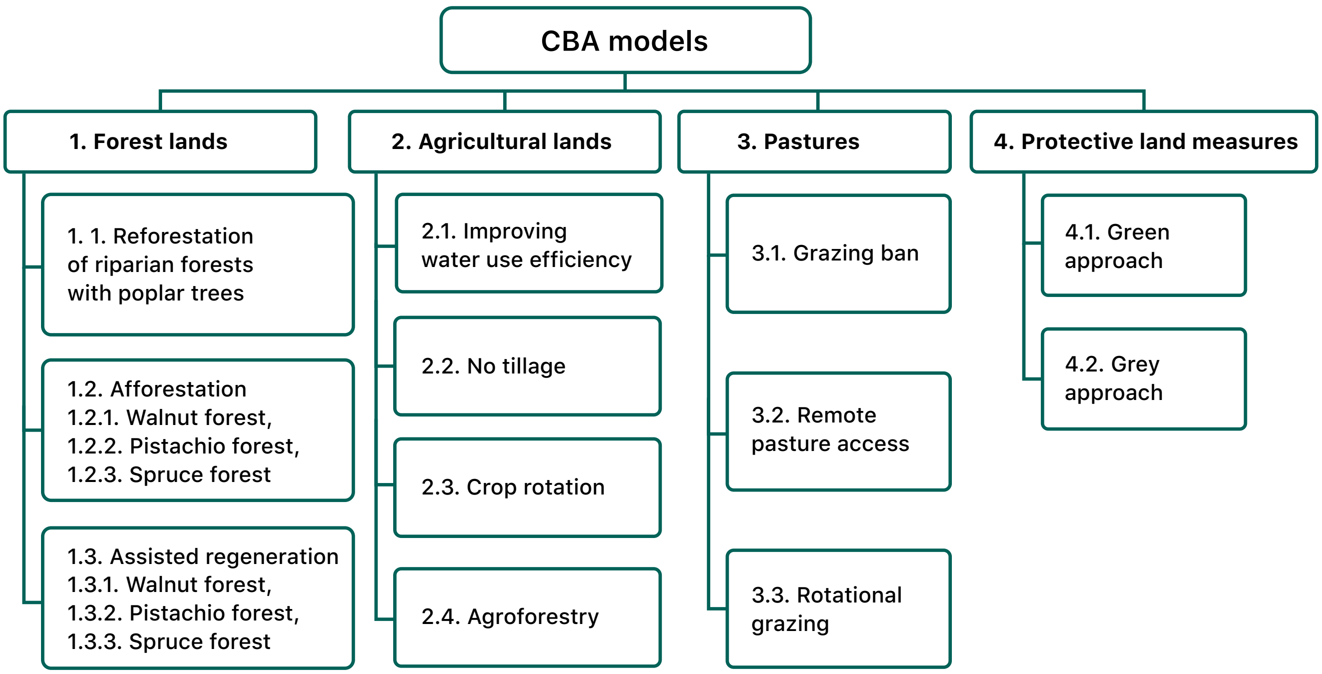
The restoration measures were divided into four land type groups (Figure 16). Fourteen per hectare models were developed. Each model used data from field trips, interviews with experts, national government agencies, previous UNIQUE projects, and other locally implemented projects. In addition, the CBA analysis was presented and updated after the feedback from participants at the validation workshop in December 2021. Both terms of afforestation and reforestation were used. Depending on the situation, either could be applied. The last group on protective land measures includes riverbank protection and gully stabilization through green infrastructure (plantation of adapted grass, bush, and tree species) and grey infrastructure (gabions, concrete, rocks, and so on). For these measures, the CBA was not included and no specific areas for restoration were identified, since these would require site-specific visits and assessments. The same applies for croplands: a CBA analysis was done but due to the limitations of identifying degraded croplands through the applied methodology, no specific cropland restoration areas were identified (see previous Section 3.2.4).

The period for the CBA is 20 years using the current discount rate of 8 percent as given by the National Bank of the Kyrgyz Republic. This represents the safest market rate in the Kyrgyz economy as it is guaranteed by the reserve bank. In line with standard practice for CBA, this rate was adopted for the calculation of NPV. Alternative discount rates were also used for the sensitivity analysis (see below). In the cashflow models, real prices (as opposed to nominal prices) were used for the analysis, meaning that inflation was not considered. Because inflation would apply to both costs and revenues at the same rate, it is not necessary to consider the effects of inflation. If nominal prices were used, a nominal discount rate would also be used, which would cancel out any inflationary impact. The sensitivity analysis was conducted using several increase values in costs compared to revenues (see below).

The carbon sequestration estimates were derived from EX-Ante Carbon Balance Tool (EX-ACT) models for agriculture and forestry-related measures and from a previous study implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation, GIZ) on pasture-related measures (this study has a higher level of accuracy than EX-ACT). A price of US$5 per sequestered ton ($tCO_2e$/ha/year) of carbon was used. Although the current market prices for nature-based solutions carbon credits are above US$5, this price has been chosen as a conservative estimate on achievable carbon benefits for restoration options. A price of US$40 per ton of carbon was used for the GCF Project in the Kyrgyz Republic (CS FOR project). This resulted in an IRR of 71.3 percent and NPV of US$353,7 million for a 20-year period for improved rangeland, which is remarkably high. The World Bank Guidance Note on shadow price of carbon in an economic analysis of 2017 also suggests a price of US$40 per tCO2 as the social value of carbon. According to the study's nature, the assessment of carbon benefits of restoration is higher than typical carbon credit certification. This higher estimate leaves room for uncertainty. It is a good practice to encounter this uncertainty by estimating conservatively. A conservative price estimate forms part of a conservative estimate of overall carbon benefits. A sensitivity analysis for changing carbon prices from US$5 to US$50 per ton of carbon was conducted (Table 26). The carbon price significantly affects the economic performance of the afforestation and assisted regeneration restoration measures. For restoration measures such as agricultural lands and pasture, there is a less noticeable impact.

The analysis did not include an assessment of financing required to fund these cashflows. This analysis would require an estimate of the equity and debt proportion of the loans, as well as data on the market rate of interest available to smallholders (often much higher than the official rate offered by commercial banks).

Figure 16: CBA models, per hectare



Source: Original elaboration for this publication.

The analysis was undertaken using economic and production data available in the Kyrgyz Republic as well as data collected by two members of our team during a field trip in 2021. The report used previous studies and models completed in the country, and whenever possible, studies that took place in the target area. Ecosystem services — benefits that are received from nature and do not have direct market prices — are a key component of this calculation. Since the country currently does not have official national ecosystem services assessment, the most reliable projects (for example, GCF-FAO) and studies done by the Economics of Land Degradation (ELD) Initiative were used. According to the ELD study in the Kyrgyz Republic, the value of ecosystem services was US$6.8 per ha (Sabyrbekov and Abdiev 2016), which was used for all restoration models. Table 27 gives an overview of ecosystem services. ELD Central Asia Regional Report, based on the Kyrgyz Republic, lists ecosystem services for three pilot sites, including water, fodder, tourism, mushroom, timber, fuelwood, nuts, NTFPs, and recreation.

In the CBA, ecosystem benefits from wood, fodder, nuts, and carbon were calculated and a value of

US$6.8 per ha was included in the afforestation, reforestation, assisted regeneration, and pasture cashflow models. Thus, these ecosystem services have been double counted in the cashflow models, where carbon revenues or ecosystem services benefits are already included. However, because the value of US$6.8 includes *all* the services (such as tourism, recreation, fodder, and wood production) and cannot be disaggregated, double counting was allowed in this study since the ELD value also includes other benefits not accounted for in our CBA. Also, the value is low (see also CS FOR project calculation in the GCF proposal). Table 10 presents an example of a benefit analysis for an agroforestry model with walnut trees.

Table 10: Walnut afforestation model benefits, 20-year period

Benefits	Sum in 20 years, in US$ per ha
Walnut revenues	52,199
Benefits from ecosystem services	136
Carbon sequestration	1,830
Hay revenues	7,104
Total benefits	**61,269**

Source: Original elaboration for this publication.

The **sensitivity analysis** was done in two ways. First, changes in the **discount rate** were modelled, from 5 percent to 14 percent. Second, the sensitivity of the results to cost changes was tested via total **cost increases** of 10 percent and 20 percent. This analysis was applied because current prices fluctuate significantly and can have an impact on investment and rate of return.

For each of the CBA models, a detailed list of assumptions of costs / inputs and benefits were made.

3.3.2. Forestry models

The developed models relied on a CBA of Agroforestry Models in Southern Kyrgyz Republic in 2020 as well as models in the GCF proposal CS FOR – 'Carbon Sequestration through Climate Investments in Forests and Pastures Project', 2018. Basic cost and yield expectations (per ha) were ascertained from primary data sources or by using a value transfer approach through the sources mentioned earlier.

The forestry models included the following:

- Afforestation models (walnut forest, pistachio forest, and spruce forest)
- Reforestation or afforestation of riparian forests with poplar
- Assisted regeneration (walnut forest, pistachio forest, and spruce forest).

Model assumptions

The common activities of the forestry models were fencing, seedling plantation, haymaking within the fenced areas, use of NTFPs (walnuts and pistachio), and watering through irrigation. The costs included seedlings for afforestation, the labor cost of planting, loosening of the soil after planting, irrigation materials, fencing and related labor costs. In addition, each forest type model has specific assumptions. An example of walnut forest afforestation is provided in Table 11.

Table 11: Walnut afforestation model costs, Year 1, US$/ha

Cost	Value (US$)	Unit	Timing
Seedlings	472	US$/ha	Year 0
Planting labor	708	US$/ha	Year 0
Maintenance labor: Three-fold loosening of the soil on the plots and weeding around the seedlings	91	US$/ha	Years 5, 10, 15
Fence installation	613	US$/ha	Year 0
Fence maintenance	12	US$/ha/year	Years 1 – 20
Land lease	9.1	US$/ha/year	Years 1 – 20

Source: Original elaboration for this publication.

An example of benefit assumptions for the walnut forest is given in Table 12. More detailed information about models is available in Annexes 8 and 9. In the example of walnut afforestation, costs for plants; labor costs for planting, protecting, and maintenance; costs for fencing / protection material; and labor and harvesting costs for walnuts and hay were calculated. Land lease costs were included in the forest models (US$9.1/ha/year). Fertilizer was not included in the forest models since it is not a widespread practice. It was included in the agriculture models.

Table 12: Walnut afforestation model assumptions

Benefit assumptions	Unit	Value
Number of trees	tree/ha	278
Harvesting start	year	7
Yield at Years 7–9	kg/tree	5
Yield at Years 10–12	kg/tree	10
Yield at Year 13 and onwards	kg/tree	15
Ratio of marketable walnuts	%	50
Carbon sequestration at Years 1–20	tCO_2e/ha/year	18.3
Hay	Yield starts decreasing from Year 8	

Source: Original elaboration for this publication.

Results for forestry models

Table 13 depicts the results of the forestry models. The results showed that the positive NPV ranged from US$632 to US$13,680 and the IRR was from 11 percent to 31 percent. The highest economic feasibility indicators were in walnut forest models that is primarily driven by high market prices for walnuts. On the other hand, the spruce forest has a negative NPV and IRR due to the long ripening periods.

Table 13: Forest model CBA

No.	Activity - model	NPV (US$)	IRR (%)
1	Afforestation/Reforestation - walnut forest	13,680	31
2	Afforestation/Reforestation - pistachio	632	11
3	Afforestation/Reforestation - spruce forest	-1,821	−9
4	Afforestation/Reforestation - riparian forest	3,174	16
5	Assisted regeneration - walnut forest	10,054	31
6	Assisted regeneration - pistachio forest	-2,207	−4
7	Assisted regeneration - spruce forest	-2,959	Cannot be determined

Source: Original elaboration for this publication.

Sensitivity analysis for forestry models

The results were not significantly affected by changes in discount rates (see Table 42, Annex 9). The only exception was the afforestation pistachio forest model — at a 14 percent discount rate, the NPV became negative.

Cost increases have a high to moderate impact on NPV and IRR. The highest sensitivity was registered for spruce forest model (see Table 43 in Annex 9).

3.3.3. Agricultural land models

Agricultural land models have four submodels based on the proposed restoration interventions: water use efficiency improvement, no tillage, crop rotation, and agroforestry. The crops in the models are typical to the study area and include potato, alfalfa, and barley. The productivity rates for each crop are based on the latest data from the National Statistics Committee. Where data were unavailable, data from other studies were used. For modelling purposes, it was assumed that 1 ha is equally divided between three crops.

Model assumptions

The agricultural land models included investment in irrigation improvement, high-quality seeds, use of no tillage seeder (usage costs), transportation, and fencing. All costs and benefits are market prices, except non-market benefits such as carbon and ecosystem services. An example of input costs calculated for the model is presented in Table 14.

Table 14: Water use efficiency improvement model inputs, Year 1, US$/ha

Costs	US$/ha
Irrigation (materials, installation, labor)	1,946
Maintenance labor cost	106
Maintenance materials	118
Transport	35
Seeds	590
Fertilizers	72
Total costs	**2,867**

Source: Original elaboration for this publication.

The productivity gains from the improved irrigation scenario are based on completed studies (such as a GIZ study on potato production in the Naryn area). So, the average potato yield increase is 32 percent, the average alfalfa yield increase is 20 percent, and the average barley yield increase is 10 percent. The no tillage/minimum tillage model has cost implications for capacity building for farmers because this agricultural practice is new to the Kyrgyz Republic and knowledge is still scarce. A budget should be allocated for this within a technical assistance fund. This was foreseen as a cost item (see Section 3.5).

Results

Table 15 shows the results of this assessment. Among these models, the highest NPV was found in the water use efficiency model, equal to US$4,324.

Table 15: Agricultural land model CBA

Activity - model	IRR (%)	NPV (US$)
Agricultural lands - Watering improvement	49	4,324
Agricultural lands - No tillage	23	3,447
Agricultural lands - Crop rotation	2	2,398
Agricultural lands - Agroforestry	21	1,600

Source: Original elaboration for this publication.

Sensitivity analysis for agriculture models

The changes in discount rates decreased the NPV to 2,430 in the first model — the magnitude of change was highest in the water use efficiency model (see Table 42 in Annex 9.).

The cost increases affected through varying decreases of NPV and IRR. The highest sensitivity was registered for the agroforestry model (see Annex 9).

3.3.4. Pasture models

The pasture models were developed on per hectare assumptions and livestock unit (LU) costs and benefits (1 LU = five sheep). There are three submodels: grazing ban, improved access to remote pastures, and pasture rotation. The model includes the use of smart land management practices and investments to improve pasture productivity and reduce degradation.

Model assumptions

The model assumes a temporary grazing ban. This implies moving the animals to other areas and additional forage costs during the grazing ban period. The costs include fencing, transportation, investments in road and bridge construction or improvement, and additional forage. It is assumed that with fencing, a wide area can be temporarily excluded from grazing. An example of model inputs for one of the pasture models can be found in Table 16. The cost of pasture access right was included in the grazing cost calculation.

Table 16: Grazing ban pasture model, Year 1, US$/ha

Cost	Value (US$/ha)	Unit	Timing
Additional fodder per LU	9.4	US$/ha/year	Years 1 – 20
Increased shepherd's fee per LU	14.2	US$/ha	Years 5, 10, 15
Fencing materials per ha	613.0	US$/ha	Year 0
Fencing labor maintenance	60.0	US$/ha	Years 1–20
Total cost	**696.6**		**Year 1**

Source: Original elaboration for this publication.

The implementation of the investment activities results in increased yields of meat and milk. Additionally, ecosystem services and carbon sequestration were included. Table 17 shows an example of benefits incurred.

Table 17: Grazing ban pasture model annual benefits

Name	Value (US$)
Benefit from meat US$ per LU	84
Benefit from milk US$ per LU	47
Number of LU per ha	1
Sub-total benefit from meat per ha	84
Sub-total benefit from milk per ha	47
Ecosystem services per ha	6.8
Carbon sequestration per ha	1.25
Total benefits	**139.1 (Year 1)**

Source: Original elaboration for this publication.

Results

Table 18 shows the CBA results of three pasture models. The highest NPV is found for the remote pasture access model, at US$1,268 and 19 percent of IRR.

Table 18: Pasture model CBA

Activity - model	IRR (%)	NPV (US$)
Pasture - Grazing ban	16	923
Pasture - Remote pasture access	19	1,268
Pasture - Rotational measures	19	1,256

Source: Original elaboration for this publication.

Sensitivity analysis for pasture models

The NPV of pasture models is overly sensitive to changes in the discount rate. Change of discount rate from 8 percent to 11 percent caused changes of NPV in the range of 129 to 1,705 (grazing ban) and 327 to 2,157 (rotational pasture). This is detailed in Table 42 in Annex 9.

In terms of sensitivity to cost increases, the remote pasture access model had the highest sensitivity. The details are shown in Table 43 in Annex 9.

3.3.5. Protective land model

The protective land model was developed to assess the benefits of land protective measures. The model included two approaches. First, the green approach implied use of green infrastructure as a primary vehicle. However, the grey approach included installation of industrial goods-based protective infrastructure with gabions.

Model assumptions

The model's main assumption is that the main benefit is protection of riverbanks from erosion. The cost of a typical dwelling is calculated at KGS 6,360,000 or US$75,000. Below is an example of the riverbank protection model with green infrastructure (planted crops to reduce erosion). The model assumes that without the protective measures, a dwelling will be destroyed completely every year. Therefore, the annual benefit equals the cost of the dwelling (US$75,000 per ha). The other assumption is that 1 ha has 100 m of riverside that must be protected. Hence, the costs are calculated on a 100 m basis per ha. No benefits were assumed for carbon sequestration in this model.

Table 19: Cost of green infrastructure for riverbank protection, US$

Cost	Value (US$)	Unit	Timing
Cost of hedge brush layer on top of gabions	4,718	US$/100 m	Year 0
Materials (trees, soil)	1,769	US$/100 m	Year 0
Labor to install green gabions	495	US$/100 m	Year 0
Annual maintenance materials cost	236	US$/100 m/year	Years 1–20

Source: Original elaboration for this publication.

Results

The results showed that both models had high positive NPV (see Table 20).

Table 20: Protected Lands CBA

Activity - model	IRR (%)	NPV (US$)
Protective lands - Green	Not applicable	727,581
Protective lands - Grey	Not applicable	726,255

Source: Original elaboration for this publication.

Sensitivity analysis

The two models in this category are insignificantly sensitive both to changes in discount rate and cost change - see Annex 9 (Table 48 and Table 49).

3.3.6. Total cost of restoration

By applying the per hectare model of all restoration measures to the areas identified as suitable for restoration, the total up-front costs for restoring priority areas amount to over US$45 million. It is assumed that users of forest, agriculture, and pasture lands and respective governmental partners will be able to co-finance the proposed investment. This kind of co-investment mechanism has been piloted through various projects on afforestation and agroforestry in the country and has proven to be successful. It is also recommended that about 10 percent of the total investment is topped in the investment budget for capacity building (US$1 million), investment management (US$800,000), and technical assistance (US$500,000) (all are rough figures). It means the total investment costs from third-party organization(s) would sum up to US$25.13 million (see Table 25 and Section 3.5).

3.3.7. Investment level economic results

The overall NPV of the investment was calculated by extrapolating individual hectare models across the intended landscape and summing costs and revenues to get a net revenue figure at the landscape level for both the baseline and the investment case. The incremental income (or the net difference between the 'with investment' and 'without investment' scenario) was projected over a 20-year time horizon and a discount rate of 8 percent was used to determine an NPV of US$93.33 million. The discounted benefit-cost ratio (BCR) of the investment is 2.4, that is, US$2.4 is generated from the investment of US$1. The return on investment, or total net revenue divided by total cost, was calculated at 138 percent.

These results include the value of carbon sequestration but do not reflect other nonmonetary benefits which would contribute to improved livelihoods through environmental and socioeconomic benefits such as employment, access to wood and non-wood forest products, and increase of income, among others. The results are presented in Table 21.

Table 21: Investment-level economic results

Economic indicator	Unit	Value
NPV (8%)	US$	93,332,284.10
BCR (discounted)	Ratio	2.4
Return on investment	%	138

Source: Original elaboration for this publication.

3.3.8. Carbon sequestration estimations and carbon costs

In the above models, carbon sequestration was calculated, as presented below. A conservative price of US$5 per sequestered ton was calculated in the CBA models. A sensitivity analysis with alternative carbon prices — the average price on the voluntary carbon market and the social carbon price — was also prepared (Table 22).

GHG assessment methodology

For this assessment, the BAU and intervention scenarios appropriate to the local context were defined. Using the EX-ACT (version 9.2) developed by the FAO, the carbon impacts of restoration options in the Kyrgyz Republic are quantified. EX-ACT is a land-based carbon accounting system, which estimates the carbon balance (C stock changes, that is, emissions or sinks of CO_2) as well as GHG emissions per unit of land, expressed in equivalent tons of CO2 per ha per year. The scope of the estimate included all five carbon pools (above-ground biomass, below-ground biomass, deadwood, litter, and SOC) and estimated coefficients of CH4, N2O, and selected other CO2 emissions based on IPCC default factors (Tier 1). For prioritized restoration options, the GHG assessment estimates the effects of these measures on GHG emissions. The restoration options are molded into 1 ha scenarios encompassing certain assumptions documented in the baseline report. The per hectare models can then be upscaled to assess the technical GHG reduction potential of the different interventions. The EX-ACT Excel tables are provided in a separate file.

GHG estimation of restoration options

All interventions are modelled over standardized 1 ha models (except for option 'Efficient use of water resources', see description below), which can then be extrapolated to the applicable extent in each scenario ('upscaling'). To model GHG emissions for different interventions, assumptions on the investment outline have been made. All models assume the following parameters.

The modelling period is 20 years, which is a common period for land-based carbon accounting. The resulting GHG emission balance (in tCO_2e/ha/year) is the average annual change rate of this modelling period. So, changes in carbon stocks are assumed to happen in a linear manner.

Zero-baseline assumption: For all models it is assumed that in the baseline scenario, degradation levels and management continue as before. Neither improvements nor further degradation is assumed over time.

Permanence of the modelled intervention is assumed beyond the modelled period. For example, a restored forest is assumed to stay at a defined level of degradation (see below) even beyond the modelled period. This means the model does not account for any degradation that would appear after 20 years.

Zero leakage is assumed for the modelled interventions.

The applicable climate for most models is assumed to be cool temperate dry. Only two models for higher altitude forests use boreal dry climate.

ROAM projects future options for restoration potential without knowing the specific sites where the measures will be implemented. Therefore, further assumptions in all models were made about the average conditions at the future restoration sites.

All interventions happen on high activity clay (HAC) soils. According to the Harmonized World Soil Database, all dominant soil types in the Kyrgyz Republic fall in this category. Dominant soil types in the study regions are Calcisols, Kastanozem, and Leptosols, all of which classify as HAC.

No fire occurrence is considered in all scenarios. Fires do occur in the Kyrgyz Republic. However, it is assumed that most interventions do not change the current fire regime. Thus, the modelling of baseline and investment scenarios omit the aspect of fires.

The Kyrgyz Republic lies in a mountainous region. Land use therefore happens on high altitudes (above 800 m). As per IPCC definition 2006 (Ch. 4 'Forest land'), altitudes in cool temperate regions above 800 m translate into the ecological zone of mountain systems, which is assumed for all forestry models (1–5).

For the three agriculture models (6–8), some assumptions on the prevalent cropland cultivation in the Kyrgyz Republic were made: Full tillage of the soil is frequent practice on most fields. Medium C input is assumed. This is to reflect the fact that most residues from crops are left on fields and consumed by livestock (therefore exported) but also receive organic inputs from livestock droppings. Irrigation in agriculture is not common in the Kyrgyz Republic; thus, irrigation systems need to be installed by applying some restoration options. When irrigation is used, it is mostly flood or furrow irrigation practices. Fertilizer use is 138 kg/ha on average but will only be affected in the 'no tillage' model.

For the pasture models, a methodology presented and used during the NDC update in 2021 was adopted. The values were validated and accepted by the national stakeholders and therefore those were applied.[17] The main assumptions are as follows:

- The baseline carbon stock is estimated using a reference SOC stock that is the weighted average of different climate zones. It was assumed all soils are HAC in the IPCC definition, and that alpine, mid-mountain, and foothill grassland types correspond to boreal, temperate, and tropical climate zones, respectively.
- Stock change factors from IPCC (2019) for severely and moderately degraded grassland are applied to the reference carbon stocks to estimate SOC stocks before intervention.
- The only management measure considered is grazing management (for example, timing and intensity of grazing).
- The stock change factors entered in the with-intervention scenario assume that after 20 years of improved management, severely and moderately degraded pasture soils could return to the reference (non-degraded) state. No consideration is given for use of auxiliary measures such as reseeding or fertilization.
- For the green and grey infrastructure investments (riverine restoration), the carbon sequestration potential was not calculated.

Table 22 gives an overview of the carbon sequestration potential. Further model-specific assumptions are described in Annex 11. Moreover, the tables also indicate the estimated GHG emission balance of the modelled interventions.

The numbers on emission balance differ from the GCF estimations (CS FOR project) on carbon sequestration for different tree species in both afforestation/reforestation and assisted natural regeneration/enrichment planting (Table 22). The difference of the values is first explained by the fact that the GCF is not counting SOC. By looking only at the values for biomass carbon (that is, without SOC) from EX-ACT models, it is possible to conclude that the values are approximated. The GCF values are more conservative.

17 Analysis of livestock and pasture sectors for the NDC revision in Kyrgyzstan, June 2021.

Table 22: Restoration measures and their GHG emissions balance, tCO_2e/ha/year

Scenario	Emission balance	Only biomass (No SOC)	GCF value[18]
Measure 1: Afforestation/Reforestation with pistachio, walnut, almond	−18.3	−13.4	−4.5[19]
Measure 2: Afforestation/Reforestation with spruce and juniper	−9.2	−2	−3.5[20]
Measure 3: Afforestation/Reforestation in riparian forests	−18.6	−13.7	−5.8[21]
Measure 4: Assisted natural regeneration in pistachio, walnut, and almond forests	−5.7	-	−1.2[22]
Measure 5: Assisted natural regeneration in spruce and juniper forests	−1.1	-	−1[23]
Measure 6: Agriculture - Efficient use of water resources	−0.7	-	-
Measure 7: Agriculture - No tillage/Minimum tillage	−0.3	-	-
Measure 8: Agriculture - Introduction of crop rotation and cover crops	−0.1	-	-
Measure 9: Agroforestry walnut/fruit	1.2	−1	-
Measure 10: Agroforestry poplar	−0.2	−2.4	-
Measure 11: Pasture grazing ban	−1.2	-	-
Measure 12: Remote pasture access	−1.2	-	-
Measure 13: Pasture rotation measures	−1.2	-	−1.25

Source: Original elaboration for this publication.

18 For reasons of comparison, values of GCF have been calculated as the average over 20 years.
19 Values for afforestation with pistachio and walnut combined.
20 Values for afforestation with spruce and juniper combined.
21 Value for afforestation with poplar.
22 Value for enrichment planting with walnut.
23 Values for enrichment planting with spruce and juniper combined.

3.4. Readiness assessment

3.4.1. Methodology

As a first step, the availability of enabling sector strategies and bottlenecks in the forest, biodiversity and conservation, agriculture, pasture and livestock, water, and energy sectors were analyzed. A detailed review of existing national and sector policies and strategies was included in the inception report and is summarized in Annex 12.

As a second step, semi-structured interviews were conducted with key stakeholders in the target sectors. At the national level, respondents from the Ministry of Agriculture (Pasture and Livestock Department, Plant Production Department, and Forest Policy Department) and from the Forestry Service were interviewed. At the district level, interviews were conducted with the District Department of Agricultural

Development in Naryn and Toktogul districts. At the local level, interviews took place with representatives from Leskhozes, PCs, and several land users living in and around the selected field sites. Representatives from nongovernmental organizations and international organizations were also contacted by email as it was not possible to meet them during the mission. The full list of respondents is available in Annex 1.

Six key dimensions were addressed during the interviews. Each of them was given a weight (very high, high, and medium high), in relation to the importance of the dimension to fulfill the Astana pledge.

Table 23: Key dimensions for FLR readiness

Dimension	Importance
Political leadership	Very high
Policy and legal framework	High
Financing instruments	Very high
Technical feasibility	High
Knowledge and skills	High
Socio-cultural aspects	Medium high

Source: Original elaboration for this publication.

The interviews with national-level stakeholders focused on all six dimensions. At the provincial and local level, only dimensions 4, 5, and 6 were considered, as the focus of these meetings was on practical considerations of restoration implementation.

Given the limited size of the sampling group (19 respondents), the interviews were analyzed only qualitatively. Little information could be gathered about the agricultural sector as representatives from the Ministry of Agriculture were not available for a meeting and did not answer the subsequent formal request sent by the study team. The main results therefore focus on forest and pasture-related stakeholders and are presented in the next section.

3.4.2. Findings on readiness assessment

Findings are summarized in Table 24. More details can be accessed in Annex 12.

Table 24: Readiness assessment key findings

Dimension	Key enabling factors	Bottlenecks
Political leadership	▪ Experts who prepared the pledge are still in decision-making positions ▪ New government structure pooled forest, pasture, and agriculture sectors under a single ministry	▪ Limited lobbying from State Forest Service (SFS) about FLR and the Bonn Challenge within the government ▪ Limited coordination of SFS with national-level government bodies
Policy and legal framework	▪ Enabling policy framework in all sectors to upscale FLR	▪ Poor integration of sector strategies ▪ There is no clear policy for coordinating international processes involving several governmental organizations such as FLR. ▪ Forest, pasture, and agriculture land management, respectively, managed by governmental, nongovernmental, and private stakeholders, making hierarchy unclear and coordination complicated ▪ At the local level, there are legal constraints connected to budget disbursement for restoration measures on land owned by a different stockholder
Financing instruments	▪ Increasing private investments in restoration of forest and agriculture lands ▪ Enough budget flexibility exists at the local level to direct investments to forest and pasture restoration ▪ Several past and ongoing projects made large investments in forest and pasture restoration, thereby generating best and inefficient practices ▪ Successful examples of resource pooling between local stakeholders to upscale restoration measures	▪ Limited financial resources available for investment in forest (US$1 million annually from the government budget) and pasture (PC budget - no national-level figure) restoration ▪ Government budget allocation procedures prevent timely disbursement for restoration activities
Technical feasibility	▪ Successful examples of local agreements between governmental and nongovernmental stakeholders demonstrate a sustainable implementation of restoration measures ▪ Several past and ongoing projects improved the equipment and technical means of forest and pasture management bodies	▪ Low-cost restoration measures lead to limited improvements and require annual investments ▪ Government procurement procedures make it difficult to select the most qualified contractor ▪ The technical capacities of local land managers are limited which is an important constraint to the implementation of restoration measures
Knowledge and skills	▪ Knowledge about pasture degradation and restoration is available among local managers and improvement through trainings provided by various projects	▪ Missing knowledge about the FLR concept at all levels ▪ Outdated technical knowledge in the forest sector and no established structure for continuous capacity building ▪ High turnover of land managers at the local level preventing efficient knowledge management
Cultural aspects	▪ Local stakeholders search for local compromises with other land users and managers	▪ If not properly mitigated, conflicts over grazing in forest areas can be a serious limitation to successful restoration

Source: Interview with national partners.

3.5. Finance and investment options

The costs for restoration given in Table 25 are based on statistics for the Naryn River Basin and for the whole country. Areas within and outside the Naryn River Basin with high degradation were identified. These are degradation classes 4–6. In some cases, only degradation classes 5–6 were used where class 4 was too large; thus, restoration would be too costly (see 'Target area description' column in Table 25). As a result, restoration investments are recommended on 8,909 ha of forest areas, 39,818 ha of pastureland, and 1,300 ha of croplands, amounting to a total of 50,027 ha. For the forest measures, a percentage of afforestation and regeneration was considered as indicated in the column 'Target area description'.

It is suggested that about 10 percent of the total costs be allocated for investment management, capacity building, and technical assistance. The total investment would sum up to US$45.3 million. It is also suggested to include 10 percent of potential investment for capacity building, consultancies, and investment management (see section 3.3.6). Average costs and revenues relate to a 20-year period. Results are shown in the same table.

Up-front investment costs (Year 1) of restoration shall be covered and financed. Although some of the measures do have an interesting economic return, it should be noted that market prices (not on-farm prices) were used and that economic benefits from carbon sequestration and ecosystem services were included. It is assumed that forestry, agriculture, and pastureland users would be able to co-finance the investment. Land users are increasingly interested in investing in restoration activities. This trend concerns agricultural land but less so forest land, which is managed by the state, and lease holders of these lands are interested in fast-growing plantations. This kind of co-investment mechanism has been piloted through various projects on afforestation and agroforestry in southern Kyrgyz Republic and has proven to be successful. The co-investment was done through labor, local material, fencing material, irrigation equipment, seeds, and seedlings. The funds available for land restoration from the state budget would need to be increased to implement the proposed restoration interventions. For example, according to the available information, the Kyrgyz Republic allocates over KGS 90 million (US$1 million) annually for all reforestation and afforestation activities in the entire country.[24]

Small and medium enterprises supported by the technical assistance can have access to the credit lines of the Russian-Kyrgyz Development Fund (RKDF). The loans will be provided at 5 percent per year in dollars and at 10 percent in local currency, for a term of about 3–5 years, to existing enterprises representing eligible value chains. Co-investment can therefore be provided through loans by the interested persons. Doscredobank is currently seeking GCF accreditation. This bank could also be an option for credit in future.

[24] http://en.kabar.kg/news/kyrgyzstan-to-allocate-kgs-97.4-mln-this-year-for-forest-protection/.

Table 25: Suggested investments per restoration measure in and outside the Naryn Basin per hectare, US$

Average cost per ha (avg/ ha over 20 years)	Financial revenue (avg/ha over 20 years)	Nonmonetary benefit (avg/ ha over 20 years)	Carbon (using US$5 price)	Total cost Year 1	Cost (international cooperation organizations or develop-ment banks)	ha	Target area description (NB - Naryn basin. ON - outside Naryn basin)	Total cost (international cooperation organizations or develop-ment banks)	NPV (8%)	IRR (%)
Restoration measure: Forest - Afforestation - Walnut										
184	2,965.13	6.80	91.50	1,813	907	937	100% of degradation classes 4-6 (20% afforestation. 50% regeneration)	849,169	13,680	31
Restoration measure: Forest - Afforestation - Pistachio										
184	279.59	6.80	91.50	1,813	907	1,932	50% of class 5 ON 70% afforestation. 30% regeneration	1,751,650	633	11
Restoration measure: Forest – Reforestation - Riparian Forest										
841	858.79	6.80	93.00	1,568	784	200	200 ha in NB	156,840	3.174	16
Restoration measure: Forest - Assisted Regeneration - Walnut										
98	1,826.96	6.80	28.50	994	497	1,070	100% of degradation classes 4-6 (20% afforestation. 50% regeneration)	531,842	10,054	31
Restoration measure: Agricultural lands - Watering improvement										
1,075	3,111.89	-	3.50	2,867	1.433	100	NB	143,349	4,324	49
Restoration measure: Agricultural lands - No tillage										
1,165	3,187.57	-	1.50	4,563	2,281	100	NB	228,137	3,447	23
Restoration measure: Agricultural lands - Crop rotation										
342	1,740.71	-	0.50	342	171	1,000	NB	170,991	2,398	2
Restoration measure: Agricultural lands - Agroforestry										
1,053	1,963.23	-	-	3,383	1,692	100	NB and ON	169,156	1,600	20
Restoration measure: Pasture - Grazing ban										
138	435.65	6.80	6.00	696	348	15,927	40% of total NB degradation classes 5-6	5,540,684	923	16
Restoration measure: Pasture - Remote pasture access										
130	467.30	6.80	6.00	728	364	19,909	50% of total NB degradation classes 5-6	7,248,671	1,268	19
Restoration measure: Pasture - Rotational measures										
118	456.24	6.80	6.00	682	341	3,982	10% of total NB degradation classes 5-6	1,358,172	1,256	19

Table 25

Average cost per ha (avg/ ha over 20 years)	Financial revenue (avg/ha over 20 years)	Nonmonetary benefit (avg/ ha over 20 years)	Carbon (using US$5 price)	Total cost Year 1	Cost (international cooperation organizations or development banks)	ha	Target area description (NB - Naryn basin. ON - outside Naryn basin)	Total cost (international cooperation organizations or development banks)	NPV (8%)	IRR (%)
Restoration measure: Riverine protection green										
585	75,000.00			7,217	7,217	20×100 m	2 km NB	144,340	727,581	n.a.
Restoration measure: Riverine protection grey										
601	75,000.00			9,782	9,782	20×100 m	2 km NB	195,642	726,255	n.a.
Restoration measure: Forest - Afforestation - Spruce										
175	1.98	6.80	46.00	1,804	902	3,548	100% in NB and 100% of classes 4-6 ON 90% afforestation and 10% regeneration	3,200,551	***-1,821***	−9
Restoration measure: Forest - Assisted regeneration – Pistachio										
256	150.22	6.80	28.50	1,904	952	828	50% of class 5 ON 70% afforestation. 30% regeneration	788,328	***-2,207***	−4
Restoration measure: Forest - Assisted regeneration - Spruce										
247	1.98	6.80	5.50	1,895	948	394	100% in NB and 100% of classes 4-6 ON 90% afforestation and 10% regeneration	373,528	***-2,959***	n.a.
Total cost first year										
-	-	-	-	-	-	-	-	**45,362,115**	-	-
Total third-party investment										
-	-	-	-	-	-	-	-	**22,511,067**	-	-
International cooperation organizations or development banks investment										
-	-	-	-	-	-	-	-	**22,851,048**	-	-
10% for capacity building. consultancies. investment management										
-	-	-	-	-	-	-	-	**2,285,105**	-	-
Total international cooperation organizations or development banks investment										
-	-	-	-	-	-	-	-	**25,136,153**	-	-

Source: Original elaboration for this publication.

Table 26 shows the impact of changing carbon prices on the NPV and IRR of the different restoration options. NPV is calculated using a discount rate of 8 percent. The carbon price has a significant impact on the economic performance of the afforestation and assisted regeneration restoration measures as these are the measures with the highest carbon impacts. For restoration measures such as agricultural lands and pasture, there is a less noticeable impact. Green and grey riverine protection and walnut agroforestry are not included in the table because they have either zero or a net positive impact on carbon emissions. Although not all measures have a positive NPV, it is still recommended to apply these measures for other benefits such as ecosystems, biodiversity, water harvesting, landscape, tourism, reduced erosion, and improved livelihood in remote areas (although the contribution from pistachio, for example, may be low). The implementation of these measures will also help the Kyrgyz Republic meet NDC and Bonn Challenge targets and therefore needs investment and commitment

Table 26: Carbon price sensitivity of restoration options

Carbon price	US\$5/tCO_2	US\$5/tCO_2	US\$20/tCO_2	US\$20/tCO_2	US\$50/tCO_2	US\$50/tCO_2
Restoration Measure	NPV (8%) (US\$/ha)	IRR (%)	NPV (8%) (US\$/ha)	IRR (%)	NPV (8%) (US\$/ha)	IRR (%)
Forest - Afforestation -Walnut	13,679.82	28	16,374.90	36	21,765.07	67
Forest - Afforestation - Pistachio	632.84	11	3,327.92	27	8,718.08	96
Forest - Afforestation - Spruce	1,821.25	−9	466.35	5	2,243.46	25
Forest -Reforestation-Riparian forest	3,174.30	16	5,913.56	31	11,392.09	136
Forest - Assisted regeneration - Walnut	10,054	31	10,893.05	34	12,571.95	45
Forest - Assisted regeneration - Pistachio	2,206.67	−4	1,367.22	1	311.69	10
Forest -Assisted regeneration - Spruce	2,959.01	n.a.	2,797.01	n.a.	2,473.01	n.a.
Agricultural lands - Watering improvement	4,323.87	49	4,426.96	50	4,633.14	53
Agricultural lands - No tillage	3,447.08	23	3,491.26	24	3,579.62	24
Agricultural lands - Crop rotation	2,397.57	2	2,412.30	2	2,441.75	2
Pasture - Grazing ban	922.93	16	1,099.66	18	1,453.11	22
Pasture - Remote pasture access	1,267.97	19	1,444.70	21	1,798.15	26
Pasture - Rotational measures	1,255.95	19	1,432.68	20	1,786.13	25

Source: Original elaboration for this publication.

The Climate Finance Center was established by a government resolution on August 17, 2017, to support the mobilization and access to climate finance for investments in key economic sectors. It is the central unit coordinating the Kyrgyz Republic's efforts in accessing climate funds and channeling them into transformative investments supporting national development priorities. Its duties also include securing finance related to mitigation and adaptation activities. To what extent the Climate Finance Center is fully operational is not known to the authors at this stage.

GCF is a key financing option which has approved a new project (CS FOR) due to start soon, as mentioned before.

Another financing option is through a payment for ecosystem services (PES) mechanism, which is analyzed in the following section.

One important aspect would be to coordinate investments from third-party organization(s). There are often parallel initiatives and investments, which can be more proactively coordinated by the Kyrgyz Republic. A multi-stakeholder coordination body is recommended to supervise the implementation of investments.

Tracking climate finance

There are five key public organizations which regularly track information about climate finance support in the biodiversity and forestry sectors:

- SFS (forestry and biodiversity national public and external finance)
- Ministry of Finance (Official Development Assistance [ODA] flows as a part of the public budget and the entire public budget)
- Ministry of Economy and Commerce (ODA technical aid and grants provided directly)
- National Statistics Committee (foreign direct investment - FDI)
- National Bank of the Kyrgyz Republic (Foreign investments).

The new organization of SFS was yet to be fully known during the study. Therefore, the financing flow may change.

3.6. Social and environmental benefits

While benefits from carbon sequestration and environmental services were included in the monetary CBA, additional important social and environmental services cannot be accounted for in a direct monetary way. The additional benefits are therefore described in Table 27.

Table 27: Restoration measures and their ecosystem and social services

Restoration measures	Benefits from ecosystem and social services
Forest lands	
Afforestation/reforestation with high-quality seedlings and polybags with protection measure (pistachio, walnut, juniper, and spruce)	▪ Water flow regulation ▪ Biodiversity increase ▪ Soil stabilization, avoided erosion ▪ Carbon sequestration ▪ Non-wood benefits (nuts) and firewood ▪ Landscape aesthetic, tourism ▪ Regulation of atmospheric temperature and humidity ▪ NTFPs ▪ Employment and seasonal employment

Table 27

Restoration measures	Benefits from ecosystem and social services
Reforestation in riparian areas/forests	▪ Water flow regulation ▪ Biodiversity increase ▪ Soil stabilization, avoided erosion ▪ Carbon sequestration ▪ Wood production (construction and firewood) ▪ Landscape aesthetic, tourism ▪ NTFPs ▪ Employment and seasonal employment
Assisted natural regeneration (pistachio, walnut, juniper, and spruce forests)	▪ Water flow regulation ▪ Biodiversity increase ▪ Soil stabilization, avoided erosion ▪ Wood and non-wood benefits ▪ Carbon sequestration ▪ Landscape aesthetic, tourism ▪ NTFPs ▪ Employment and seasonal employment
Agricultural lands	
Efficient use of water resources	▪ Soil conservation, water harvesting ▪ Carbon sequestration ▪ Reduced use of fertilizer and pesticides
No tillage/minimum tillage	▪ Soil conservation, water harvesting ▪ Carbon sequestration thanks to increased biomass in the soil ▪ Avoided watercourse siltation ▪ Reduced use of fertilizer and pesticides
Introduction of crop rotation and cover crops	▪ Soil conservation, water harvesting ▪ Carbon sequestration ▪ Avoided watercourse siltation ▪ Reduced use of fertilizer and pesticides
Agroforestry models combining walnut trees, fruit trees, fast growing trees (hedgerows), native bushes, hay production, and agriculture in SFFs and private lands	▪ Biodiversity increase ▪ Soil conservation ▪ Wood and non-wood products ▪ Carbon sequestration in trees and soil ▪ Landscape aesthetic ▪ Employment and seasonal employment
Pasturelands	
Temporary grazing ban in degraded areas in all pasture types	▪ Soil conservation, avoided soil erosion ▪ Increased biomass and biodiversity ▪ Carbon sequestration thanks to increased biomass in the soil ▪ Landscape aesthetic ▪ Avoided watercourse siltation
Access to remote pastures through infrastructure improvement (for example, watering points, bridges, roads)	▪ Soil conservation, avoided soil erosion ▪ Carbon sequestration thanks to increased biomass in the soil ▪ Avoided watercourse siltation ▪ Seasonal employment
Rotational grazing, grazing schedule in summer and winter pastures for increasing productivity and improving palatability	▪ Soil conservation, avoided soil erosion ▪ Carbon sequestration thanks to increased biomass in the soil ▪ Landscape aesthetic ▪ Avoided watercourse siltation

Table 27

Restoration measures	Benefits from ecosystem and social services
Protective lands	
Riverbank protection and gully stabilization through green infrastructure (plantation of adapted grass, bush, and tree species)	▪ Carbon sequestration in the vegetation ▪ Avoided watercourse siltation ▪ Avoided damages ▪ Seasonal employment
Riverbank protection and gully stabilization through grey infrastructure (gabions, check dams)	▪ Avoided watercourse siltation ▪ Avoided damages ▪ Seasonal employment

Source: Original elaboration for this publication.

Note: Ecosystem services have been double counted in the cashflow models, where carbon revenues or ecosystem services benefits are already included. However, because the value of US$6.8 includes all the services (such as tourism, recreation, fodder, and wood production) and cannot be disaggregated, double counting was allowed in this study since the ELD value also includes other benefits not accounted for in our CBA. Also, the value is low (see also CS FOR project calculation in the GCF proposal).

Potential impacts on employment are difficult to estimate. Figures given by the International Bank for Reconstruction and Development 2017 (PROFOR, Climate Focus, and World Bank Group 2017) indicate 0.070 full-time equivalent (FTE) employees per ha for productive forest, 0.003 for reduced impact logging (Peru), and 0.050 for rotation extension (Vietnam). Restoration measures would positively affect seasonal employment for tree planting and regeneration and permanent employment for the tree nursery and within the SAF employment structure. The range could be between 0.003 and 0.050 FTE per ha.

3.7. Payment for ecosystem services (PES)

3.7.1. National strategies and regulations

The concept of ecosystem services has been steadily introduced in several policies and strategic documents of the Kyrgyz Republic since 2013. Several documents make direct reference to the terminology 'ecosystem services', for example, the Green Economy Program of the Kyrgyz Republic 2019–2023 (2018), where the 'development of a methodology for the economic valuation of ecosystem services' is planned for 2022 (a draft was prepared by a national working group but is not approved yet - 6th report to Convention on Biological Diversity [CBD] 2019). It was also widely used in the biodiversity conservation priorities of the Kyrgyz Republic until 2024 (2014) as well as in the 5th and 6th National Reports to the Convention on Biodiversity (2013, 2019). However, the 6th report to the CBD underlines that 'ecosystem services' is not yet officially defined in any regulatory document. Recently, definitions of ecosystem services and PES have been included in a modified version of the Forest Code. However, it is not yet approved by the government.

Ecosystem services principles, that is, the benefits Kyrgyz citizens get from sustainably managed resources, are also underlined in other strategic documents, but without making explicit use of the term 'ecosystem services':

- The Development Program of the Kyrgyz Republic for 2018–2022, 'UNITY, TRUST, CREATION', paves the way to a full-fledged implementation of the principles elaborated in the Green Economy Program. This includes aspects related to ecosystem services—as it underlines the necessity to "take into account the principles of green growth for the revision of the economy's structure and the transition to development with minimal impact on the natural environment."
- The Concept of Forest Sector Development 2040 aims at the sustainable management of forests to ensure the economic well-being of people, social prosperity, environmental safety,

and a favorable environment for the life of citizens of the Kyrgyz Republic. It acknowledges the importance of ecosystem services provided by forest ecosystems to underpin the three main pillars of sustainable development. It lists provisioning and regulating ecosystem services (without calling them as such), such as clean and stable water provision, avoided natural hazards, clean air, and NTFPs.

The term 'PES' is mentioned in only one national strategy: The biodiversity conservation priorities of the Kyrgyz Republic until 2024, which indicates that such mechanisms are not developed yet in the country but are necessary to engage vulnerable rural communities in a more rational and profitable management of natural resources. As mentioned above, a definition of PES is also given in draft modifications to the Forest Code.

3.7.2. PES pilots

Several projects piloted PES-like schemes at the watershed level, for example the Regional Environmental Center for Central Asia in 2014 and 2017. Considering the lack of finance available among ecosystem services beneficiaries, transaction costs associated with a transparent payment mechanism, and legal and financial barriers, these projects followed a pragmatic approach, which did not entail any financial transaction. Instead, local agreements were sought after, in which ecosystem services beneficiaries provided an in-kind reward to providers in the form of a labor contribution for land restoration (for example, reforestation). Research conducted on these pilot projects (Kolinjivadi et al. 2016; Saraswat et al. 2015) underlined that intense community mobilization, local negotiations between land users, and flexibility in designing a reward mechanism that is accessible to ecosystem services buyers and interesting for ecosystem services sellers were key factors for the success of these PES schemes.

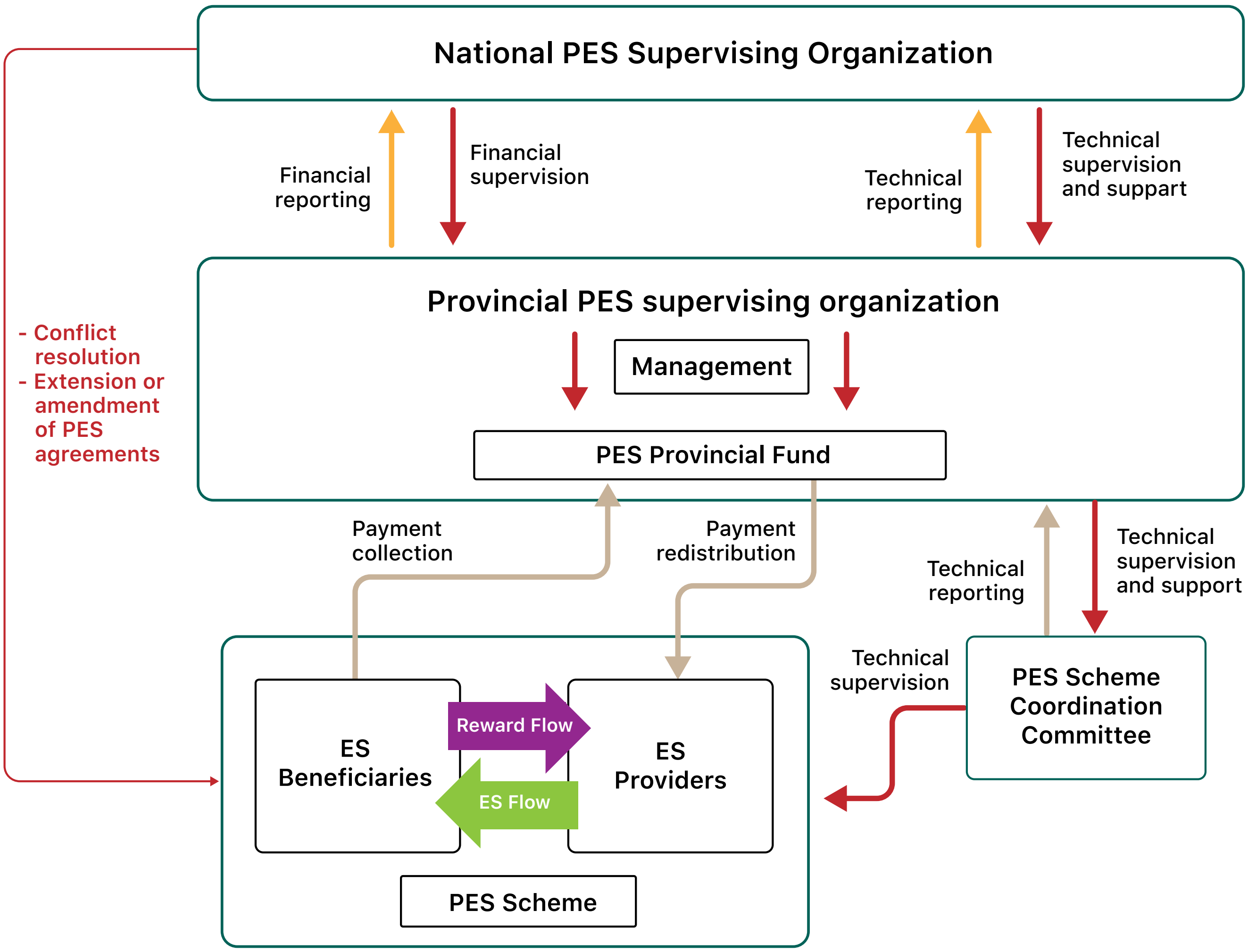
A relevant study by UNDP[25] (2012) explored the possibility to set up a PES mechanism in the frame of which herders from Suusamyr valley would receive a payment from the Toktogul HPP for avoided land degradation and the consecutive transport of sediments to Toktogul Reservoir via the Kokomeren River. The river being a marginal contributor to the reservoir's total inflow, and erosion processes not being widespread in Suusamyr valley, no correlation was found between unsustainable pasture management and sedimentation in the reservoir. Additionally, Toktogul HPP management indicated its lack of concern with sedimentation which is a marginal phenomenon compared to the reservoir capacity and occurs several dozen kilometers away from the dam. No financial resources are allocated to removing sediments, as this would generate no benefit for power production in the long term. It means that one of the basic conditions for setting up a PES mechanism, that is, a clear demand for the ecosystem service from a buyer (Fripp 2014), is missing. The structure of a PES mechanism was drafted (Figure 17), but never brought forward due to these preliminary conclusions.

In this study, it was also possible to confirm that degraded land is not a major contributor for siltation of Toktogul Reservoir over the next decades (see baseline report). There are therefore doubts on whether land restoration measures have the potential to significantly decrease the negligeable issue of water sedimentation. It means that a second key condition for a PES mechanism is also missing—additionality (Fripp 2014)—that is, restoration interventions have the potential to increase the supply of an ecosystem service (here avoided sedimentation). A PES system would not contribute to avoiding siltation of the reservoir.

The same UNDP study and another report from the Regional Environmental Centre for Central Asia (CAREC 2014) also point out several limitations in the legislation and public finance management system of the Kyrgyz Republic, which need to be addressed before large-scale, transparent, fair, and verifiable PES mechanisms can be established in the country.

[25] United Nations Development Programme.

Figure 17: PES structure in the Kyrgyz Republic



Source: UNDP 2012.

Interviews with national experts and former managers at SFS underlined that in the last years discussions at the national level on natural capital accounting and PES have lost momentum. This can be attributed to the following:

- The management of key government partners such as the former State Agency for Environmental Protection and Forestry (SAEPF) has changed several times in the past years, leading to knowledge being lost along the way.
- Several projects piloting PES initiatives ended and since 2017, there are no on-the-ground PES activities. The World Bank Waves initiative is the only remaining process working on natural capital accounting in the country.

Consequently, the various legal, institutional, and financial shortcomings identified by the projects listed above have not been addressed and remain today.

4.Results from Capacity Building

Capacity building of stakeholders was done through three technical workshops. One workshop focused on restoration measures, where measures were prioritized by the participants themselves.

A second small technical workshop took place with SFS staff during the team visit to the country, where preliminary results of the degradation were discussed and validated.

A third workshop took place in December 2021, where preliminary results of the whole study were presented and validated by the participants. In this workshop, the suggested prioritized Leskhozes and PCs for restoration implementation were confirmed and adjusted.

Another dimension of capacity building was the field work itself, where degradation and restoration options were discussed with land users and land managers in the field. As indicated in the 'readiness assessment' section, there are a lot of good experiences in the country, but no systematic approach for implementing and financing the FLR pledge. The technical capacities of local land managers are limited, which is an important constraint to the implementation of restoration measures. A strong technical assistance component in the foreseen restoration program is therefore suggested.

5. Conclusion and Recommendations

5.1. Readiness preparedness

Several enabling factors and bottlenecks to upscale FLR in the Kyrgyz Republic were presented in Table 24. Based on those, it is recommended to follow up on the following key actions for each of the six dimensions of readiness. For each topic, a lead agency(ies) has been identified and actions have been categorized by time priority, with a time horizon of 20 years.

Stakeholder engagement was limited during the assignment due to major institutional reforms and changes in government members throughout the assignment. Thus, an overarching additional recommendation is to start any upcoming investment in FLR in the country from a mobilization phase of key stakeholders, including the Ministry of Agriculture, and a validation of the information outlined in this report.

Political leadership

Lead agency: SFS (under the Ministry of Agriculture)

Key actions

- Support SFS to initiate an awareness raising campaign within the government to communicate on the objectives of landscape restoration, inform on the country's pledge, and highlight the opportunities offered by the Bonn Challenge and associated initiatives to leverage funding. **Time horizon: short term.**
- Support SFS lobby for FLR to be a topic of discussion in existing inter-ministerial working groups. **Time horizon: short term to midterm.**

Policy and legal framework

Lead agency: Ministry of Agriculture

- Review national sector strategies to identify key topics requiring strong coordination and cooperation between sectors. Develop specific actions to ensure these cross-cutting topics are addressed jointly by the respective ministries. **Time horizon: short term.**

Financing instruments

Lead agencies: Ministry of Agriculture, Ministry of Finance

- Review government budget allocation procedures and develop practical recommendations for timely disbursement and effective spending of funds for restoration activities. **Time horizon: midterm.**
- Explore opportunities for repurposing public expenditures and assessing how efficient spending of public resources currently is. It has the potential to allocate resources to more sustainable and efficient programs, such as potential restoration activities**. Time horizon: long term.**
- Streamline investments of development partners to the priority restoration measures identified during the ROAM analysis. **Time horizon: midterm to long term.**

Technical feasibility

Lead agency: Ministry of Agriculture

- Improve the technical capacities of land managers through upgrading key equipment and material. **Time horizon: short term to midterm.**

- Develop and share effective and affordable restoration measures with land managers and users. **Time horizon: mid erm to long term.**

Knowledge and skills

Lead agencies: Ministry of Agriculture, SFS

- Resume the development of a permanent training center for the forest sector. This center should offer onboarding training for inexperienced staff (technical, administrative, and management) and regular courses on innovative approaches and procedures for continuous improvement of workers' capacities. FLR courses should be provided for technical and management staff to create awareness about the concept and its applications. **Time horizon: short term to midterm.**
- Support the initiative of the Pasture Department to hold online training for District Departments of Rural Development through improvement of technical material and equipment upgrading. **Time horizon: short term to midterm.**
- Substantial capacity development material was developed by nongovernmental organizations and in the frame of International Fund for Agricultural Development (IFAD), World Bank, and GIZ projects, on topics such as development of pasture management plans and pasture improvement measures. These courses have often been designed to be held offline and their digitization as online courses would help disseminate them to a larger audience. There is also no common repository where this information can be made available online for pasture users and other interested stakeholders. Such a platform, hosted by the Ministry of Agriculture, would help keep this knowledge. It would also offer the possibility to the government and projects to develop specific online and offline capacity-building programs based on this existing knowledge database. **Time horizon: midterm to long term.**
- In the agriculture sector, the main need lies in improving the knowledge of the young generation on soil conservation practices, such as effective fertilizer application, cover crops, mulching, crop rotation, and agroforestry. This is the role of the District Department of Rural Development, which should be supported with capacity building, training material, and improvement of its equipment. **Time horizon: midterm to long term.**

Sociocultural aspects

Lead agency: Ministry of Agriculture

- Usage conflicts between forest management units and pasture users must be addressed through intense mediation before planning forest restoration measures. It is recommended to develop standard procedures for information sharing and public consultations which must be used when restoration measures may generate a conflict situation. **Time horizon: short term.**
- Awareness raising of the general population on land restoration and FLR is necessary to decrease the social pressure put on land managers concerning the implementation of unpopular — though necessary — measures, such as forest cuttings to promote forest regeneration. **Time horizon: short to long term**.

It is considered important to incorporate these recommendations within a future FLR support program by assigning budgets for capacity building, awareness raising, training measures, and knowledge management, in addition to the necessary technical investments.

5.2. Financing of restoration

Financing restoration through a PES mechanism has proven to have limited possibilities in the Kyrgyz Republic for political and legal reasons but also for the weak links between sedimentation and issues for hydropower production.

The CBA of restoration options shows that part of them cannot be expected to generate monetary benefits, at least not with the assumption of a carbon price of US$5 per ton. In these conditions, private investments can only be expected to be leveraged for the measures with the highest expected monetary return. Other measures must be financed through public funding, for example, from the state budget; grants and credits from international cooperation organizations and development banks; and private financing through local banks or specific funds, such as the RKDF.

The total investment for restoring degraded areas is US$45.3 million, to implement landscape restoration interventions across 50,027 ha (including 39,818 ha of pastures, 8,909 ha of forests, and 1,300 ha of cropland). It is suggested that 10 percent of the total costs be allocated for investment management, capacity building, consulting services, and technical assistance.

The overall NPV of such a restoration investment is US$ 93.33 million, over a 20-year time horizon and a discount rate of 8 percent. The discounted BCR of the investment is 2.4, that is, US$ 2.4 is generated from the investment of US$ 1. The return on investment was calculated at 138 percent.

5.3. Limitations and additional research

Due to government reforms and changes within the SFS, it has been challenging to have direct interactions with government partners throughout the study. As a result, it is acknowledged that interaction was limited to several workshops and capacity-building efforts within small expert groups.

Remote sensing was intensively used in this analysis to identify suitable areas for restoration. Although this has advantages, particularly because large areas can be covered at a limited cost, it also has its limitations. The indexes selected for the analysis did not make it possible to identify degradation trends in agricultural lands precisely. The 250 × 250 m grid used for the assessment gives a good overview of the situation on the ground but needs to be finer to produce precise maps of the sites to be restored.

Further studies are recommended to confirm the potential correlation between land degradation, sedimentation, and storage loss for other reservoirs in the Naryn River Basin, considering the impacts of climate change. It is also recommended to assess the potential contribution of the proposed restoration measures to the mitigation and reduction of natural hazard risks.

The proposed restoration measures could contribute to disaster alleviation and natural hazard risk reduction, although this was not directly assessed. Improved soil structure and vegetation cover, in combination with other disaster alleviation activities, can improve ground stabilization, thereby increasing the basin’s resilience to mudflows, landslides, rockfalls, and slumping. Landscape restoration can also help reduce flooding hazards and increase watershed drought tolerance and water retention. These benefits were not estimated, and further investigations are required to assess the full potential in natural hazards reduction. Some of the proposed financing options, particularly those connected with carbon finance, require institutional and legal preconditions which need to be further researched and clarified.

If a restoration program is initiated in the Kyrgyz Republic, further local planning will be necessary to match the maps of areas that are potentially suitable for restoration with local biophysical realities, current land use, and conflicts between the objectives pursued by restoration and those of local land users. In this sense, community involvement in detailed restoration planning at the local level will be instrumental in the sustainability of the interventions. In addition, the precise localities for riverine protection would need a more in-depth study to assess where investment would make sense to protect infrastructure and housing.

Additional research would be required on several topics which were not addressed in this study:

- Additional studies will be needed to identify, together with local stakeholders, the exact locations of restoration measures.
- Further studies are recommended to confirm the potential correlation between land degradation, sedimentation, and storage loss for other reservoirs in the Naryn River Basin, considering the implications of climate change. In-depth studies, integrating climate modelling approaches with field observations, will require new bathymetric surveys and revision of the dead storage capacity of existing and proposed reservoirs in the Naryn River Basin. This information would allow to identify the reservoirs at higher risk of siltation in the short and medium term along the Naryn River and to prioritize landscape restoration measures, targeting the reservoirs that are more prone to future siltation.
- Fine sediments can reduce the turbine lifespan and climate change will impact on sediment transport within the reservoir. Further studies are required to quantify or estimate this impact for Toktogul HPP specifically.
- Improved soil structure and vegetation cover, in combination with other disaster alleviation activities, can improve ground stabilization, thereby increasing the basin's resilience to mudflows, landslides, rockfalls, and slumping. Landscape restoration can also help reduce flooding hazards and increase watershed drought tolerance and water retention. These benefits, which will become more significant as the impacts of climate change escalate, were not estimated. Further investigations are required to assess the full potential of the proposed interventions in natural hazards reduction.
- Spatiotemporal modelling tools are needed for a quantitative assessment of baseline conditions and scenario analyses of different land management and climate change projections. Field measurements of erosion and suspended sediment concentrations are required for calibration and validation of such models. The existing knowledge base of erosion and sedimentation in the Kyrgyz Republic across different terrains and land use types is limited and a wide range of values has been documented in the studies that do exist.
- The applied methodology was not able to identify degraded agriculture cropland. It is also not of major importance in the Naryn River Basin (less than 1 percent of the total Naryn Basin) related to degradation and erosion. Further efforts will be required to identify farmers willing to apply the suggested restoration measures.
- The issuance of carbon credits is not yet regulated in the Kyrgyz Republic, although there are ongoing efforts to establish a supportive legislative framework. Further studies are needed to explore realistic options for leveraging voluntary carbon market financing and to assess their time horizon.
- Effectively managed silvopasture can increase overall productivity and long-term income through the simultaneous production of tree crops, forage, and livestock. It can also provide environmental benefits such as carbon sequestration. The use of silvopasture agricultural practices in highly degraded areas in the Kyrgyz Republic should be investigated as a potential option to accelerate land restoration.

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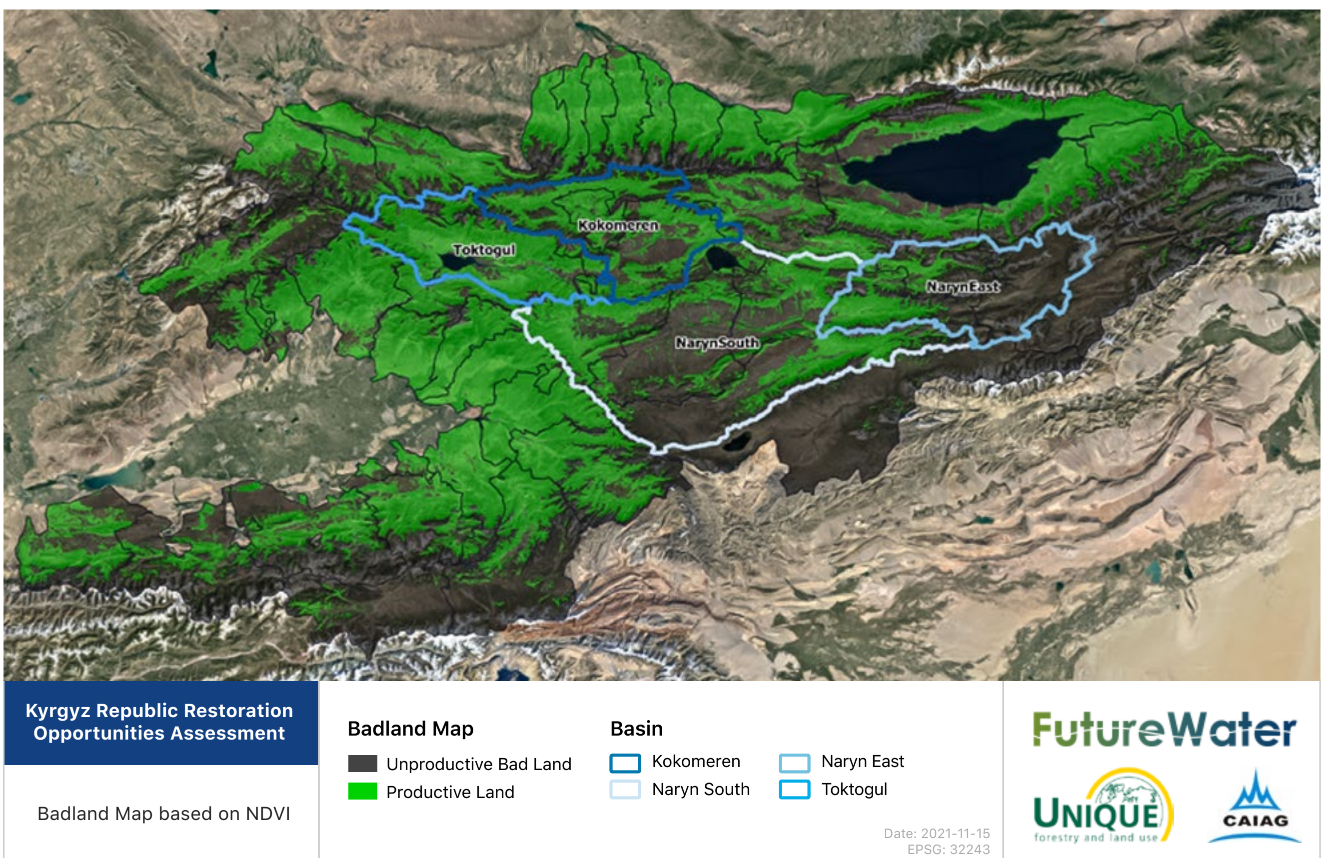
Annex 1. Interviewed stakeholders

#	Position	Institution
1	Head of Department	Department of Forest Ecosystem Development, Forest Service
2	Head of Division	Department of Forest Ecosystem Development, Forest Service
4	Head of Department	Forest Policy Department, Ministry of Agriculture
5	Chief Specialist	Pasture Department, Ministry of Agriculture
6	Specialist	Pasture Department, Ministry of Agriculture
7	Director	Plant Production Department, Ministry of Agriculture
8	Director	Toktogul RUAR
9	Director	Naryn RUAR
10	Director	Nichke-Say PC
11	Director	Chek-Nura PC
12	Director	Jan-Bulak PC
13	Director	Sary-Bulak PC
14	Pasture user	Emgekchil PC
15	Director	Naryn Leskhoz
17	Director	Ak-Talaa Leskhoz
18	Project Manager	UNDP Conservation of Globally Important Biodiversity of the Western Tian Shan
19	Project Expert	FAO project Carbon sequestration through climate investment in forests and rangelands in the Kyrgyz Republic

Annex 2. Badland identification

The preliminary map of degraded areas and of feasibility of restoration interventions was updated, after ground truthing unveiled that some of the land classified as degraded were in fact considered by local land users and experts as ‘badlands’, that is, naturally unproductive areas due to their soil and geological characteristics. As a result, the degradation maps were updated by removing these badlands from the degradation classification. This was done by ‘masking’ these areas, using NDVI and SOC data. The most accurate badland mask was created using an upper NDVI threshold of 0.2 (the mean value for 2000–2020), and this layer was used to extract unproductive lands from the maps. An NDVI value typically ranges between -1 and 1. Low positive values, i.e., 0.2, represent shrub and grassland and thus exclude the unproductive lands. Hence all the negative values, and values below 0.2, were left out during this operation. This updated ‘badland’ (naturally non-productive areas) mask is presented in Figure 18 below.

Figure 18: Badland identification map



Source: original elaboration for this publication

Annex 3. Restoration opportunities in the Naryn river basin leskhozes

Table 28: Restoration opportunities in the Naryn River Basin Leskhozes

Leskhoz	Priority Status	ha	% of total Leskhoz area
Toktogul	Consolidation	4,111	2.9
Toguz-Toro	Consolidation	3,491	3.5
Naryn	Consolidation	1,443	3.1
At Bashy	Initial	9,248	9.4
Ak Talaa	Consolidation	17,677	14.4
Jumgal	Initial	424	7.0

Source: original elaboration for this publication

Note: These results are based on data of prioritized Leskhoz and degradation classes 3-6. Exact Leskhoz boundaries were not available. Some deviation of the total area is therefore possible.

Annex 4. Restoration Opportunities within pasture committees

Table 29: Restoration opportunities within pasture committees

Pasture Committee	Priority Status	ha	% (of PC)
Prioritized Pasture Communities			
Nichke Say PC	Initial	9,993	12.0
Jan Bulack PC	Initial	3,972	12.7
Emgek Talaa PC	Initial	6,070	15.8
Check Nura PC	Consolidation	15,483	33.1
Akman PC	Consolidation	-	-
Jargylchak PC	Consolidation	53	0.1
Jergetal Ak Talaa PC	Consolidation	4,581	4.9
Jergetal Naryn PC	Consolidation	12,255	19.2
Kara Burgon PC	Consolidation	1,660	1.8
Min Bulak PC	Consolidation	16,989	23.3
Ortok PC	Consolidation	2,490	11.3
Cholpon Ata PC	Consolidation	12,918	8.8
Ugut PC	Consolidation	1,396	2.6
Ulahol PC	Consolidation	4,955	41.1
Non-Prioritized Pasture Communities			
Atai PC	Excluded	2,066	10.3
Jany Talap PC	Excluded	3,605	9.1
Kargalyk PC	Excluded	17,495	19.7
Kok Irim PC	Excluded	4,681	4.7
Togolok MoldoPC	Excluded	3,776	4.9
Toguz Toro PC	Excluded	14,841	12.8
Emgekchill PC	Excluded	7,378	17.7
Kazan Kuigan PC	Excluded	4,767	38.6
Kok Jar PC	Excluded	2,675	7.5
Kuzul Beles PC	Excluded	1,268	7.1
Kyzyl Ozgorush PC	Excluded	3,484	10.2
Ak Chiy PC	Excluded	403	0.9

Source: original elaboration for this publication
Note: These results are based on data of prioritized pasture committees and degradation classes 3-6.

Annex 5. Restoration Opportunities by Forest CROPS and CLASSES

Table 30: Overall Spruce and Juniperus Restoration Opportunity statistics for each subbasin

Class number	Kyrgyz Republic		Naryn Basin		Naryn Basin South		Naryn Basin East		Toktogul Watershed		Kokomeren Watershed	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
1	168,915.7	0.8	23,911.5	0.5	10,982.6	0.5	7,550.3	0.7	2,718.2	0.3	2,660.4	0.3
2	31,718.3	0.2	6,623.7	0.1	3,265.3	0.1	2,466.2	0.2	671.0	0.1	221.2	0.0
3	11,200.8	0.1	842.1	0.0	466.3	0.0	207.2	0.0	113.1	0.0	55.5	0.0
4	1,752.3	0.0	385.0	0.0	230.5	0.0	112.0	0.0	31.1	0.0	11.5	0.0
5	1,916.8	0.0	179.2	0.0	44.7	0.0	43.2	0.0	80.0	0.0	11.3	0.0
6	273.2	0.0	79.8	0.0	18.1	0.0	35.3	0.0	25.9	0.0	0.5	0.0
Total	**215,777.1**		**32,021.3**		**15,007.5**		**10,414.2**		**3,639.3**		**2,960.6**	

Source: original elaboration for this publication
Note: percentage total not equal to 100 due to non-applicable areas in region

Table 31: Overall Pistachio / Almond Restoration Opportunity statistics for each Leskhoz

Class number	Kyrgyz Republic		Naryn Basin		Toktogul Leskhoz		Toguz-Toro Leskhoz		Naryn Leskhoz		At-Bashy Leskhoz		Ak Talaa Leskhoz	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
1	22333.0	0.1	0.1	0.0	0	0	0	0	0	0	0	0	0	0
2	10.3	0.0	0	0	0	0	0	0	0	0	0	0	0	0
3	4232.9	0.0	0	0	0	0	0	0	0	0	0	0	0	0
4	0.4	0.0	0	0	0	0	0	0	0	0	0	0	0	0
5	5520.2	0.0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**32,096.8**		**0.1**		**0**		**0**		**0**		**0**		**0**	

Source: original elaboration for this publication
Note: percentage total not equal to 100 due to non-applicable areas in region

Table 32: Overall Walnut Restoration Opportunity statistics for each Leskhoz

Class number	Kyrgyz Republic		Naryn Basin		Toktogul Leskhoz		Toguz-Toro Leskhoz		Naryn Leskhoz		At-Bashy Leskhoz		Ak Talaa Leskhoz
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha
1	32700.9	0.16	6.3	0.00	100.0	0.07	0	0	0	0	0	0	0
2	152.3	0.00	0.1	0.00	3.8	0.00	0	0	0	0	0	0	0
3	4890.7	0.02	0.2	0.00	7.6	0.01	0	0	0	0	0	0	0
4	10.7	0.00	0.0	0.00	2.2	0.00	0	0	0	0	0	0	0
5	1313.2	0.01	0.4	0.00	16.3	0.01	0	0	0	0	0	0	0
6	14.0	0.00	0.0	0.00	1.4	0.00	0	0	0	0	0	0	0
Total	**39,081.8**		**7**		**131.3**		**0**		**0**		**0**		**0**

Source: original elaboration for this publication
Note: percentage total not equal to 100 due to non-applicable areas in region

Annex 6. Degradation and Sedimentation Assessment*

Identification of hotspots of land degradation and sediment sourcing

Land cover-specific soil erosion values are available from a UNDP study on Suusamyr Valley, which is in the upstream part of the Naryn River Basin (UNDP, 2016). Reported values range between 0.25 ton/ha/yr and 0.55 ton/ha/yr for different pasture types. The contribution of glacially eroded sediment to the sediment budget of the watershed is assumed insignificant. According to various estimates, the share of glacial waters in Naryn River discharge is around 6-10%16F[26], with a total glaciated area of the Naryn River Basin of ~2%. At an overall distance of > 300 km, the glaciers are situated far from Toktogul Reservoir.

Overview of data sources

To produce the maps of land degradation and sediment sourcing, various data sources were used, such as elevation models, precipitation soil organic carbon, and others. A variety of open-source datasets were used in this analysis. Where possible, widely used and openly available datasets were selected to enhance the reproducibility of results. Table 33 shows an overview and description of datasets. Their specific implementation in the various steps of the analyses is discussed in detail in the next sections.

For many applications in the baseline analysis, different gridded datasets are combined to create composite products. To combine datasets, they were first re-sampled to a common grid. The common grid hereby used was the 250 m resolution gridding used by MODIS. Re-gridding was accomplished using one of two resampling techniques depending on the data type – for continuous values (e.g., Elevation), bilinear resampling was used, and for discontinuous (e.g., Land Use) Nearest Neighbor was used.

Table 33: List of data sources

Data	Type	Resolution	Source	Reference
Elevation	Raster	30m	SRTM	https://www2.jpl.nasa.gov/srtm/
Precipitation	Raster	0.05 degrees (~5000m)	CHIRPS	https://www.chc.ucsb.edu/data/chirps
Soil Organic Carbon	Raster	250m	SoilGrids	https://www.isric.org/explore/soilgrids
Land Use	Raster	~20m	FAO	Martin-Ortega (2019)
NDVI	Raster	250m	MODIS	https://modis.gsfc.nasa.gov/data/data-prod/mod13.php
Erosion Observations	Vector	NA	Collect Earth	Martin-Ortega (2019)
Administrative Boundaries	Vector	NA	GADM	https://gadm.org/maps.html

Source: original elaboration for this publication

[26] Dikikh A.N., Usubaliev R.A., Moldoshev K.O . The state of glaciation of the Tien Shan in the second half of the 20th and early 21st centuries: evolution, ecology, and direction of glacial runoff. // Materials of the international scientific-practical conference "Problems of improving the management of natural and socio-economic processes" dedicated to the World Earth Day and the 10th anniversary of the FEM BSU. - Special. issue of the Bulletin of the BSU named K. Karasaeva, № 2 (8). - Bishkek, 2007. -- P. 13-16.

* As presented in the baseline report.

Baseline land degradation assessment

General

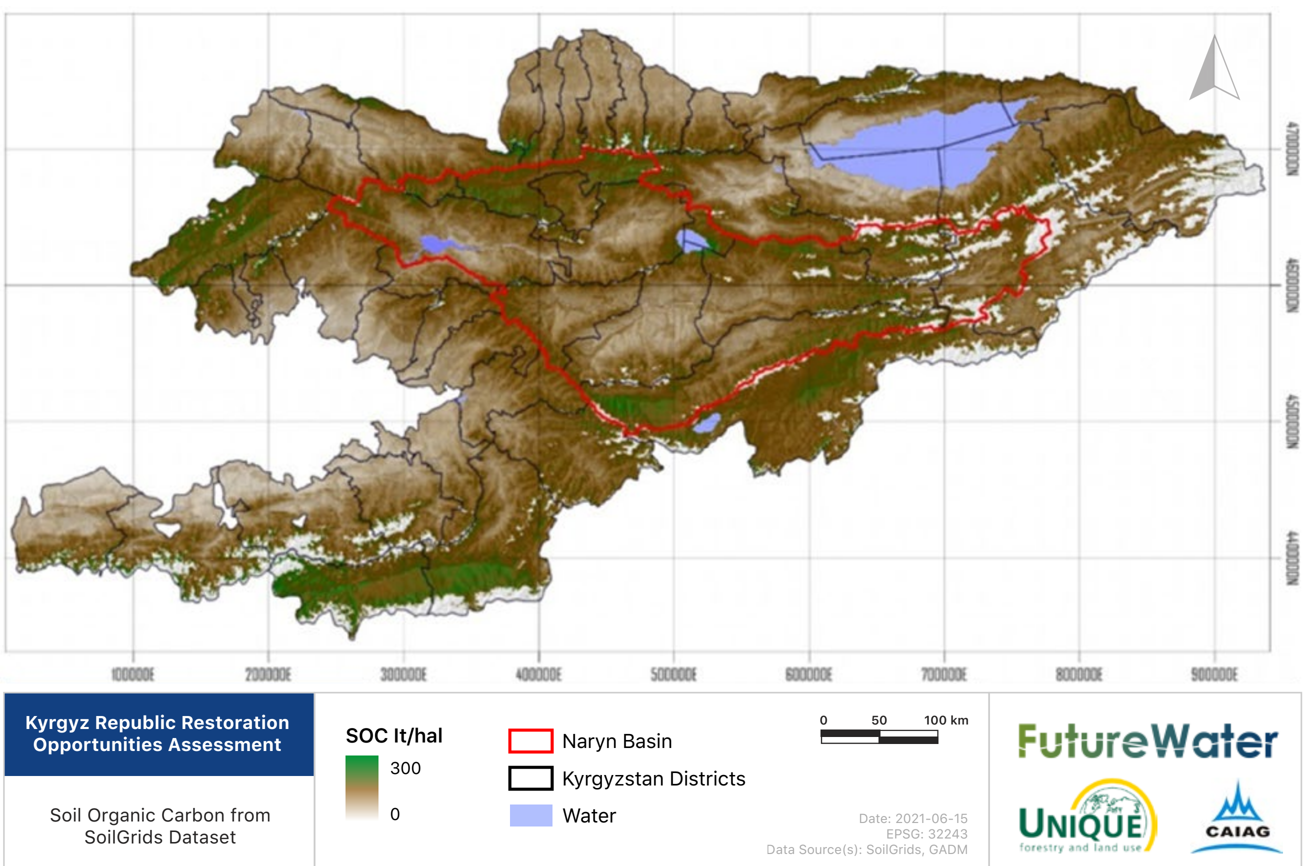
The Normalized Difference Vegetation Index (NDVI) was used as a representative variable for vegetation health as it is an easily accessible output at high resolutions from several remote sensing products, calculated as the normalized difference between Near Infrared (NIR) and Red bands with the following equation:

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

This index is widely used for studies on drought, agricultural productivity and (most appropriately) land degradation. Most simply, NDVI is an index which represents plant health via calculating how well plants reflect light at certain frequencies, with healthy plants better reflecting NIR light. The MODIS product was selected for assessing NDVI as this provides continuous imagery at high resolution (250 m) with an 8-day frequency from 2001-2020.

Soil Organic Carbon (SOC) can also indicate the level of degradation in the soil layer. This metric is a proxy for total organic matter contained in the soil layer and is therefore indicative of both soil health and its ability to sustain vegetation – increased organic matter is related to greater nutrient content and increased moisture retention. Soils with lower SOC are therefore likely to be either marginal or in a state of degradation due to anthropogenic or climatological pressures. The Soil Organic Carbon (SOC) map in Figure 19 shows that SOC is highly variable in the Kyrgyz Republic, with the richest soils found in the mid elevations on hillslopes and poor soils in lower arid areas and higher glaciated areas.

Figure 19: Soil organic carbon map of the Kyrgyz Republic



Source: ISRIC SoilGrids

Two key factors were calculated from NDVI and SOC datasets to determine the status of land degradation at a national scale:

- Trends – change in vegetation health over an observed period
- Deviation from agroclimatic class mean – the extent to which values in one area deviate from the mean value for a given class (in terms of land cover, elevation, and precipitation)

For resulting images from both analyses, bare earth (classified as a mean NDVI from the full MODIS series of < 0.2) and water bodies were removed to prevent falsely classifying these areas as degraded. Bare earth areas (*badlands*) are considered extremely low productivity due to factors other than land degradation (for example geology, extreme climate, steep slope, rocks, glacier moraine).

All factors described below were scaled between values of 0 and 1, and multiplied to arrive at a comprehensive, qualitative baseline land degradation map with three classes (*major degradation, minor degradation, no degradation*).

Trends

Calculation of trends in annual NDVI values serves to identify the sites where vegetation health has deteriorated over the past two decades, which can be considered a strong indicator of degradation. To compute trends in NDVI, a spatio-temporal time series of NDVI data from MODIS was used. The full period of this dataset (2001-2020) was accessed using Google Earth Engine.

The NDVI dataset was analyzed per-pixel for significant trends using Mann-Kendall testing. This testing yields a p-value per pixel which is indicative of whether the series contains a statistically significant monotonic upward or downward trend over time. The dataset was also analyzed using Sen’s Slope to yield a non-parametric estimate of the slope of increase or decrease which is not reliant on a “straight line” linear trend (Sen, 1968). A mask was created for significances of p-values less than 0.05 from the Mann-Kendall test and applied to the slope raster to finally yield a raster showing significant trends in NDVI over time.

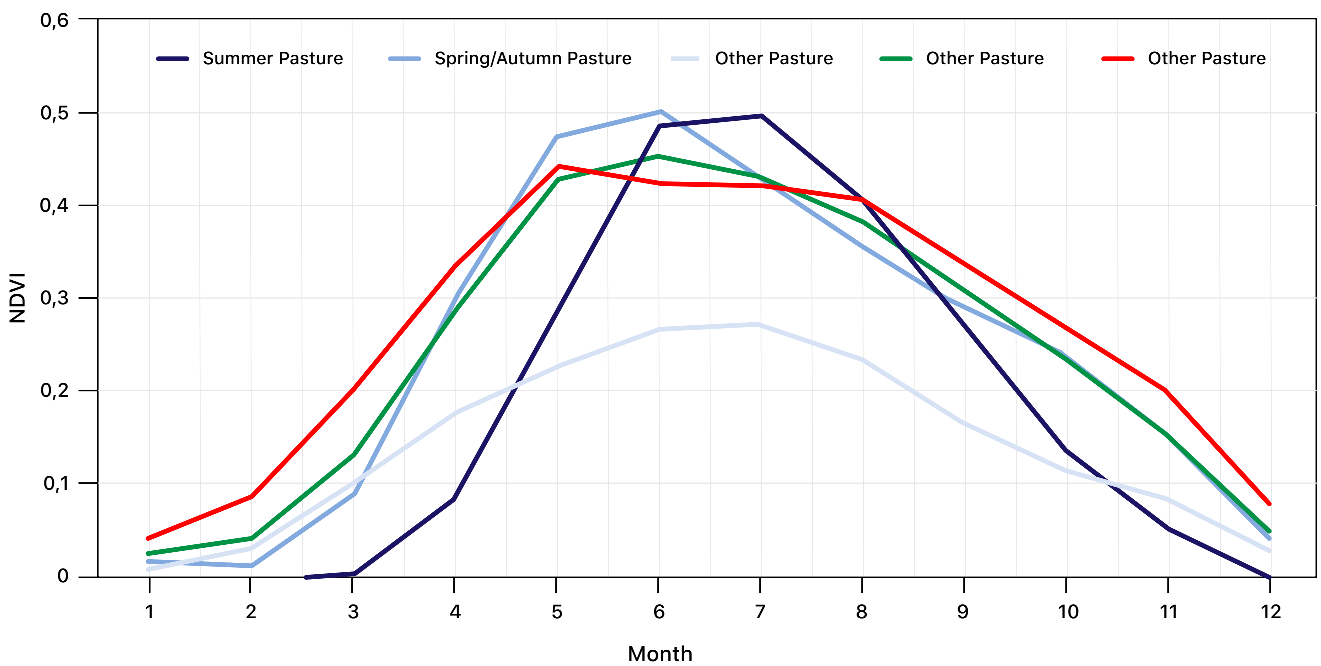
Pastures are used in spring, summer, and winter periods with different intensity. To detect degradation of pastures, the pastures need to be classified according to their grazing period time. The grazing seasonality highly depends on the elevation. The vegetation or biomass (measured as NDVI) must be determined per pasture class over the grazing period to identify degradation. For the grassland land use class, the total image series was therefore subsetted for images which fall in a period containing both peak-growth and the months after, corresponding to grazing periods. This period was indicated by local experts as the most critical to examine to show degradation from grazing of livestock and is also used in another key study on land degradation using remote sensing (Eddy et al., 2017). To determine peak grazing periods, the grassland class from the land cover dataset. was subdivided into different pasture types based on elevation-based classifications found in Zhumanova et al. (2018). The peak grazing periods for these classes were determined through a combination of consulting with local partners, examining the definitions of different pasture types and grazing periods found in Zhumanova et al. and implementing an analysis of seasonal NDVI patterns in MODIS data (Figure 20). These yielded the grazing periods detailed in Table 34.

Table 34: Division of pasture types and grazing periods

Pasture Class	Elevation Range [m]	Grazing Months
Summer	2800-3500	May-July
Spring / Autumn	1300-2800	June-August
Other	0-1500	Year-round

Source: original elaboration for this publication based on Zhumanova et al. (2018)

Figure 20: Seasonal NDVI profiles, 2001–2020



Source: original elaboration for this publication based on NDVI MODIS data 2001–2020.
Note: based on mean value per month per land use class calculated from the full MODIS dataset.

For all other land use classes including the "other" pasture class, forest, and cropland, NDVI images for all months were considered to reflect the assumption that degradation will negatively impact annual averages of vegetation conditions. While implementing this analysis, it turned out that **no meaningful trends could be identified for the cropland class**. This can be attributed to changes in cropping patterns and land use during the 20-year period under consideration. For this reason, **cropland was excluded from the remote sensing-based analyses described in this report**.

Finally, trend maps for pasture classes and forest classes were merged to show significant trends in NDVI for the full domain.

Trends in SOC were not assessed due to a lack of time series data on SOC for most regions of the world, the Kyrgyz Republic included. As such no appropriate datasets exist to perform this analysis.

Deviation from Agroclimatic Class Means

The aim of calculating deviation in NDVI and SOC from agroclimatic class means is to identify areas which are comparatively degraded in relation to the average state of land in similar climatological and physiographic zones. To develop agroclimatic classes, the land use raster was subdivided into classes according to precipitation and elevation. Table 35 shows the final 23 climatological and physiographic classes used for the deviance analysis while Figure 21 shows these spatially. This classification follows the approach developed for the Kyrgyz Republic by Korintenberg et al. (2021).

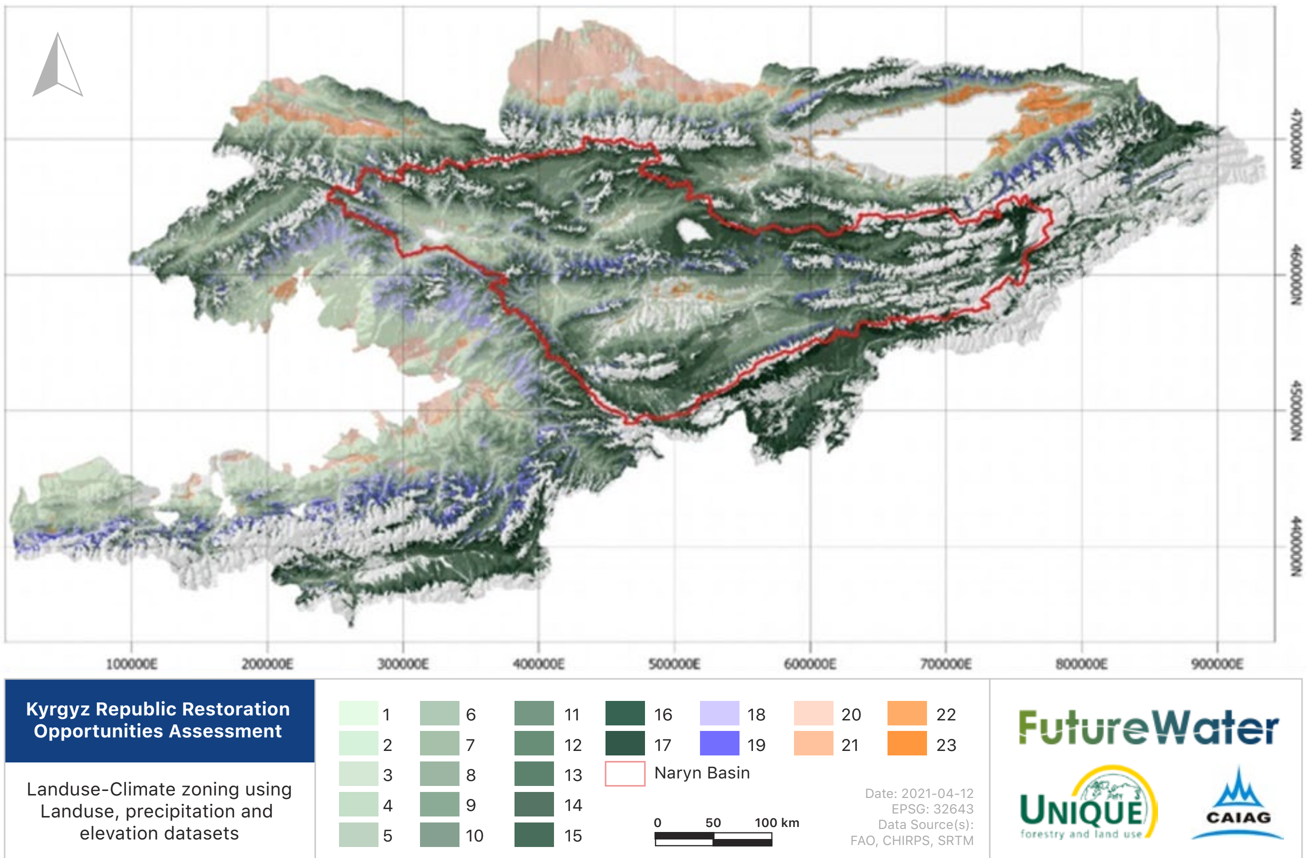
Following division into agroclimatic classes, the average NDVI and SOC per class is calculated. The difference between the class mean value and the value of every pixel the given class is then calculated, yielding the deviance from the agroclimatic class mean. If a specific pixel value is lower than the class mean, it can therefore be considered degraded. Most important, however, are values which are significantly different to the class mean and therefore the image is subsetted to show only pixels which are greater than one standard deviation away from the class mean.

Table 35: Class divisions according to Land use, Elevation and Total Annual Precipitation

Class Number	Land use Class	Elevation Range [m]	Precipitation Range [mm/yr]
1	Grassland	0-1500	0-300
2	Grassland	0-1500	300-600
3	Grassland	1500-2000	0-300
4	Grassland	1500-2000	300-600
5	Grassland	1500-2000	600-2000
6	Grassland	2000-2500	0-300
7	Grassland	2000-2500	300-600
8	Grassland	2000-2500	600-2000
9	Grassland	2500-3000	0-300
10	Grassland	2500-3000	300-600
11	Grassland	2500-3000	600-2000
12	Grassland	3000-3500	0-300
13	Grassland	3000-3500	300-600
14	Grassland	3000-3500	600-2000
15	Grassland	3500-4000	0-300
16	Grassland	3500-4000	300-600
17	Grassland	3500-4000	600-2000
18	Tree-covered areas	0-2500	300-600
19	Tree-covered areas	2500-4000	300-600
20	Cropland	0-1000	200-600
21	Cropland	1000-1500	200-600
22	Cropland	1500-2000	200-600
23	Cropland	2000-2500	200-600

Source: original elaboration for this publication based on Korintenberg et al. (2021).

Figure 21: Agroclimatic classes map of the Kyrgyz Republic based combined land use, precipitation, and elevation datasets



Source: original elaboration for this publication
Note: The legend refers to classes shown in Table 35.

Vulnerability to land degradation

General

Alongside the current state, a crucial factor to consider in this assessment is the potential vulnerability of land to on-going and future degradation processes. A range of biophysical factors were hereby considered relevant to determine land vulnerability. These focus on the land's physical characteristics, which may make it more susceptible to erosion (slope, vegetation cover, soil erodibility) and the dominant agents of erosion (rainfall intensity). Biophysical factors were derived from either one or a combination of the data sources described in Section C.1.2. All factors described below were scaled between values of 0 and 1, and multiplied to arrive at a comprehensive, qualitative vulnerability map with two classes for each of the three key land cover types (forest, pastures, and agriculture).

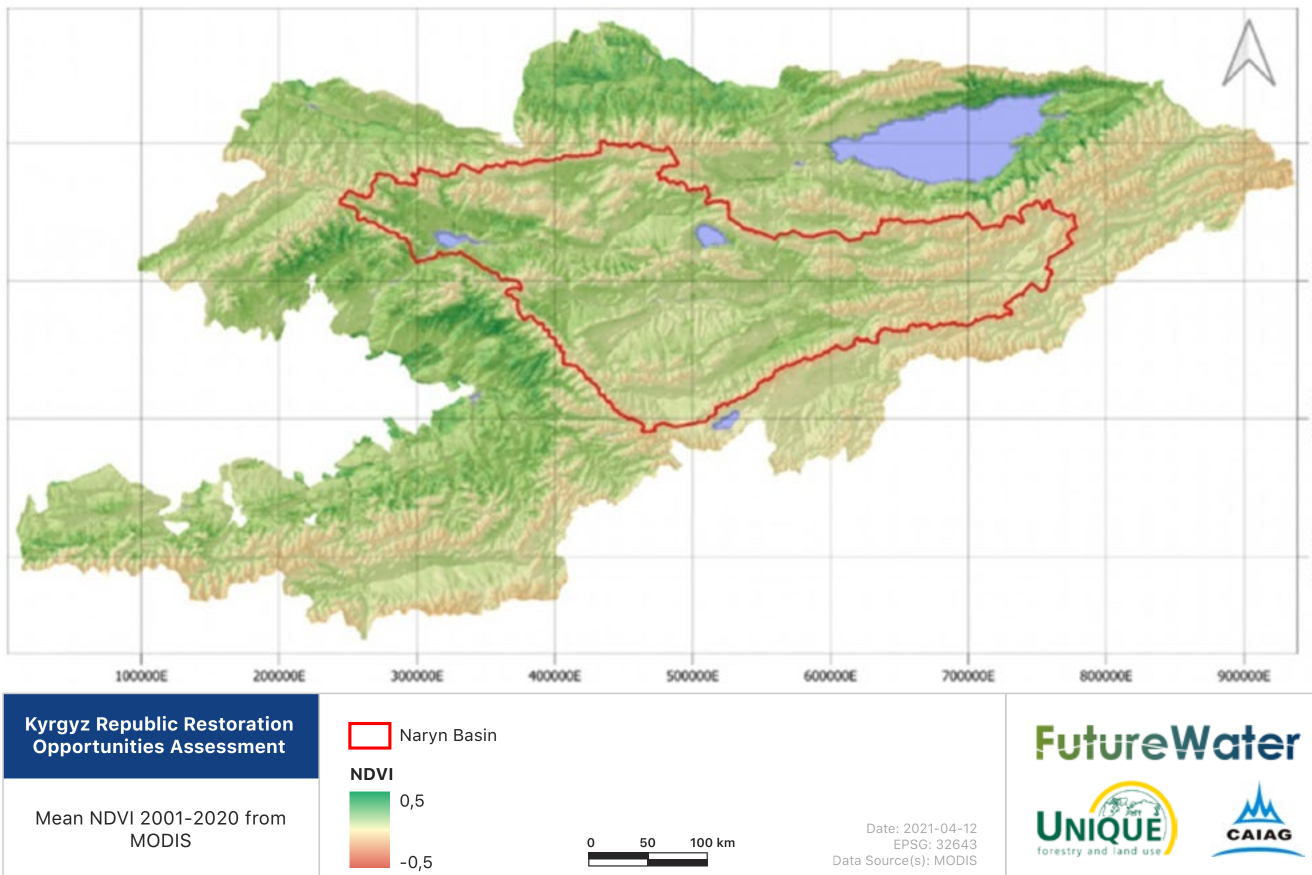
NDVI

NDVI is representative of the vegetative health and the extent of vegetative cover (see also Section C.1.2. Areas in which vegetative cover is limited or where vegetation is in poor state are more likely to be vulnerable to erosion due to the increased exposure of bare earth and decreased protection of underlying soil offered by healthy vegetation. Mean NDVI from the full

MODIS timeseries (2001-2020) was therefore calculated to determine the average distribution of vegetation across the Kyrgyz Republic.

Figure 22 shows the mean distribution of NDVI across the country. This shows higher NDVI values in Northern and Western areas, with lower values found along mountainous areas and in Eastern regions. In the Naryn River Basin area, lower values are found in the upper basin, with higher values around Toktogul Reservoir indicating good vegetative cover and health.

Figure 22: Average NDVI across the Kyrgyz Republic based on all available MODIS images, 2001–2020

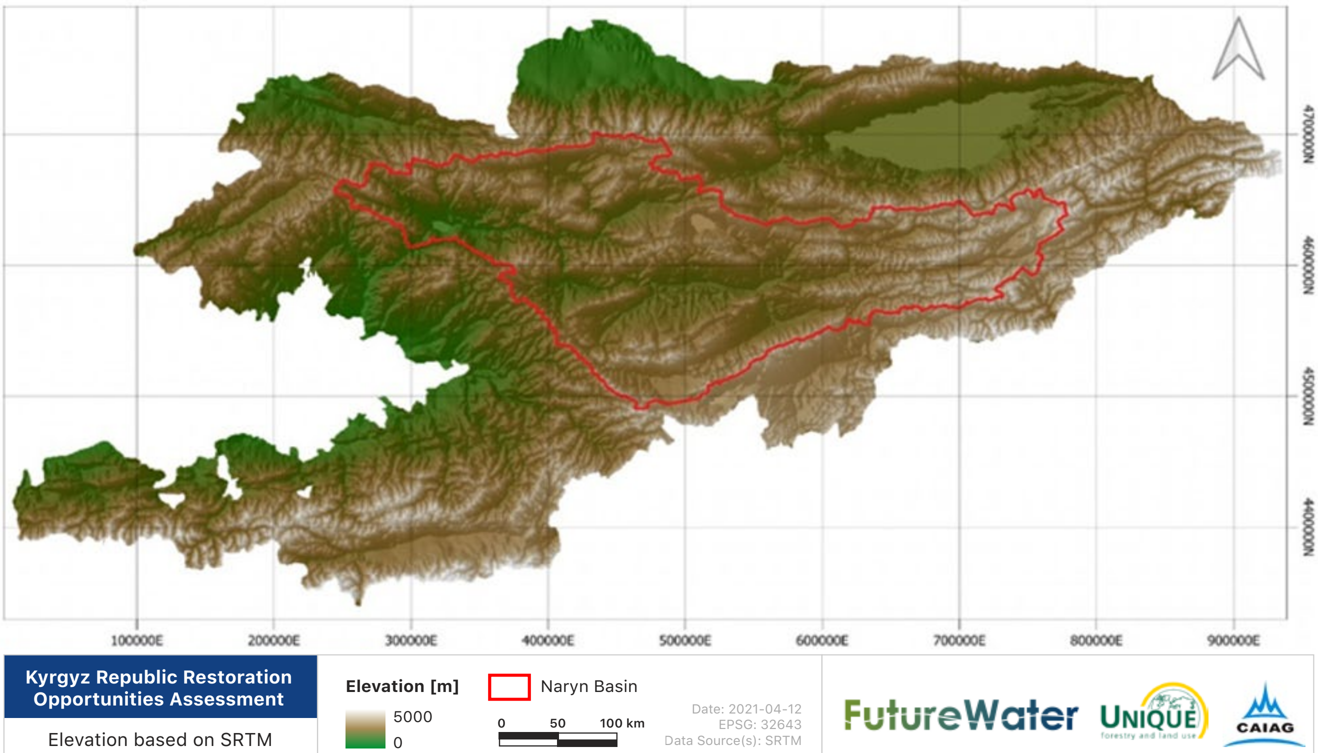


Source: original elaboration for this publication based on NDVI data from MODIS 2001 -2020

Slope

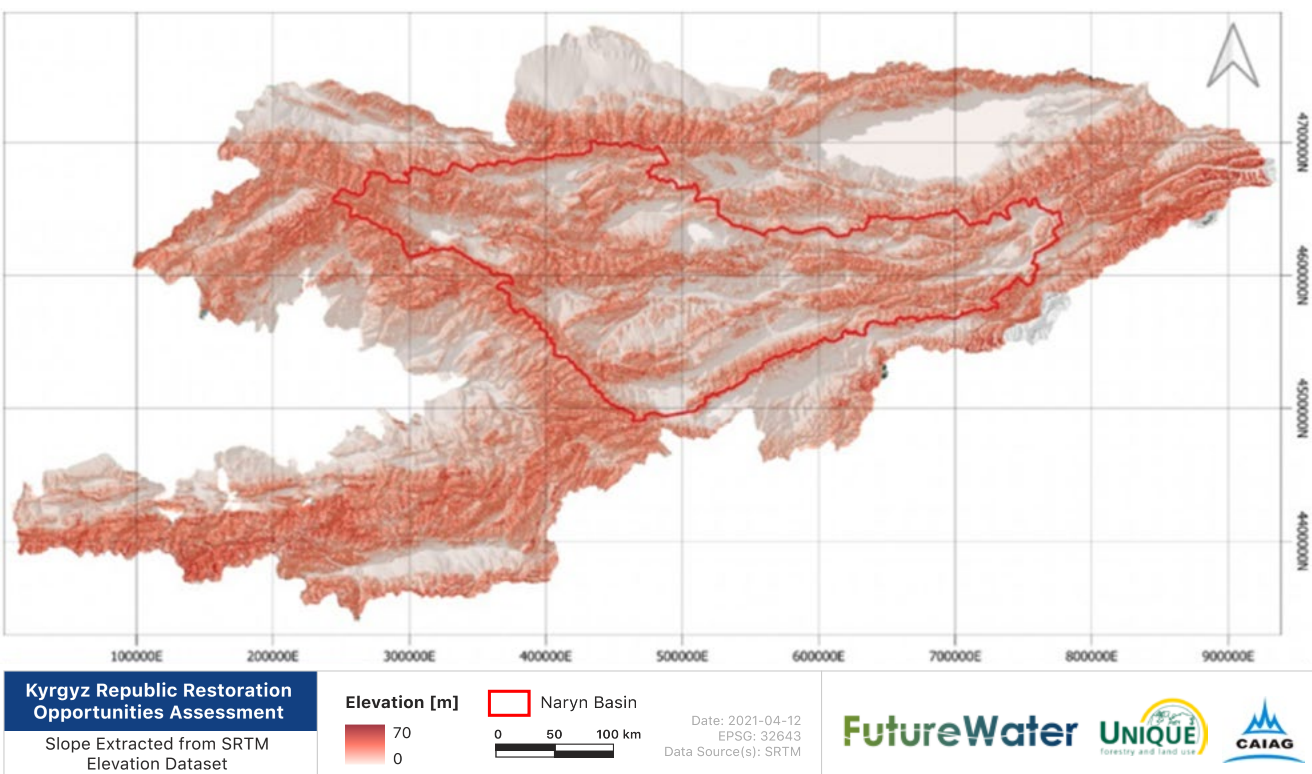
Slope is a key factor which influences vulnerability to erosion. Erosion on steeply sloping areas is likely to be much more pronounced due to increased probabilities of landslides and the accumulation of runoff in steeply sided gulley features. Slope was derived from the Shutter Radar Topography Mission (SRTM) elevation product using Google Earth Engine scripting. Figure 23 shows the SRTM map, clearly illustrating that the Kyrgyz Republic is a country with extreme relief, with mountain ranges covering the full area and elevations in the range of 100-5000m. Figure 24 shows the derived slope values for the whole of the Kyrgyz Republic.

Figure 23: Elevation map of the Kyrgyz Republic



Source: original elaboration for this publication based on SRTM data

Figure 24: Slope of land in the Kyrgyz Republic



Source: original elaboration for this publication based on SRTM data

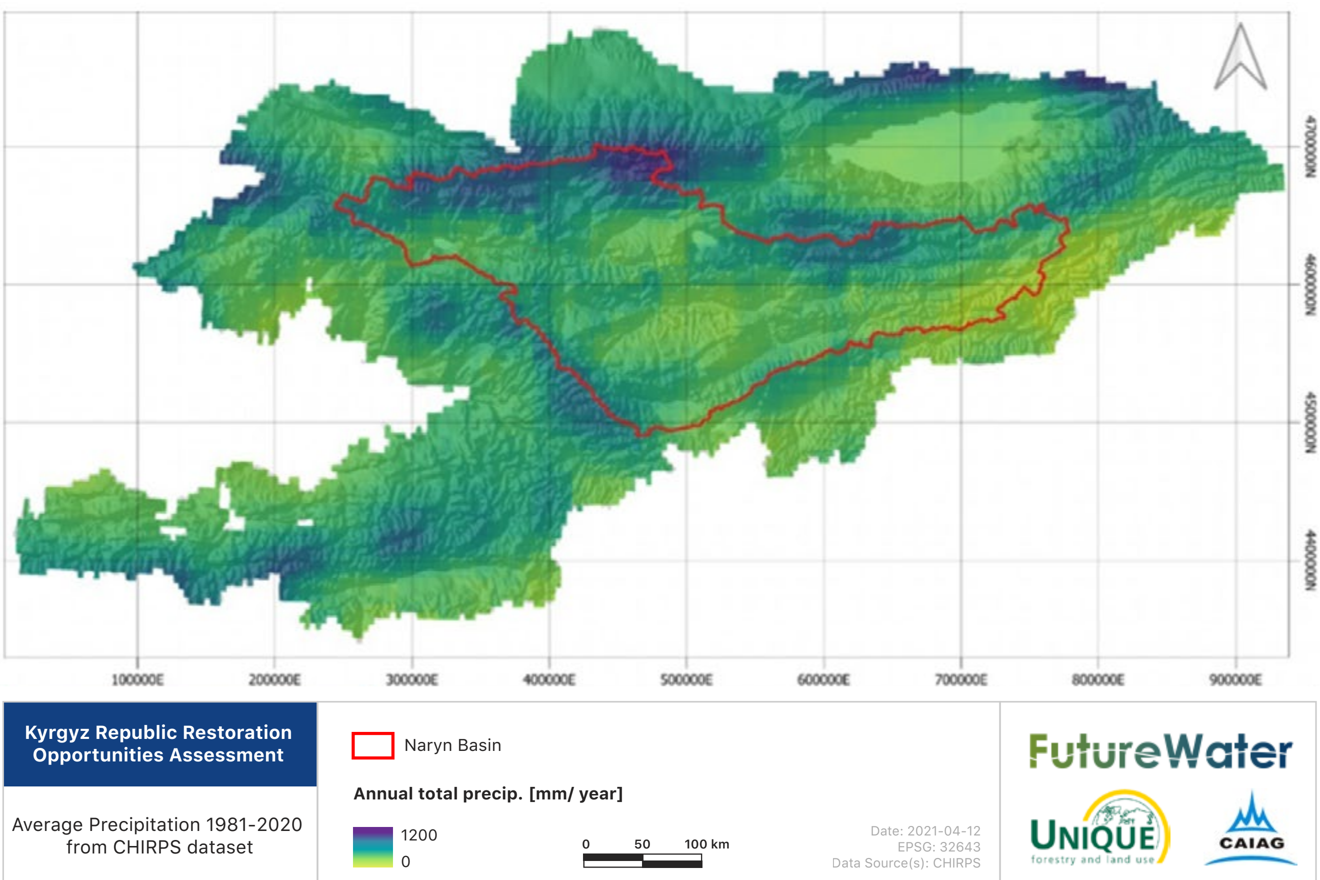
Rainfall intensity

Rainfall intensity is a key parameter which affects the erosion of sediments. In areas that experience high rainfall intensity, it is likely that erosion will be more problematic due to both raindrop erosion and the accumulation of precipitation and subsequent surface runoff leading to sheet, rill, and gulley erosion.

The precipitation range in the country is around 400-1200 mm/year, with the largest amount of precipitation falling over mountains and arid areas evident at lower elevations, especially in the Southeast (Figure 25). Rainfall intensity was calculated for the entire country from daily Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data using the Climate Data Operators (CDOs) open-source climate data tool. Precipitation intensity is calculated as the total amount of precipitation for the time-period divided by the number of days on which rain occurred (>1 mm/day).

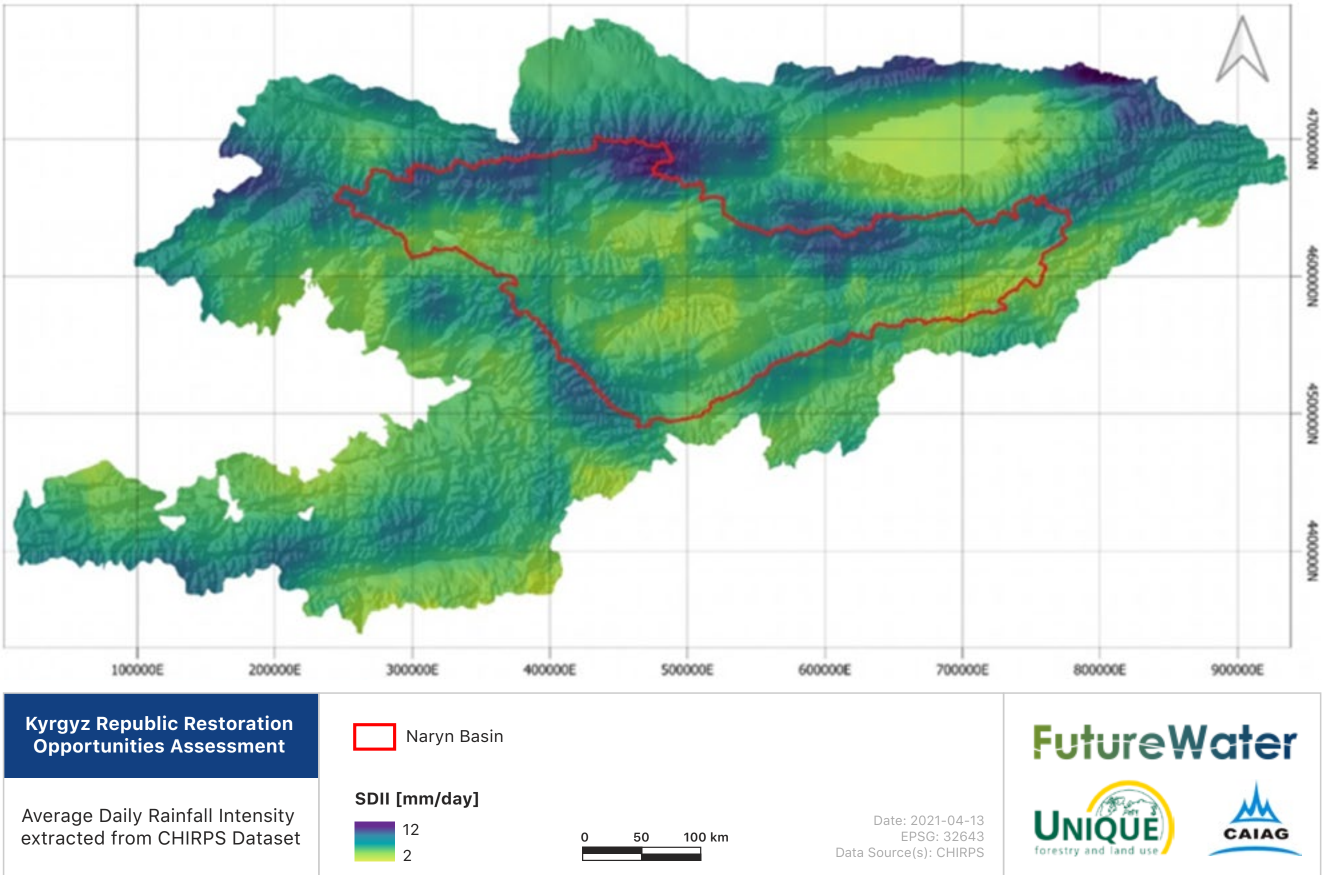
Figure 26 shows precipitation intensity for the Kyrgyz Republic based on data from 1981-2020. This shows that the highest precipitation intensity is, intuitively, associated with the high mountain areas. In the Naryn River Basin, this coincides with the high areas which make up the boundary of the basin.

Figure 25: Mean annual total precipitation, 1981-2020



Source: original elaboration for this publication based on CHIRPS global precipitation dataset 1981-2020

Figure 26: Simple precipitation intensity index (SDII), 1981–2020



Source: original elaboration for this publication based on CHIRPS global precipitation dataset 1981-2020

Soil erodibility

Soil erodibility (*K*) is the intrinsic susceptibility of a soil to erosion by runoff and raindrop impact. It is one of the key factors in the Universal Soil Loss Equation (USLE) and is therefore an important parameter to consider in the vulnerability mapping. Generic, empirical equations are available from literature, that are often applied in an analogous manner worldwide and commonly rely primarily on soil texture.

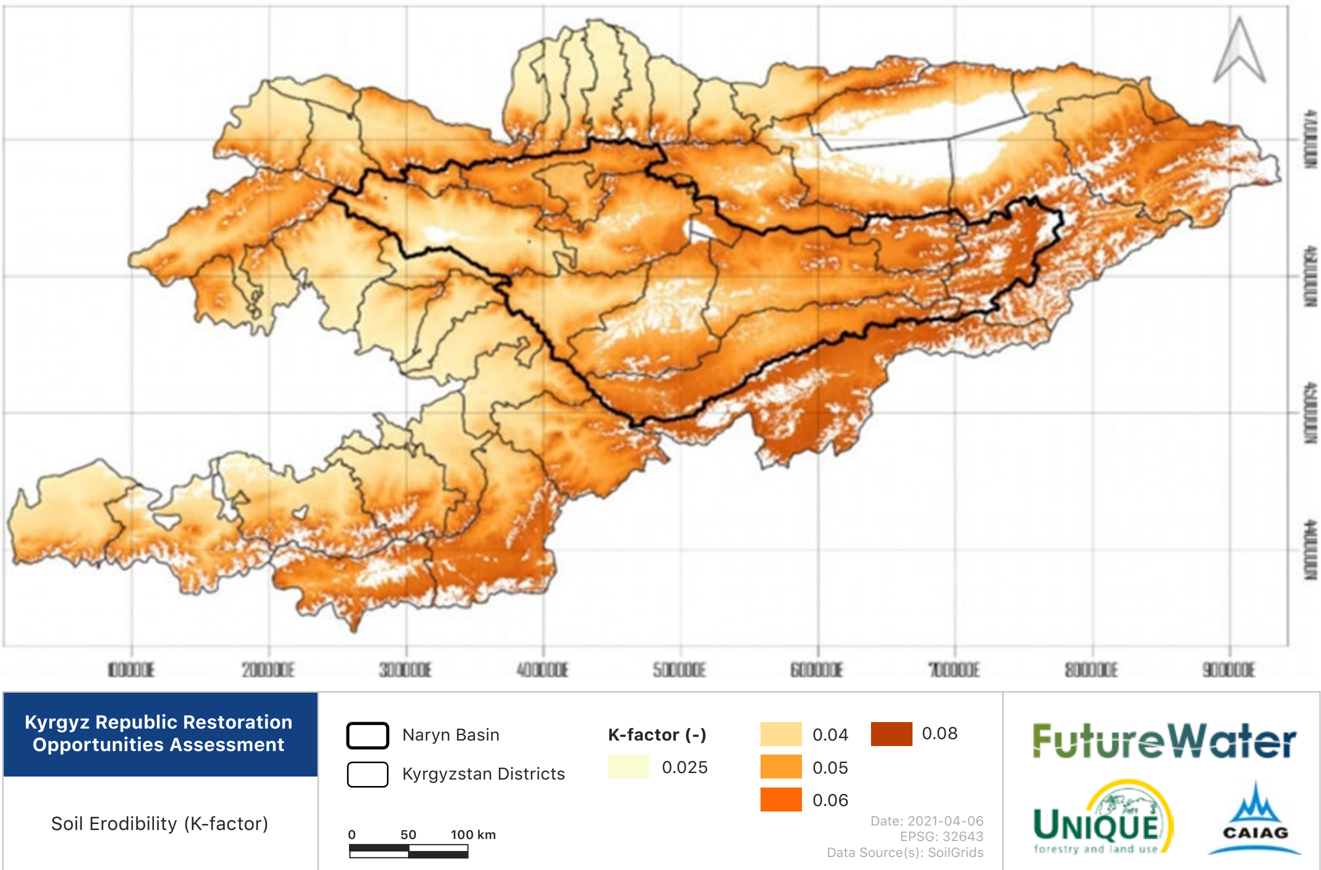
For the Kyrgyz Republic, a tailored method for soil erodibility estimates is available from Kulikov et al. (2020)we mapped soil erodibility at two sites, both representing grazing rangelands in the mountains of Kyrgyzstan and having potentially different levels of grazing pressure. We collected a total of 232 soil samples evenly distributed in geographical space and feature space. Then we analyzed the samples in laboratory for grain size distribution and calculated soil erodibility values from these data using the Revised Universal Soil Loss Equation (RUSLE. They integrated soil sample analyses with satellite remote sensing and GIS analyses to derive a multiple linear regression equation that succeeded in estimating *K* with satisfactory accuracy for southern Kyrgyz Republic. Their equation was adopted for this study:

$$K = 2.684 * 10^{-2} + 9.658 \times 10^{-6} \times CNBL - 2.46 \times 10^{-2} \times SER + 8.8 \times 10^{-4} \times \sin(A)$$

Where *CNBL* is the Channel Network Base Level, *SER* is a Soil Enhancement Ratio representing hydroxyls of clays, and *A* is the hillslope aspect.

CNBL was derived from the DEM using the SAGA-GIS package in QGIS. *SER* was derived from Landsat-8 satellite imagery as the normalized ratio between bands 6 and 7 (both in the shortwave-infrared domain), according to USDA (2017). A 2020 annual Landsat-8 composite was used for assessing *SER*. The resulting map of *K* for the Kyrgyz Republic is displayed in Figure 27.

Figure 27: USLE soil erodibility factor (*K*) in the Kyrgyz Republic



Source: original elaboration for this publication based on Landsat 8 data from 2020 and the SRTM Global Elevation dataset.

Connectivity related to sediment export

With an overarching objective of proposing effective landscape restoration options, it is important to not only consider status and trends locally but also the situation of a point in the overall catchment. Factors such as upslope and downslope land cover, slope gradient, size of the upstream area, and distance to a stream can be used to quantify an "index of connectivity" (*IC*). This *IC* reflects the likelihood of material eroded from a certain site reaching a stream sink, potentially contributing to siltation.

The Sediment Delivery module[27] of the InVEST model was applied to incorporate the connectivity dimension. This module calculates a so-called Sediment Delivery Ratio (*SDR*) for each pixel *i*,

[27] https://invest-userguide.readthedocs.io/en/latest/sdr.html

which is defined as:

$$SDR_i = SDR_{max} / (1 + \exp(IC_0 - IC^i / k))$$

where SDR_{max} is the maximum theoretical *SDR*, set to an average value of 0.8, and IC_0 and k are calibration parameters that define the shape of the *SDR-IC* relationship. The default InVEST values for these parameters are used in this study.

IC is a function of both the area upslope of each pixel (D_{up}) and the flow path between the pixel and the nearest stream (D_{dn}). It is calculated as follows:

$$IC = \log_{10} (D_{up} / D_{dn})$$

where D_{up} is the upslope component and D_{dn} is the downslope component. D_{up} is defined as:

$$Dup = \bar{C}\bar{S}\sqrt{A}$$

where C^{-} is the average USLE *C* factor of the upslope contributing area, S^{-} is the average slope gradient of the upslope contributing area (m/m) and *A* is the upslope contributing area (m^2).

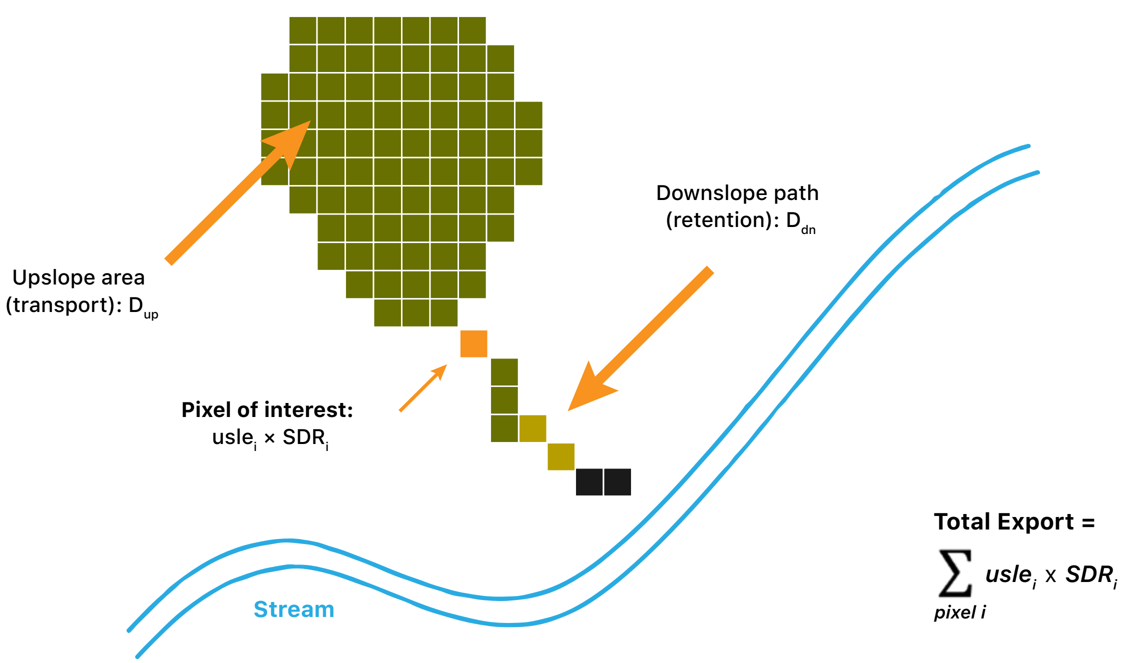
The downslope component of *IC* is defined as follows:

$$D_{dn} = \sum_i \frac{d_i}{C_i S_i}$$

where d_i is the length of the flow path along the *i*th cell according to the steepest downslope direction (m), C_i and S_i are the C factor and the slope gradient of the *i*th cell, respectively.

The methodology described above is illustrated by Figure 28. It was applied for the Naryn River Basin.

Figure 28: Sediment delivery ratio (SDR) Conceptual Approach

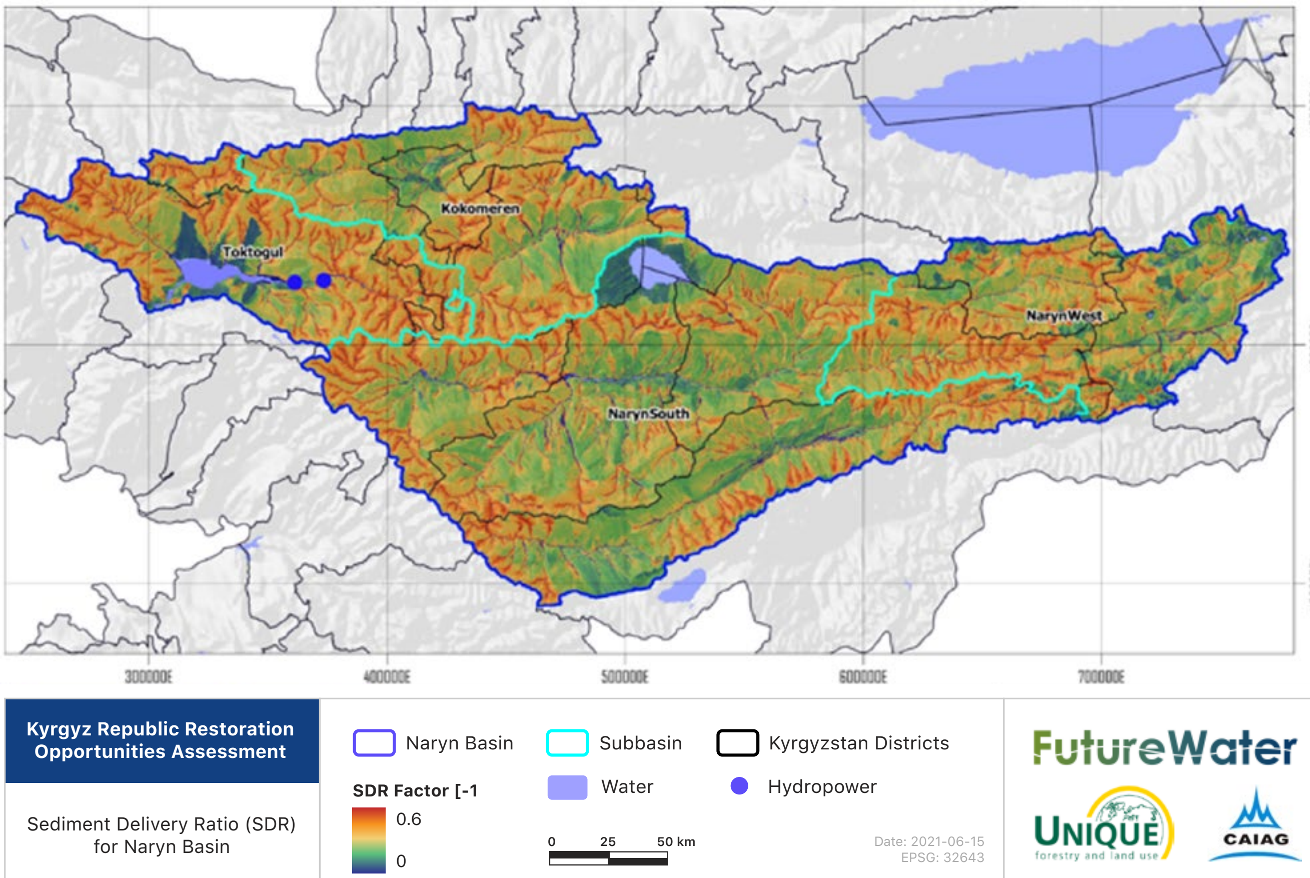


Source: InVEST user manual
Note: The *SDR* for each pixel is a function of the upslope area and downslope flow path. Figure adapted from the InVEST user manual.

As the SDR is already a unitless ratio between 0 and 1, no further scaling needs to be applied for integration in the next mapping steps.

Figure 29 shows the Sediment Delivery Ratio (SDR) value across Naryn River Basin, as calculated using the InVEST model with the methodology explained in Appendix C.1.4. It is a useful measure of connectivity, with red areas on the map highlighting the sites that are most strongly connected to the hydrological network given their upslope and downslope conditions. This means that any soil material eroded from these locations is more likely to end up in a downstream river, lake, or reservoir.

Figure 29: Sediment delivery ratio in the Naryn River Basin



Source: original elaboration for this publication

Mapping overall land degradation and sediment sourcing hotspots

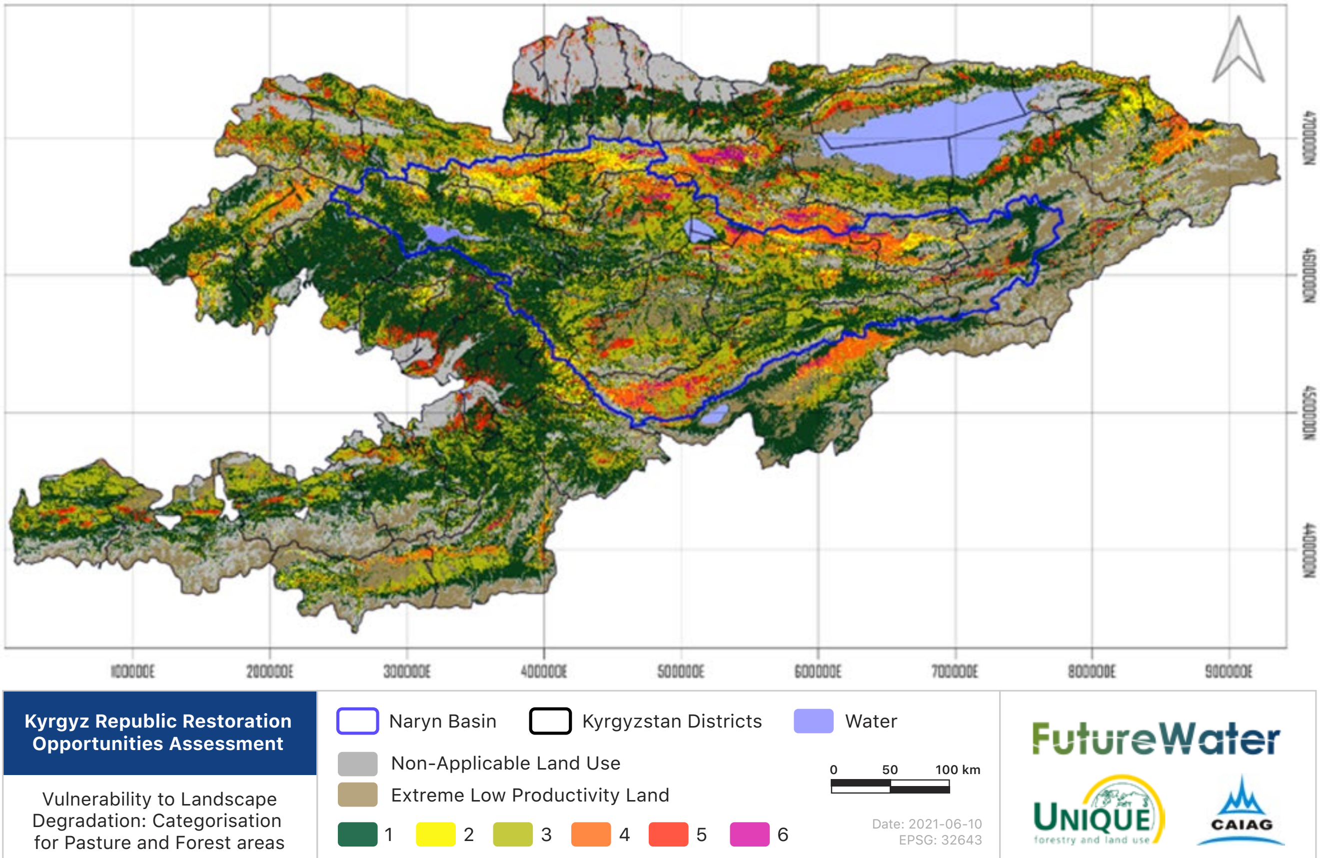
The previous three sections described the methods associated with producing maps A, B, and C shown in the baseline report. As shown, the two final outputs of the identification of hotspots of land degradation and sediment sourcing are a map of overall land degradation, and a map of sediment sourcing hotspots.

Overall land degradation assessment (A x B)

This map integrates the baseline land degradation (A) and vulnerability to soil erosion (B) maps Figure 30).

Focusing on Naryn River Basin, areas of interest in terms of major land degradation and/or vulnerability to soil erosion are western At-Bashy district, the southern section of Panfilov district (Kokomeren watershed), parts of Jumgal district, and a large stretch of land east of Son Kol Lake in Naryn and Kochkor districts. These are areas which could be explored for follow-up analyses and identification of restoration options.

Figure 30: Overall land degradation with six qualitative classes



Source: original elaboration for this publication

Note: legend categories are 1) No Degradation, Minor Vulnerability, 2) No Degradation, Major Vulnerability, 3) Minor Degradation, Minor Vulnerability, 4) Minor Degradation, Major Vulnerability, 5) Major Degradation, Minor Vulnerability, and 6) Major Degradation, Major Vulnerability.

Table 36: Overall land degradation statistics for each subbasin*

Class number	Naryn Basin		Naryn Basin South		Naryn Basin East		Toktogul Watershed		Kokomeren Watershed	
	ha	%	ha	%	ha	%	ha	%	ha	%
1	1,314,039	26	53,6255	23	251,116	24	368,281	44	157,722	17
2	161,725	3	35,869	2	28,481	3	23,801	3	73,547	8
3	397,237	8	284,540	12	15,280	1	29,559	4	67,859	7
4	152,679	3	67,132	3	38,207	4	3,996	0	43,274	5
5	43,610	1	25,281	1	7,860	1	545	0	9,924	1
6	20,941	0	9,255	0	5,217	1	197	0	6,264	1
Total	**2,090,231**		**958,332**		**346,161**		**426,379**		**358,590**	

Source: original elaboration for this publication
Note: percentage total not equal to 100 due to non-applicable areas in region

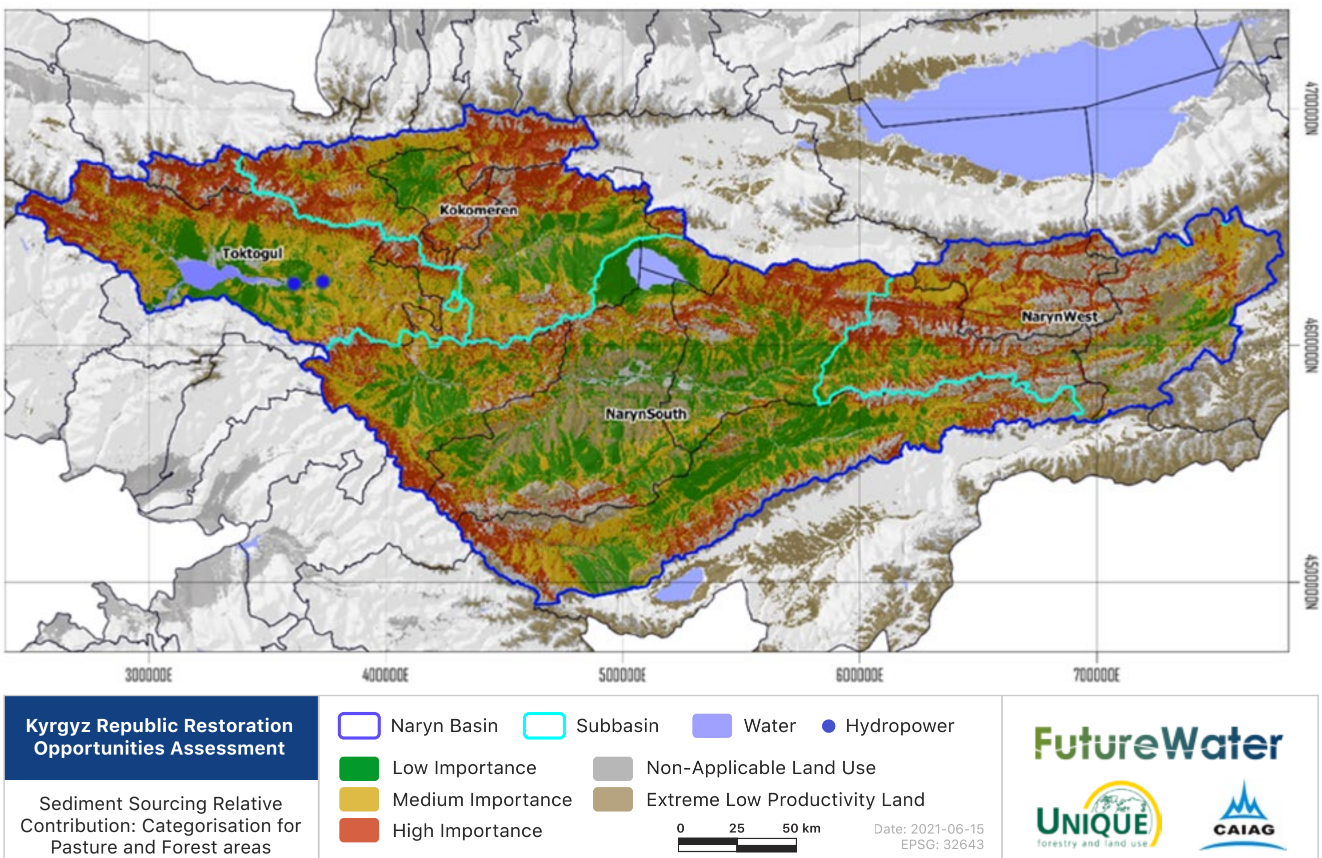
* See Figure 33 for an explanation of class numbers.

Sediment sourcing hotspots (B x C)

This map integrates the baseline land degradation (A) and sediment connectivity (C) maps. It is delivered for Naryn River Basin only and should be evaluated in relation to the location of downstream assets that are potentially vulnerable, such as hydropower projects. Although Toktogul Reservoir is known to not be prone to siltation over the next decades, this is not the case for other hydropower projects in the area.

Red areas, indicating high land degradation, are especially located in Kokomeren watershed, east of Son Kol, and Upper Naryn River Basin. This confirms the potential risk for the hydropower projects that have been proposed for this area, including in Kokomeren 1 and 2, which could suffer significant siltation hazards. Upslope areas in Toktogul watershed are also identified as potentially relevant sources of sediment, while the areas immediately around the reservoir indicate that land degradation over the past 20 years remain stable here. The map also shows the sites of Kambarata-1 (under construction) and Kambarata-2 (operational since 2010) hydropower projects in blue (Figure 31). These are surrounded by sites of medium land degradation activity. While there are no obvious direct sediment sourcing areas immediately near these sites, sediments from degradation occurring further upstream is expected to impact Kambarata 1 and 2 HPPs’ storage and operation.

Figure 31: Sediment source areas with three qualitative classes for the Naryn River Basin



Source: original elaboration for this publication

Reservoir sedimentation

The Toktogul hydropower dam was built in 1975 on the Naryn River in Jalal-Abad Province. This hydropower dam is the largest in the country. It is of high economic importance as it provides around 40% of national power production. The Toktogul Reservoir has a full storage capacity of 19.5 km^{3}, of which 14 km^{3} is active storage. This section synthesizes several previous studies to investigate the extent to which upstream land degradation processes may contribute to sedimentation of the reservoir.

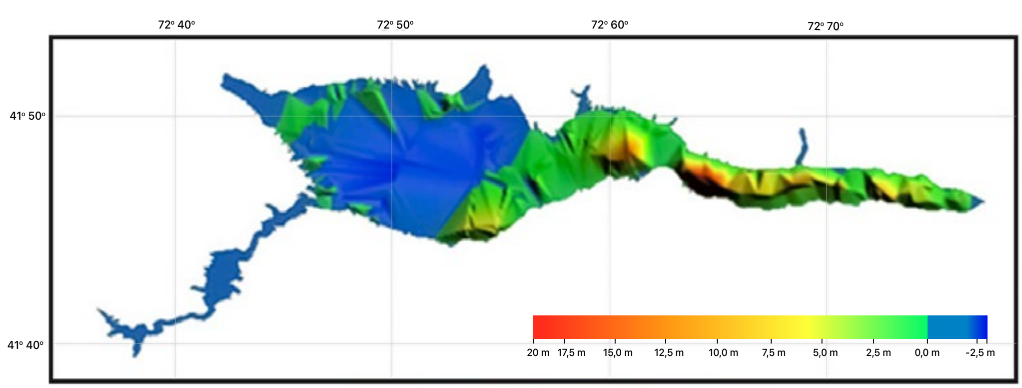
Toktogul Reservoir accumulates all suspended sediments that the Naryn River transports across its entire basin starting from the headwaters. Sediments are not removed from the reservoir since they are deposited at the bottom of the water area of the reservoir and do not reach the dam. The dam is almost 62 km from the inflow point of the Naryn River. The western part of the reservoir for 18 km is a narrow canyon, up to 200 m wide in places, branching off from the main thicket of the reservoir, which hinders the transfer of sediments by currents from it towards the dam. The main sediment deposition occurs in the narrow (1 - 2.5 km) eastern part of the Toktogul Reservoir, about 20 km long, where the Naryn River flows into it.

The above was concluded from sediment concentration measurements suspended in the water of the Naryn River (data from Kyrgyzhydromet) at the Uch-Terek gauging station. The Uch-Terek station has been operating since 1963 and is in the eastern part of the Toktogul depression. In 1974-2009, the average annual volume of suspended and entrained load in the Naryn River varied from 8 million m3 to 12 million m^{3} per year. In 2017-18 during high-water years, the volume was more than 15 million m^{3} per year[28]. Thus, over 35 years from the beginning of filling the reservoir in 1974, the volume of sediment supplied to it is estimated between 280 and 420 million m^{3}.

Studies were carried out in 2008-2009 based on geodetic measurements in the drained part of the reservoir and bathymetric surveys in its water area (CAIAG, 2016). Siltation of the reservoir during 1974-2009 was estimated at 0.38 billion m^{3} of sediment in the zone of active storage, and 0.14 billion m^{3} in the dead storage (CAIAG, 2016). This amounts to 0.52 billion m^{3} with a total siltation area of 145 km^{2}. As this equals a percentage of 4.5% of the total reservoir, it can be concluded that Toktogul Reservoir is not at risk of filling up over the next decades. This conclusion is well-aligned with similar statements made by ADB (2013).

The distribution of sediments over the water area of the Toktogul Reservoir, determined by the geodetic method, is shown in Figure 32. The bulk of sediments is deposited in the eastern part of the reservoir.

Figure 32: Differences in the absolute heights of the reservoir bottom, 1960-2008

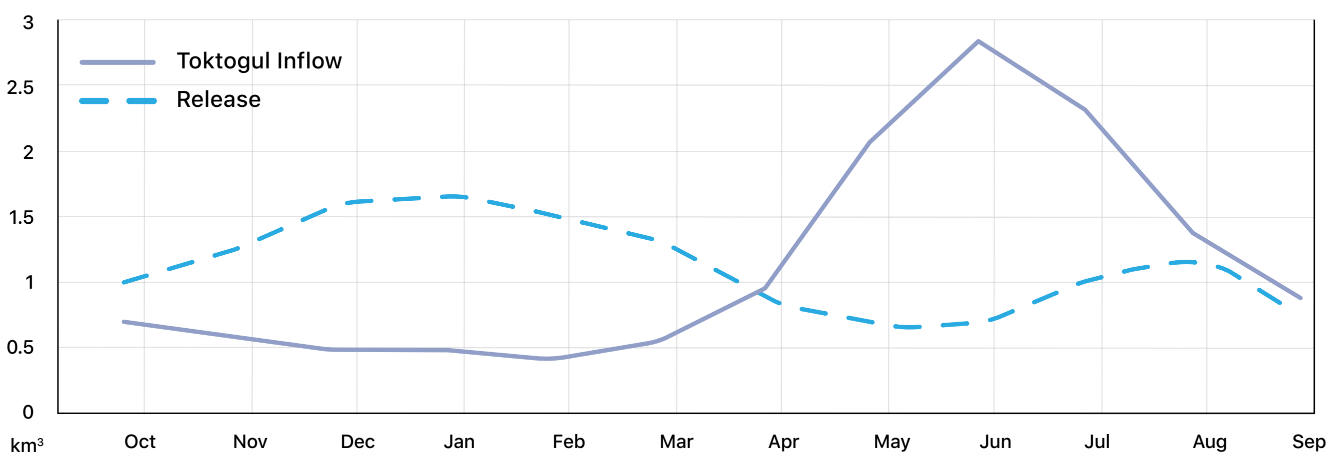


Source: B.D. Moldobekov., Sh.E.Usupaev., A.V.Zubovich., A.N.Mandychev., R.A. Usubaliev., L.Joldybaeva., Z.A. Kalmetieva., A.Shabunin., Y. Podrezova.,O. Kalashnikova.,and etc."Remote and ground earth exploration in Central Asia." CAIAG, Bishkek.: Publishing house "City Print", 2016. 206 p.

28 Study of the process of sediment deposition in the reservoirs of the Uchkurgan, Toktogul and Kambarata HPPs. Mukanov T.A. http://www.cawater-info.net/syrdarya-knowledge-base/papers/mukanov.pdf

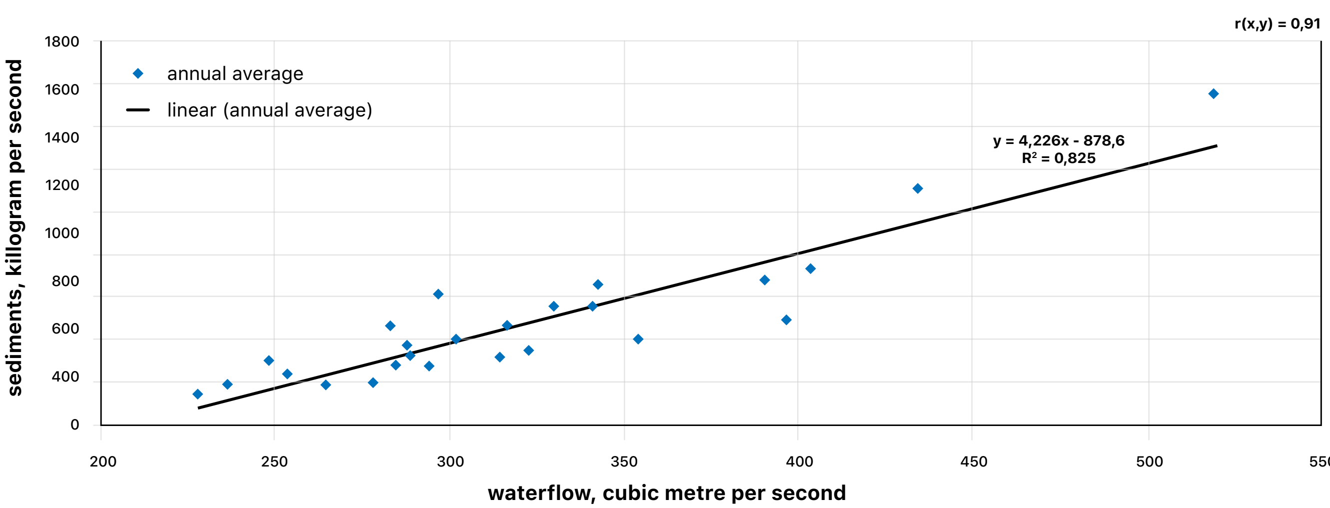
Figure 33 shows the average monthly flow at Uch Terek on Naryn River, which makes up >85% of total reservoir inflow, as well as the outflow of Toktogul Reservoir. It has been determined that the major portion of sediment inflow (88%) of the Naryn River enters the Toktogul Reservoir during the 5 months with the highest streamflow (May - September), which accounts for 70% of the annual discharge. The correlation between sediment fluxes and Naryn River runoff is shown in Figure 34. The correlation coefficient between liquid and sediment fluxes is 0.91, both for average annual values and for five-month periods of the year (May-September).

Figure 33: Average monthly inflow and outflow (release) of Toktogul Reservoir, 2000–2010



Source: Hunink et al., 2014

Figure 34: Correlation between sediment flows and river discharge at Uch-Terek post, average annual values, 1964-1992



Source: B.D. Moldobekov., Sh.E.Usupaev., A.V.Zubovich., A.N.Mandychev., R.A. Usubaliev., L.Joldybaeva., Z.A. Kalmetieva., A.Shabunin., Y. Podrezova.,O. Kalashnikova.,and etc. “Remote and ground earth exploration in Central Asia.” CAIAG, Bishkek.: Publishing house “City Print”, 2016. 206 p.

Measurements of Kyrgyzhydromet from 1963-1974 showed that the maximum suspended sediment runoff in Toktogul Watershed is 12 g/s/km^2. Accordingly, 2.1 million tons of sediments, or 1.06 million m^3, if the sediment's density is taken equal to 2t/m^3, comes to the reservoir from the entire basin area per year. It should be noted that the calculated value of the sediment inflow from Toktogul Watershed of 378 t/yr/km^2 (3.8t/yr/ha; 1.9 m^3/yr/ha at a density of 2t/m^3) is consistent with the amount of sediment inflow per year with the rest the area of the Naryn River Basin (52,000 km^2). In general, Naryn River's annual contribution of sediments to the Toktogul Reservoir is an order of magnitude higher than the smaller water courses entering the reservoir. Despite the lack of more recent measurements of suspended sediments, it is very unlikely that the amount of sediment inflow from Toktogul watershed has increased to such an extent that it comes close to total sediment yield from the upstream of the Naryn River Basin.

Although Toktogul Reservoir itself may not be at risk of siltation, there are other hydropower projects located further upstream in the watershed that are more likely to be subject to a sedimentation hazard. This is expected to be the case for Kambarata 1 (currently under construction) and Kambarata 2 (operational), Kokomeren 1 and 2 (under construction), and At-Bashy HPP (operational). In one calculation scenario, the latter is expected to not be able to operate properly because of sediments after a period of nine years (UNDP, 2016). However, the unavailability of data did not make it possible to make a thorough assessment for these reservoirs, nor of other reservoirs in the country affected by sedimentation.

Annex 7. Climate change screening

Climate risk screening of Naryn River Basin

Summary of trends

A summary of the projected trends in climate resulting from the analysis in this section is as follows:

- Historical data on temperature shows that temperatures have increased in the period 1979-2019 by around 0.8°C in 40 years (about 0.2°C/decade). The study area experiences large variations in temperature, with average daily temperatures ranging from around -20 to 18°C over the course of the year.
- For precipitation: an increasing trend in total annual rainfall is evident for the historic period, but with high variability around this trend. Most rainfall occurs in the months April – September, with the rest of the year experiencing drier conditions.
- For the 2030 horizon, temperatures are likely to go up by around 1.5°C, compared to the historic reference period (year 2000). For the 2060 horizon, this is around 3°C.
- For mean annual precipitation, the climate models suggest an increase in precipitation into the future, with high consensus among models. The predicted magnitude of change, however, varies among models.
- For rainfall extremes, analysis shows that the intensity of rainfall on average, and the magnitude of extreme precipitation events will increase into the future.

Methodology

Overall, the Climate Risk Screening is made up of the following approaches:

1. Analysis of historic climate events
2. Projections of future climates

Analysis of historic climate events

The applied methodology starts at analyzing historic observations of climate related events and to perform a trend analysis. Obviously, trends, or the absence of trends, do not imply that future changes will follow those historic trends. Any statistical trend analysis should be accompanied by understanding the underlying physical processes. Analysis of historic climate events should go beyond looking at weather parameters (e.g., temperature and wind) only, but should include parameters that might have been influenced by historic weather conditions. Given the needs of this specific study, the following parameters were analyzed:

- Precipitation and temperature
- Tropical storm frequency and storm surge risk
- Flooding
- Droughts and water shortages
- Land cover changes

The ERA5 reanalysis product[29] is used to represent historical trends in temperature and precipitation for the given area of interest. This product is used as it provides global, spatially gridded time series of climate variables at resolutions of 31 km and sub-daily (3hr) timescales. The dataset is fully operational (updated every month) and has been running from 1979 to the present. From

[29] https://www.nasa.gov/nex/data

this dataset, spatially averaged time series of precipitation and temperature are extracted for the study area at daily, weekly, and yearly timescales for the entire period that the dataset covers. This allows for the analysis of annual and seasonal trends in historical climate alongside extremes.

Projections of future climates

Projections of future climates are provided by Global Circulation Models (GCMs). The IPCC (Intergovernmental Panel on Climate Change) is the credible body on climate change projections. An important source for climate projections are the results from the CMIP 5 activities. CMIP5 is the Coupled Model Intercomparison Project Phase 5 that led to a standardised set of model simulations. Since downscaling and local adjustment of GCMs are needed, NASA has developed the so-called NEX-GDDP projections (NASA Earth Exchange Global Daily Downscaled Projections). The dataset is provided to assist in conducting studies of climate change impacts at local to regional scales, and to enhance public understanding of probable future global climate patterns at the spatial scale of individual towns, cities, and watersheds.

The NASA-NEX-GDDP exist out of 21 GCM outputs for two Representative Concentration Pathway (RCPs) (4.5 and 8.5) for a historic period and for the future up to 2100. For this climate risk screening, the data were used for two purposes: analysing changes in the average climatology and changes in climatic extremes. Two RCP scenarios were analyzed to give a range of future predictions. RCP 4.5 represents a "stabilization scenario" in which greenhouse gas emissions peak around 2040 and are then reduced. RCP 8.5, in contrast, represents a worst-case scenario, in which emissions continue unabated throughout the century. These scenarios are selected as they represent a good envelope of changes in climate and hence cover a wide range of future changes in temperature and precipitation relating to project implementation.

Alongside the two RCP scenarios, projections were evaluated at the following time horizons:

- Reference (historical) period [1990]: 1976–2005
- Near future [2030]: 2016–2045
- Distant future [2060]: 2046–2075

Climate Extremes Indices

To determine future trends in extreme climate events, CLIMDEX[30] variables were used. These represent a standardized, peer reviewed way of representing extremes in climate data and are widely used in climate analyses. These are produced through processing the NASA-NEX dataset with CDO software. This takes as input spatially gridded daily time series and returns yearly series of CLIMDEX indices. This process is useful as it effectively reduces the amount of data analysis needed whilst retaining the ability to represent extremes within data in a comparable way. For this study's purposes, the indices described in Table 37 are considered most relevant out of the 27 available.

Table 37: CLIMDEX precipitation indices used in the study

Index name	Description	Unit
SDII	Simple precipitation intensity index: sum of precipitation in wet days during the year divided by the number of wet days in the year	mm
Rx1day	Annual maximum 1-day precipitation	mm
CDD	Annual maximum consecutive dry days: annual maximum length of dry spells, sequences of days where daily precipitation is less than 1mm per day.	days
TXx	Annual maximum of daily maximum temperature	Celsius

Source: original elaboration for this publication

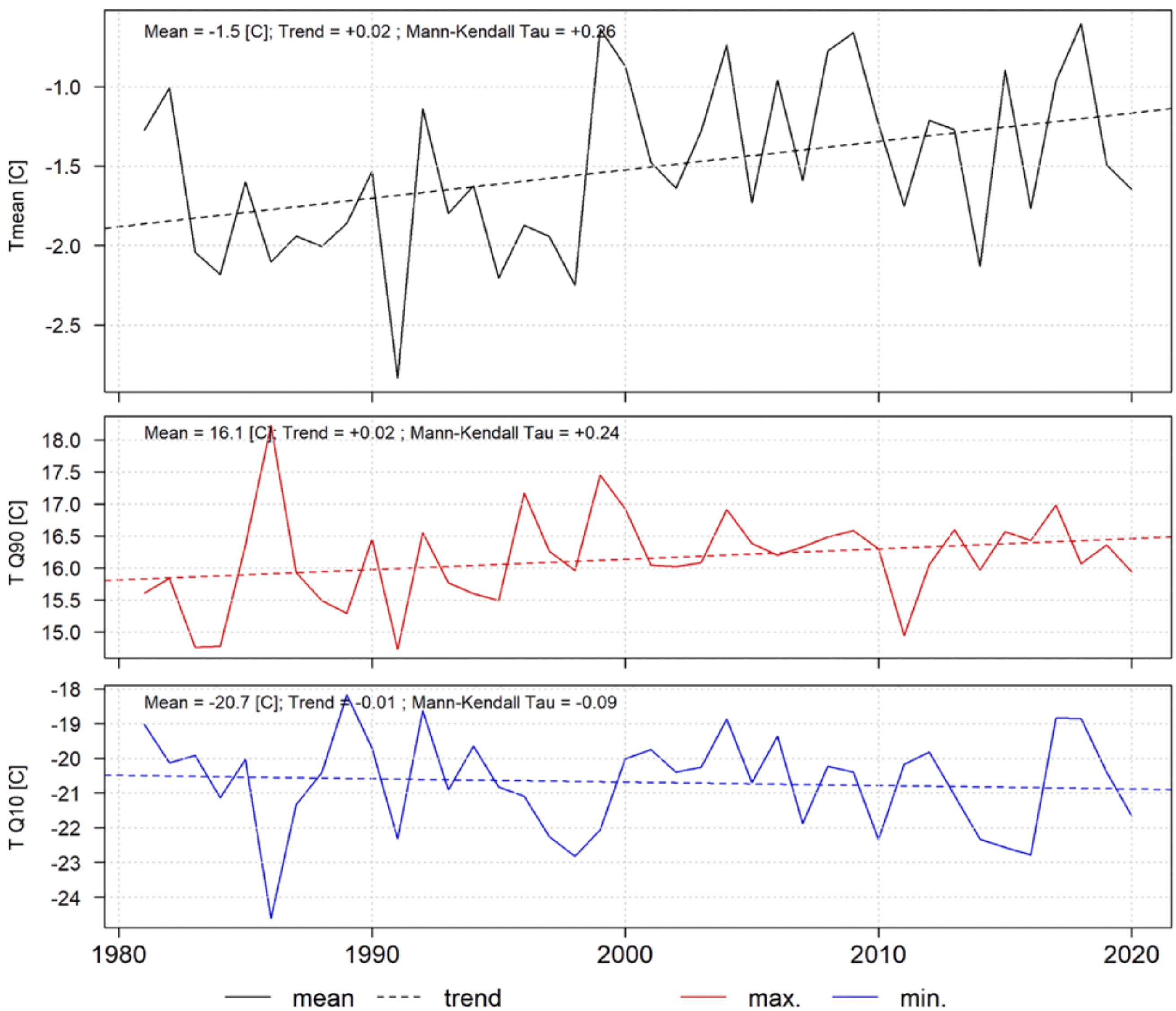
30 https://www.climdex.org/learn/

Results

Temperature trends

Historical data on temperature shows that average annual temperatures are around -1ºC for the study area. Temperature is variable throughout the year, with highest average monthly temperatures (around 18ºC) occurring during May – September (Figure 35). Analysis of temperature data shows that temperatures have increased in the period 1979-2019 (up to 0.8ºC in 40 years, see Figure 36). This trend is extracted from the yearly average temperature time series and has medium statistical significance.

Figure 35: Average annual maximum and minimum daily temperatures, ERA-5 dataset with trendline

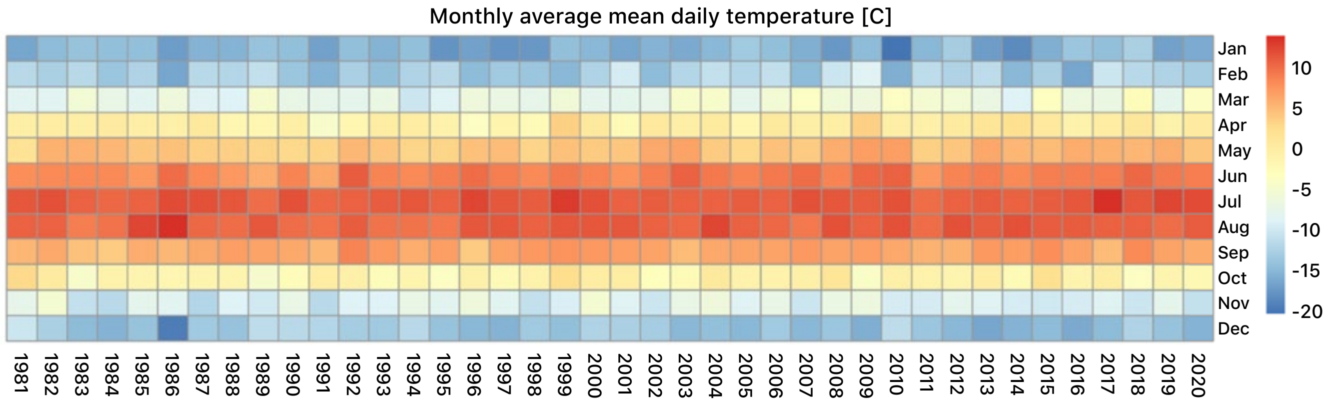


Source: ERA-5[31]

Note: Mann Kendall Tau value indicates the strength of the monotonic trend of increase or decrease in a time series, with a value of 1 indicating a strong significant trend and -1 indicating no trend.

[31] ERA-5 is the fifth-generation atmospheric reanalysis of the global climate covering the period from January 1950 to present, provided by the European Centre for Medium-Range Weather Forecasts (ECMWF). ERA5 is produced by the Copernicus Climate Change Service (C3S) at ECMWF. ERA5 provides hourly estimates of a large number of atmospheric, land and oceanic climate variables. provides hourly estimates of a large number of atmospheric, land and oceanic climate variables. https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5

Figure 36: Seasonality in temperature, ERA-5 dataset

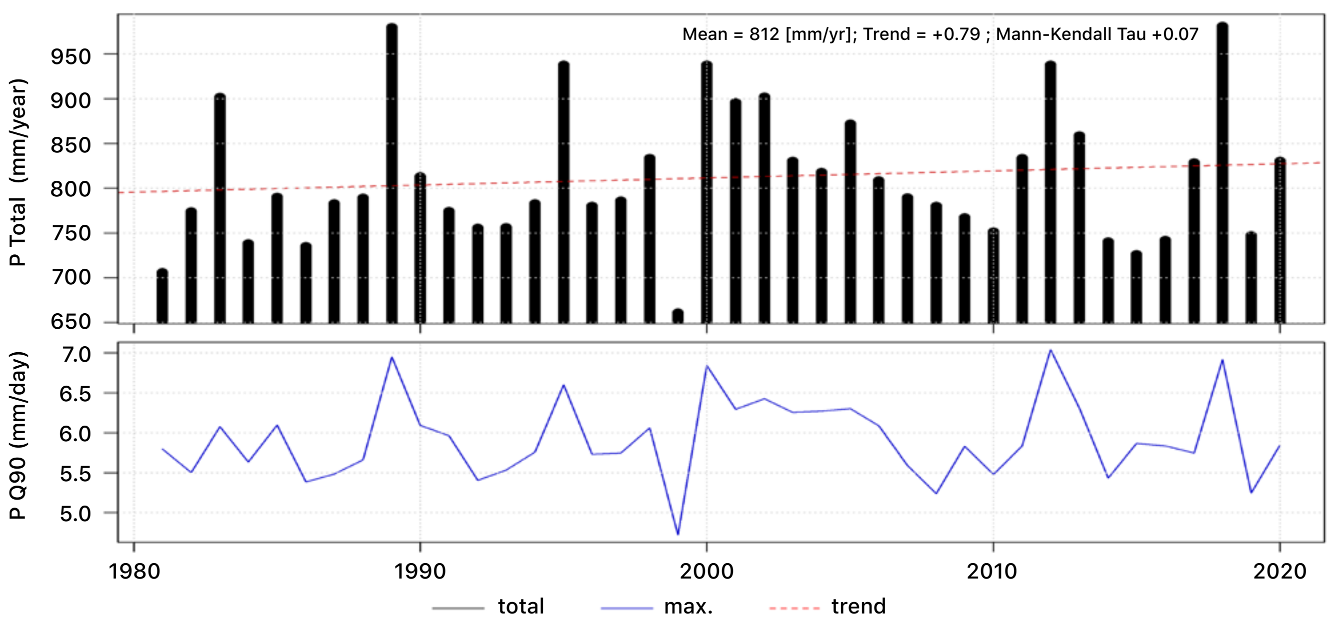


Source: ERA-5

Precipitation trends

Historical data on precipitation shows that average total annual precipitation is around 800 mm on average for the study area (Figure 37). A trend of increasing total annual rainfall is evident for this period, but with lots of variability around this and low statistical significance attached to the trend. Most of this rainfall occurs in the months April – September, with dry conditions prevailing in October – March (Figure 38).

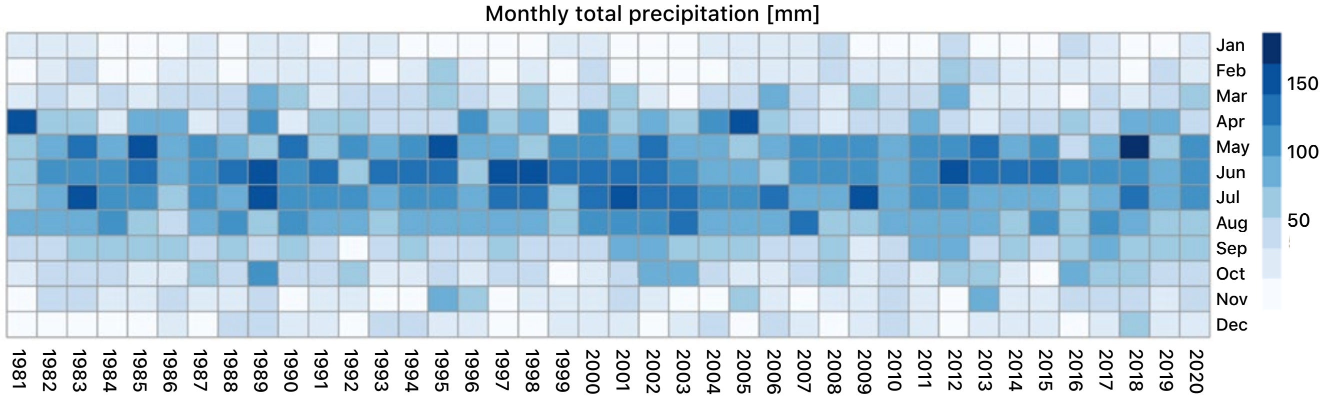
Figure 37. Total yearly and maximum one-day precipitation, ERA-5 dataset with trendline



Source: ERA-5

Note: Mann Kendall Tau value indicates the strength of the monotonic trend of increase or decrease in a time series, with a value of 1 indicating a strong significant trend and -1 indicating no trend.

Figure 38: Seasonality of precipitation, ERA-5 database



Source: ERA-5

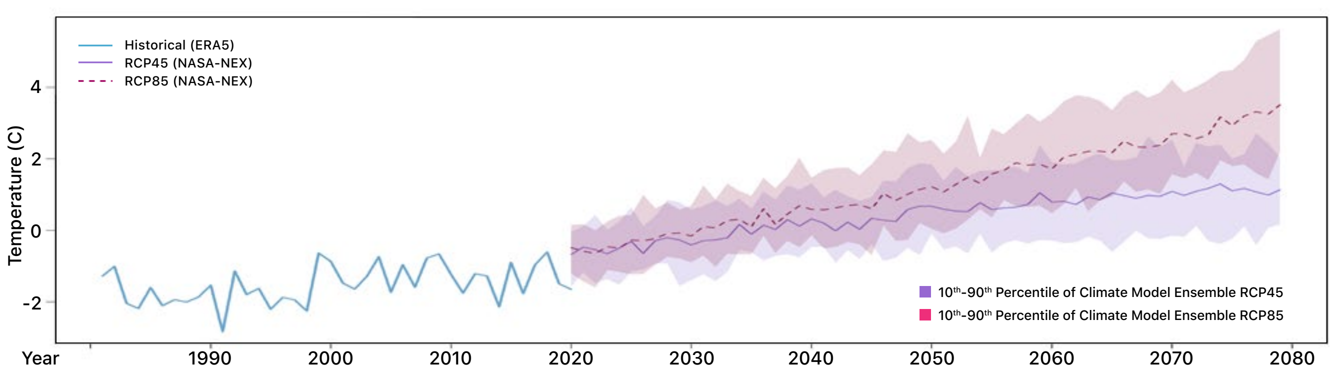
Projections of Future Climate

Average trends in temperature and precipitation

In terms of average climate trends, the climate model ensemble predicts an increase in mean temperature in the upcoming 60 years (Figure 39). It is also clear that under the higher RCP scenario, a larger increase in temperature is expected. For the short-term horizon 2015-2045, changes in temperature in the range of around 0.5-2°C are predicted by the climate model ensemble, for the longer-term horizon 2045-2075, this increases to around 1.5-5°C, with a larger spread in model predictions (Figure 40 and Figure 41).

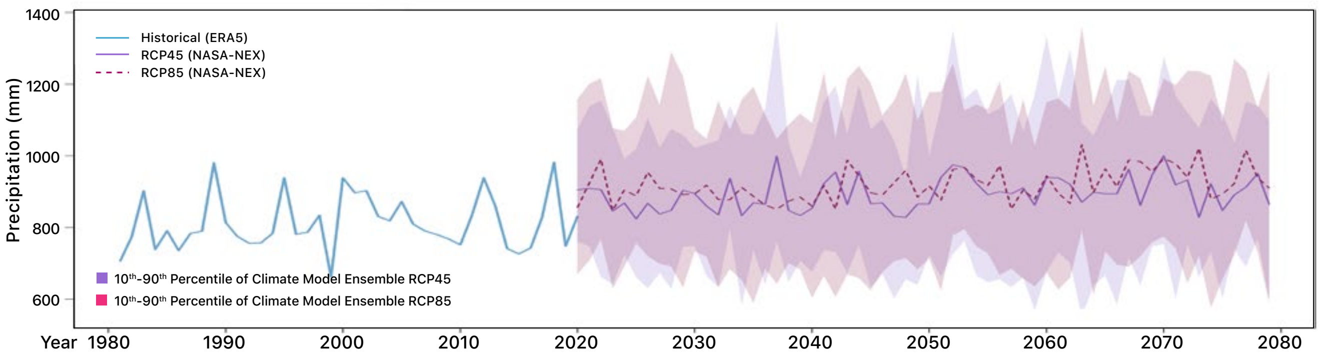
The picture in terms of precipitation is less clear. On average, the model ensemble predicts an increase in precipitation for all RCPs and time horizons, with broad consensus across most models, but the magnitude of this change is uncertain (Figure 44). Model predictions range from a -5% decrease to a 25% increase for 2015-2045, and a -15% decrease to a 30% increase for 2045-2075.

Figure 39: Time series of mean yearly temperature based on ERA5 dataset for the historical period (1979-2019), and NASA NEX (per model bias corrected) for the future period



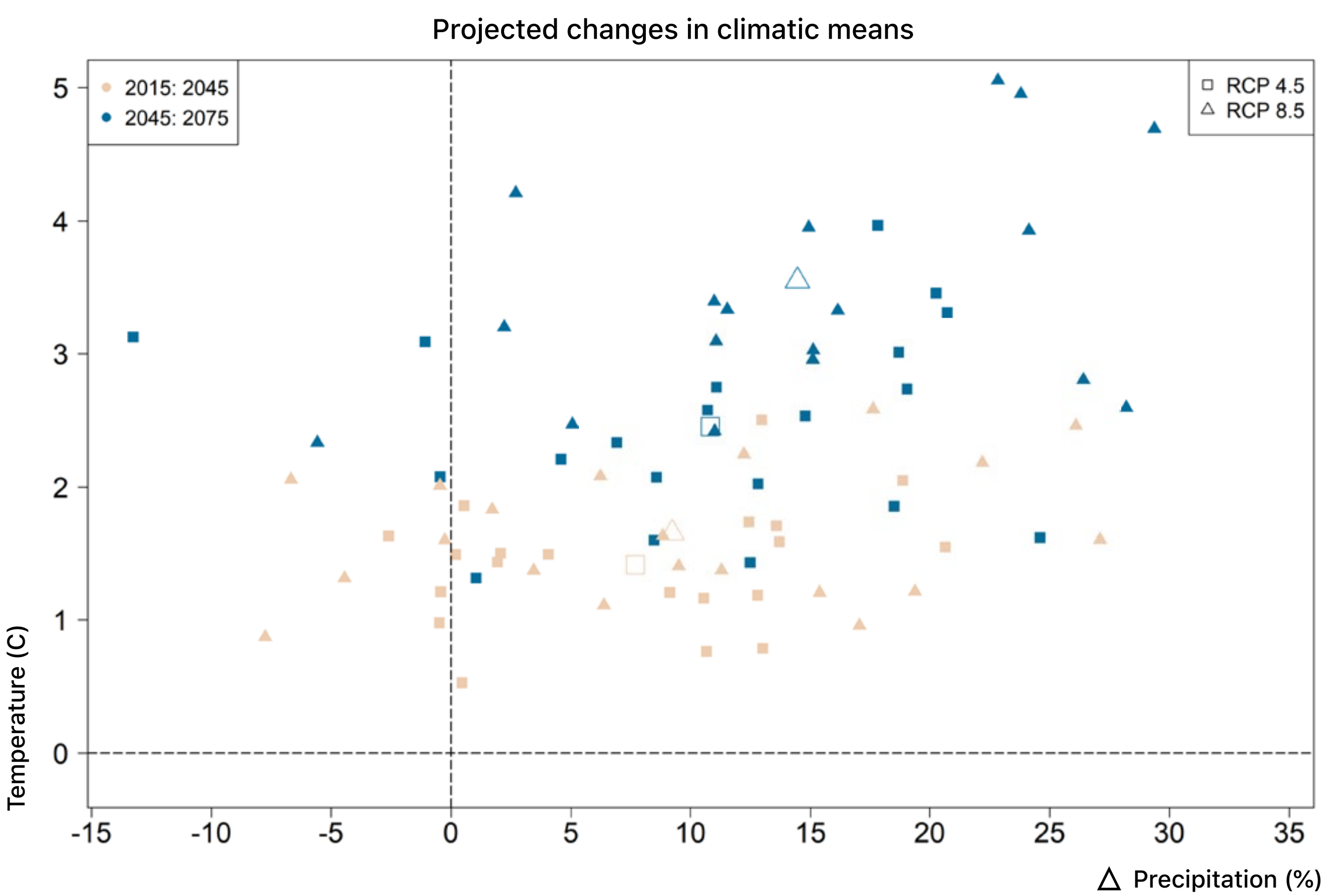
Source: original elaboration for this publication
Note: Shaded areas show the 10th and 90th percentiles in the spread of model predictions

Figure 40: Time series of total yearly precipitation based on ERA5 dataset for the historical period (1979-2019), and NASA NEX (per model bias corrected) for the future period



Source: original elaboration for this publication
Note: Shaded areas show the 10th and 90th percentiles in the spread of model predictions

Figure 41: Average temperature and precipitation changes



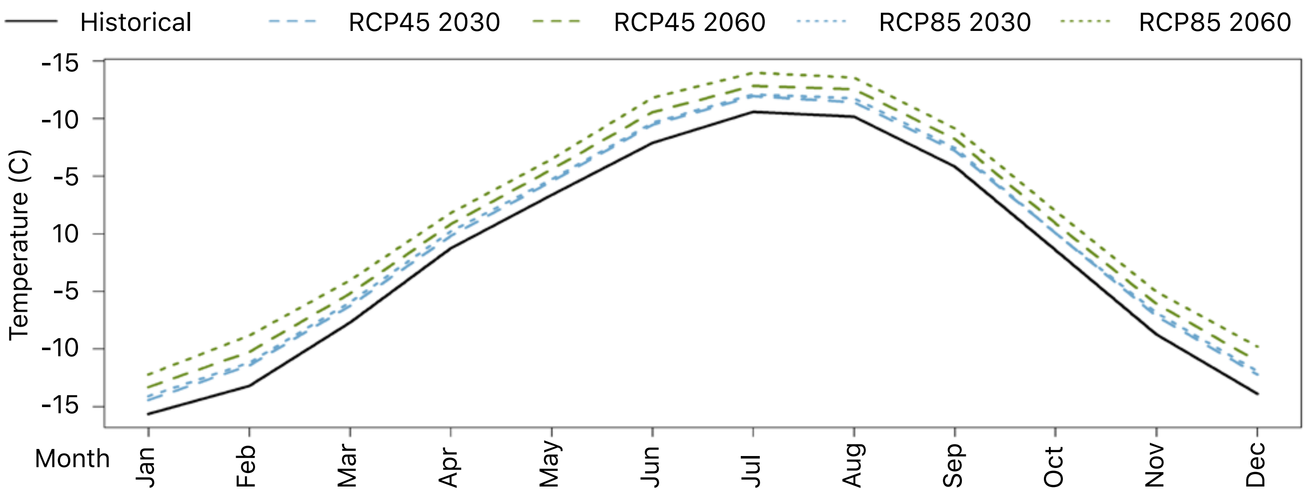
Source: original elaboration for this publication
Note: (Δ) indicate the difference between historical (1976-2005) and future (2015-2045; 2045:2075) time horizons for the two RCP scenarios

Seasonality

In terms of seasonality, climate model ensembles predict a general increase in temperatures for all months (Figure 42). A greater increase in temperatures is predicted in the longer term (2045-2075) timescale and under the higher RCP 8.5 scenario.

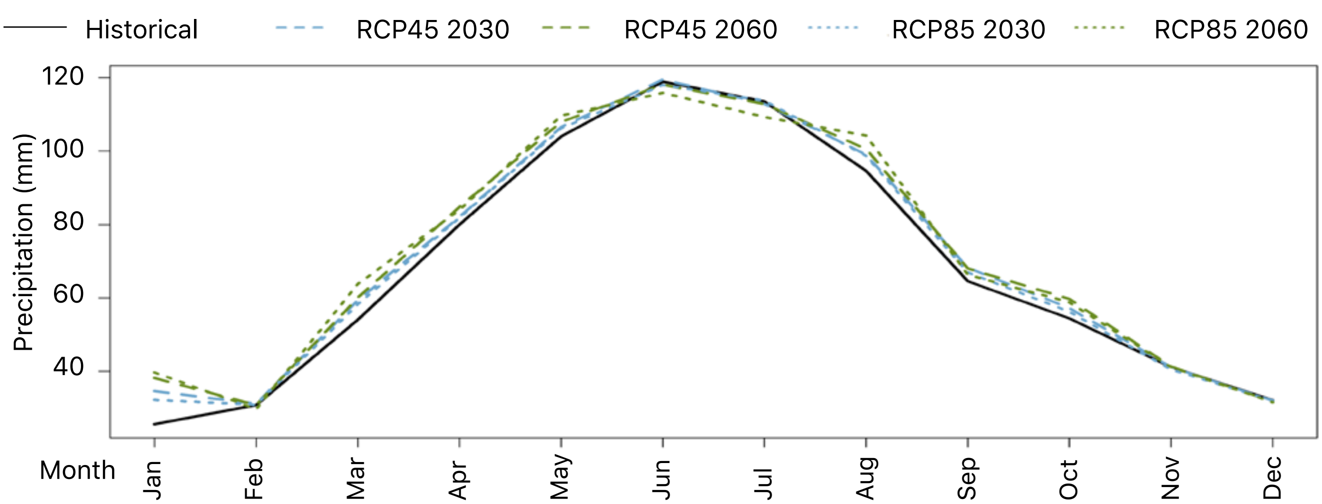
GCM ensemble results for precipitation seasonality (Figure 43) suggest an increase in precipitation for most months besides the wetter months of June and July. This trend is more extreme under the RCP85 scenario. This result must, however, be considered uncertain due to the variation shown in model predictions for precipitation.

Figure 42: Average daily temperature per month for historical (1976–2005) and future (2015–2045; 2045–2075) time horizons under the two RCP scenarios



Source: original elaboration for this publication

Figure 43: Average total monthly precipitation per month for historical (1976–2005) and future (2015–2045; 2045–2075) time horizons under the two RCP scenarios



Source: original elaboration for this publication

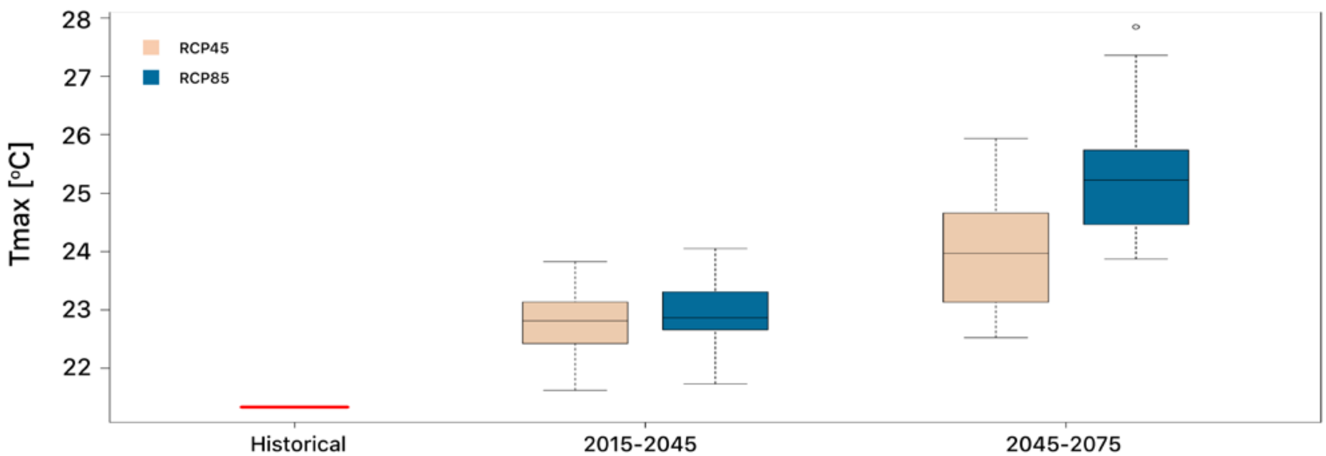
Extreme Climate Trends

When extreme trends are considered, a large level of variation is evident in climate model predictions. This is expected as climate models are inherently limited in terms of predicting trends in extremes due to the stochastic nature of these events.

In terms of extreme temperature trends, the climate model ensemble shows a clear trend of increasing extreme temperatures under both RCP scenarios and time horizons, suggesting an increase in the severity of heatwaves in the area (Figure 44).

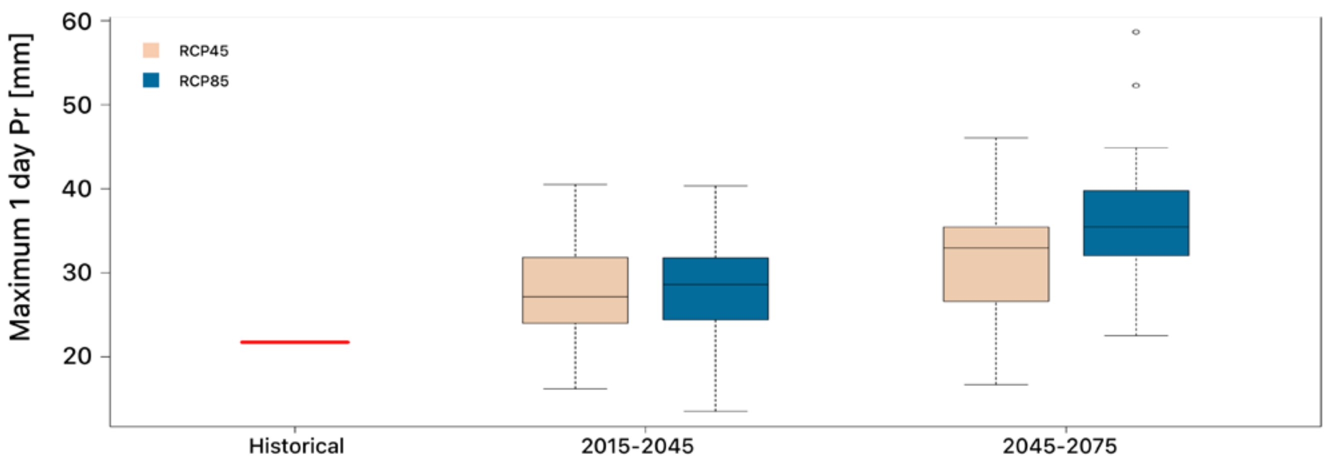
In terms of extreme precipitation trends, projections suggest that maximum 1-day rainfall (Figure 45) and rainfall intensity (Figure 46) are both likely to increase, indicating a change in precipitation patterns towards more intense and less frequent periods of rainfall. Trends in terms of consecutive dry days (Figure 47) are less clear, with models predicting both decreases and increases in dry spells.

Figure 44: Boxplots indicating the spread in climate model predictions of maximum daily temperature per year (TXX) for the historical (1976-2005) and future time periods under two RCP scenarios



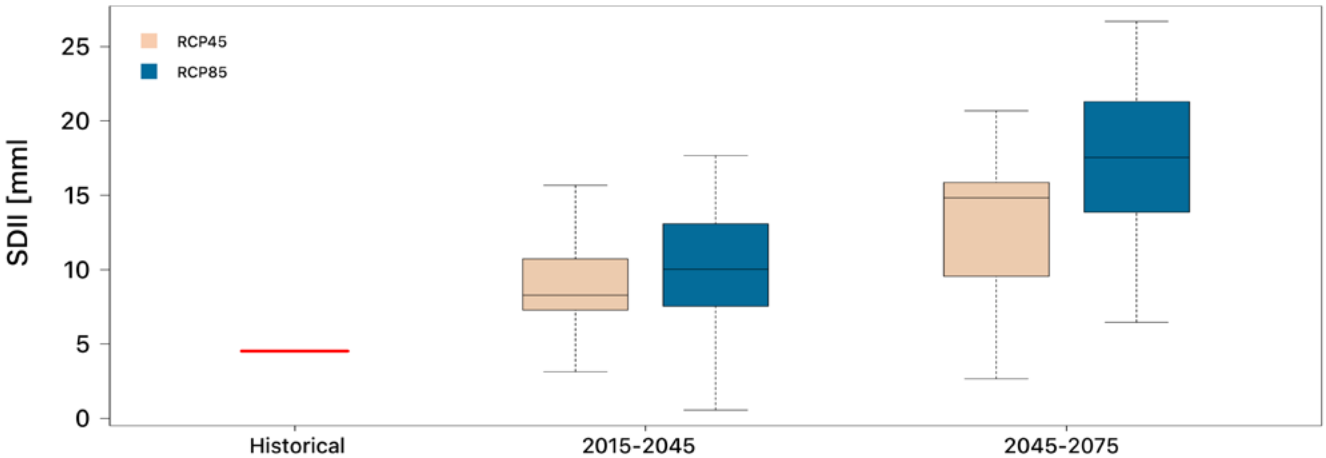
Source: original elaboration for this publication

Figure 45: Boxplots indicating the spread in climate model predictions of maximum 1-day precipitation sum per year (Rx1Day) for the historical (1976–2005) and future time periods under two RCP scenarios



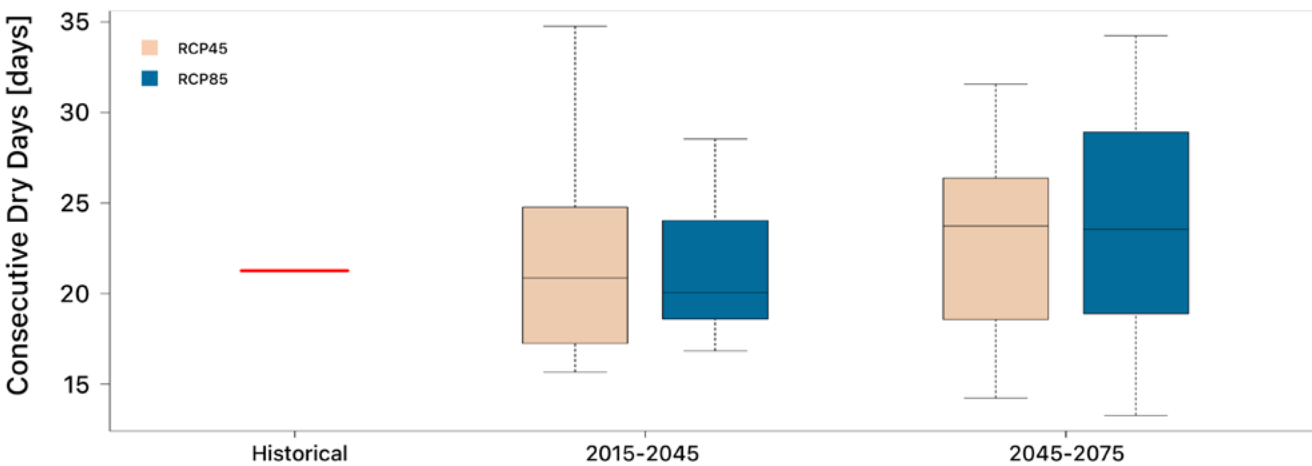
Source: original elaboration for this publication

Figure 46: Boxplots indicating the spread in climate model predictions of precipitation intensity (SDII) for the historical (1976–2005) and future time periods under two RCP scenarios



Source: original elaboration for this publication

Figure 47: Boxplots indicating the spread in climate model predictions of Consecutive Dry Days (CDD) for the historical (1976–2005) and future time periods under two RCP scenarios.



Source: original elaboration for this publication

Summary Tables

The combination of 21 GCMs, two RCPs and two-time horizons leads to a total of 84 (21 * 2 * 2) projections for the future. Table 38 shows detailed results for all 84 projections of changes in mean annual temperature and total annual precipitation.

This shows consistency between GCMs in terms of predicting a warmer future climate in the study area (especially for the longer-term horizon) but producing inconsistent predictions in terms of precipitation.

Table 38: Average climate change (delta values) in total annual precipitation and mean annual temperature predicted by the full climate model (GCM) ensemble

		bcc-csm1-1	BNU-ESM	CanESM2	CCSM4	CESM1-BGC	CNRM-CM5	CSIRO-Mk3-6-0	GFDL-CM3	GFDL-ESM2G	GFDL-ESM2M	inmcm4	IPSL-CM5A-LR	IPSL-CM5A-MR	MIROC-ESM-CHEM	MIROC-ESM	MIROC5	MPI-ESM-LR	MPI-ESM-MR	MRI-CGCM3	NorESM1-M
Precip (%)	2030_RCP45	3%	16%	19%	5%	10%	13%	2%	10%	3%	14%	1%	-2%	-2%	17%	11%	18%	9%	3%	15%	0%
	2060_RCP45	4%	16%	23%	8%	10%	19%	11%	15%	16%	12%	4%	-1%	-17%	23%	18%	18%	7%	15%	26%	9%
	2030_RCP85	8%	10%	26%	1%	11%	11%	-2%	16%	10%	-3%	-7%	0%	-10%	18%	23%	27%	19%	20%	18%	6%
	2060 RCP85	6%	18%	34%	10%	12%	27%	14%	23%	16%	7%	-5%	2%	-14%	29%	30%	24%	20%	15%	28%	9%
Tavg (oC)	2030_RCP45	1.37	1.84	2.18	1.64	1.39	1.18	1.51	2.60	1.07	0.78	0.53	1.79	2.06	1.75	1.83	1.59	1.29	1.68	0.92	1.73
	2060_RCP45	2.25	2.66	3.43	2.48	2.26	1.87	2.82	4.09	1.52	1.64	1.31	3.33	3.37	3.17	3.55	2.78	2.27	2.18	1.83	2.79
	2030_RCP85	1.58	2.24	2.57	1.92	1.60	1.39	1.68	2.69	1.23	1.40	0.87	2.18	2.28	2.40	2.25	1.66	1.22	1.45	1.11	1.83
	2060_RCP85	3.44	4.08	4.79	3.48	3.29	2.79	3.42	5.16	2.52	2.53	2.34	4.39	4.86	5.17	4.76	3.99	3.07	3.19	2.77	3.53

Source: original elaboration for this publication

Note: This indicates the difference between historical (1976-2005) and future (2015-2045; 2045:2075) time horizons for the two RCP scenarios

Table 39 and Table 40 show the main statistics (median, 10th percentile and 90th percentile) of the changes in precipitation and temperature, respectively. It also includes the number of GCMs that are showing a positive versus negative change for precipitation, and number of GCMs that are predicting a change above 2°C and 4°C.

In summary, all GCMs predict a hotter future, with most predictions lying between 1 to 2°C for 2030 and 2 to 5°C for 2060. There is a clear consensus in precipitation predictions, with most GCMs predicting a wetter future under both RCP scenarios.

Table 39: Spread in Climate Model (GCM) ensemble predictions for future changes in total annual precipitation

	Median (%)	25th Perc. (%)	75th Perc. (%)	GCMs Dryer	GCMs Wetter
2030_RCP45	8%	2%	14%	2	18
2060_RCP45	12%	8%	18%	2	18
2030_RCP85	10%	1%	19%	4	16
2060_RCP85	15%	7%	27%	2	18

Source: original elaboration for this publication

Table 40: Spread in Climate Model (GCM) ensemble predictions for future changes in mean annual temperature

	Median (°C)	25th Perc. (°C)	75th Perc. (°C)	GCMs >2°C	GCMs >4°C
2030_RCP45	+1.5	+1.2	+1.8	3	0
2060_RCP45	+2.6	+1.9	+3.3	15	1
2030_RCP85	+1.8	+1.4	+2.2	7	0
2060_RCP85	+3.7	+2.9	+4.7	20	7

Source: original elaboration for this publication

Implications for sedimentation in hydropower reservoirs in Naryn River Basin

This climate change screening enables to derive the following implications for restoration measures and for sedimentation in hydropower reservoirs in Naryn River Basin:

Increased erosion from rainfall and runoff. Increases in precipitation intensity and the magnitude of extreme precipitation events will lead to increased erosion. Areas with reduced vegetation cover, erodible soil types, and steep slopes are particularly vulnerable to erosion from intense precipitation. These changes in precipitation patterns can also lead to soil liquefaction, mudflows, and gullying, which can exacerbate land degradation in the future.

Potential risks of degradation through wind erosion during drought periods. Some climate models predict an increase in the length of dry periods. As a result, drought periods may lead to increased vulnerability of land in areas with fine soil types to wind erosion, leading to further land degradation stresses in the future.

Increased temperature stress on vegetation. Increases in extreme temperatures may negatively affect vegetation communities, vital in counteracting land degradation.

Potential increased runoff due to snow and ice melt. Increases in average and extreme temperatures in the Naryn River Basin will accelerate snow and ice melting processes within the area. This may generate increased runoff in warm periods in river channels and overland, leading to further soil erosion and land degradation.
Climate change will significantly impact erosion in this region as flows will become more variable, due to the reduced regulating role of snow and glaciers in the Naryn River Basin. Therefore, spatiotemporal modelling tools are needed for a quantitative assessment of baseline conditions and scenario analyses of different land management and climate change projections. Well-established examples of such models for erosion scenario studies are InVEST and SPHY[32].

To calibrate and validate such models, field measurements of erosion and suspended sediment concentrations are required. However, the existing knowledge base on erosion and sedimentation in the Kyrgyz Republic across different terrains and land use types is limited. Those studies that do exist report values covering a wide range, which limits their usability in model calibration (e.g. UNDP, 2016).

The impact of increased climate change-

[32] https://www.sphy.nl/

induced variability on reservoir sedimentation processes still needs to be fully assessed and will need to be considered in further, longer-term analyses. However, it can be expected that melting glaciers and increased peak flows due to warmer temperatures will cause more sediment to reach all the country's reservoirs in the future, accelerating the loss of storage capacity for most of the Kyrgyz Republic's reservoirs, including Toktogul.

Annex 8. Restoration measures and models: Description and inputs

Table 41: Restoration measures and models

<table>
<tr><td colspan="2">Scale: National</td></tr>
<tr><td colspan="2">Name of the measure: Reforestation in riparian areas/forests</td></tr>
<tr><td>Description of the measure</td><td>Main inputs</td></tr>
<tr><td>The objectives of afforestation/reforestation in riparian forests can be:
▪ Cross border landscape restoration
▪ Fuelwood production
▪ Timber production (wood for construction material)
▪ NTFP production
▪ Riverbank stabilization
▪ Cross border restoration potential
Tree species that are adapted for reforestation activities in riparian forests are fast-growing species (e.g., poplars, willows) which can be planted as cuttings.
In the Kyrgyz Republic, riparian forests belong to several State bodies, including local self-governance, the Ministry of transport and others which do not actively undertake any action related to afforestation/ reforestation.
Expected benefits:
▪ Timber production
▪ Firewood production
▪ Biodiversity
▪ Reduced erosion
▪ Carbon sequestration
▪ Natural capital increase</td><td>▪ Cuttings and seedlings
▪ Labour
• Plantation
• Watering (where necessary)
• Maintenance (several times a year for 3-5 years)
• Pest management
• Fence installation and maintenance
▪ Equipment/material
• Fencing material or exclusion of livestock through other technics
• Irrigation equipment and material (e.g., hoses, pumps, reservoirs)
• Machinery (car or light truck)</td></tr>
</table>

Table 41

Scale: **National**	
Name of the measure: **Afforestation / reforestation with high quality seedlings and polybags with protection measure (pistachio, walnut, juniper, and spruce)**	
Description of the measure	**Main inputs**
Plantation of tree seedlings on land where there were no trees before (afforestation) and where there used to be trees (reforestation). The objectives of such plantations can be: ▪ Landscape restoration ▪ Timber production (construction and fuelwood) ▪ NTFP production ▪ Erosion control ▪ Carbon sequestration ▪ Biodiversity conservation ▪ Greening Seedlings are grown in polybags to increase survival during transport and after the plantation. The plantations need to be fenced or protected to limit grazing of young seedlings. Fenced areas can be used for hay production which results in additional income, as an incentive for the land leaser and encourages weeding in the first three to five years. In the Kyrgyz Republic, leskhozes establish more than 1,000ha of new forest plantations annually. A small share of it uses seedlings in polybags. Protection against livestock is usually not foreseen. This results in a low survival rate. **Expected benefits:** Benefits are related to timber production, firewood production, NTFP (walnuts), and hay (in the first 5 years), biodiversity, reduced erosion, carbon sequestration, contribution to natural capital increase	▪ High quality seedlings (selected seeds, polybags) ▪ Labour • Plantation • Watering (where necessary) • Maintenance (several times a year for 3-5 years) • Fence installation and maintenance ▪ Equipment/material • Fencing material or other type of enclosure • Irrigation equipment and material (e.g., hoses, pumps, reservoirs) • Machinery (car or light truck)

Table 41

Scale: **National**	
Name of the measure: **Assisted natural regeneration (pistachio, walnut, juniper, and spruce forests)**	
Description of the measure	**Main inputs**
Assisted natural regeneration can involve various activities that aim at supporting the growth of young trees and bushes in existing forests. Selected tree cutting is prohibited in most forests of the Kyrgyz Republic and cannot be used to favour regeneration by decreasing shade from the canopy. The objectives of assisted natural regenerations can be: ▪ Timber production (construction and fuelwood) ▪ NTFP production ▪ Rejuvenation of forest stands Assisted natural regeneration entails activities that aim at: ▪ Providing enough sunlight to young trees ▪ Limiting disturbances (e.g., grazing) that may affect their growth ▪ Selecting and favouring the regeneration of high-value species or high biodiversity value (depending on the objective pursued - see above) ▪ Where the seedbank is too limited (e.g., intensive nut collection), enrichment plantations can be considered In the Kyrgyz Republic, leskhozes have forest regeneration objectives. However, the only activities which are usually implemented is ploughing (минеральные полосы) to improve the germination rate of seeds. Rarely, grazing bans are enforced through agreement with pasture users or using green fences. **Expected benefits:** ▪ Timber production ▪ Firewood production ▪ Local income from NTFP (pistachio, walnuts) ▪ Biodiversity ▪ Reduced erosion ▪ Carbon sequestration ▪ Natural capital increase	▪ Seedlings (in case of enrichment planting) ▪ Labour • Plantation or sowing (if needed) • Watering (where necessary) • Seedling marking (to avoid destruction during haymaking) • Grass removal around seedlings (to reduce light competition) • Tree guard installation and maintenance • Livestock management (shepherding) ▪ Equipment/material • Tree guards (rebars, mesh fence) • Machinery (car or light truck)

Table 41

Agricultural lands	
Scale: **National**	
Name of the measure: **Efficient use of water resources**	
Description of the measure	**Main inputs**
There are a range of water management practices which help in using water more efficiently than most farmers conventionally do. Some of these are technical measures, such as short-furrow irrigation, alternate furrow irrigation and more. Drip irrigation is also an efficient irrigation method. Non-technical methods are water measuring and payment per volume of water used. Leaving crop residues and mulching is also a cheap practice to maintain soil moisture **Objectives:** ▪ Efficient use of water resources ▪ Avoided erosion due to better soil cover ▪ Recovering of non-used or badly used soils for agriculture ▪ Fruit production in dry areas with irrigation **Expected benefits:** ▪ Avoided soil erosion ▪ Increased productivity ▪ Regreening of abandoned sites ▪ Carbon sequestration due to increased biomass	Different for each practice. (Ranges from leaving plant residues, mulching to drip irrigation system)

<table>
<tr><th colspan="2">Agricultural lands</th></tr>
<tr><td colspan="2">Scale: National</td></tr>
<tr><td colspan="2">Name of the measure: No-tillage/minimum tillage</td></tr>
<tr><th>Description of the measure</th><th>Main inputs</th></tr>
<tr><td>No/minimum tillage crop cultivation means direct sowing without ploughing and harrowing the soil. Direct sowing is possible on irrigated and rain-fed land. It requires special seeders. The transition to direct sowing in the first years requires the use of herbicides. Green manure should be added to maintain permanent soil cover and to produce more biomass and reduce erosion. Crop rotation is important (see also next measure).

In the Kyrgyz Republic, it is so far mainly used for maize and grain crops and is being tested for safflower. The technology is not yet widely used in the country. Direct sowing seeders for irrigated land are currently located in Kemin (Chui), in Tong rayon (IK), in Budenovka village (Chui) and with Kench seed farm in Shaidan village (Nooken). Direct sowing seeders for rainfed land are in Kadamjay, Batken and Leylek rayons, in Bazar-Korgon and in Suzak rayons of Jalal-Abad oblast. There may be some more such seeders in other locations.

Expected benefits:

With direct sowing the soil is less disturbed than with ploughing and a permanent plant cover is maintained. The main positive impacts are:
▪ Better water holding capacity in the long term
▪ Higher soil fertility, soil health
▪ Reduced need for fertilizer reduced soil erosion (wind and water erosion)
▪ Reduced erosion
▪ Carbon sequestration
▪ Disadvantages: High upfront investment costs for seeders and long-term capacity building required</td><td>▪ Quality seeds (hybrid in case of maize, special varieties of wheat and barley in case of rain-fed land) and seeds for green manure
▪ Labour
Farmer’s or hired labour force for all the cultivation operations.
▪ Fertilizers/pesticides:
• Ammophos, carbamide fertilizer.
• Herbicides (in the first 2-3 years).
• Plant protection means (depending on the crop).
▪ Equipment/material
• Special seeder for direct sowing (to be used together with a tractor; in the case of direct seeders for rainfed land a 90 Hp tractor is required).
• Disc cultivators in case of direct sowing on rainfed land that has not been cultivated for a longer period.
• Combine harvesters, straw balers
• On irrigated land: irrigation equipment and material on (e.g., hoses, pumps, reservoirs). Specific to each field
▪ Capacity building investments</td></tr>
</table>

Table 41

Agricultural lands	
Scale: **National**	
Name of the measure: **Introduction of crop rotation and cover crops**	
Description of the measure	**Main inputs**
Crop rotation is necessary for maintaining soil fertility in the long term. There are diverse suitable rotation patterns. A leguminous crop, which fixes nitrogen, is included in all sensible rotation patterns. Because of small land plots, it is not always easy to convince farmers in KR about crop rotation. Vegetables, potatoes, maize, and cotton are too often grown in sequential years. The fact that most farmers need to grow feed crops for their livestock favours rotation patterns with lucerne or alfalfa. Cover crops (green manure) are plants planted to cover the soil rather than to be harvested. Mostly they are ploughed under, after some time and act as green manure or better mulched or even better used as cover crop in direct seeding/ no tillage systems. Cover crops contribute to avoid soil erosion, maintain soil fertility, soil quality, water retention, reduce weeds, pests, and diseases, and improves biodiversity in an agroecosystem. Cover crops / green manure crops are rare in KR, because it is unimaginable for Kyrgyz farmers to plant something which is then not harvested. But there are also cover crops which can be harvested or used as fodder like winter rye, lupine, white or black oat, millet, buckwheat, safflower, alfalfa, red clover, canola, chickpea, dry pea, lentil, sunflower, rapeseed, mustard. Cover crops, which can be cut as livestock feed and only partly ploughed under or managed as no-tillage system may have a chance. Other obstacles to cover crops are low winter temperatures and lack of irrigation water in autumn when cover crops need to be planted.	**Crop rotation** ▪ Quality seeds, ▪ Fertilizers/pesticides Fertilizer, plant protection means ▪ Equipment/material • Plough, harrow, seeder • Grass cutting machines, balers • On irrigated land: irrigation equipment and material on (e.g., hoses, pumps, reservoirs). Specific to each field ▪ Labour • Farmer’s or hired labour force for all the cultivation operations. **Cover crops** ▪ Seeds ▪ Labour • Farmer’s or hired labour force for all the cultivation operations ▪ Equipment/material • Plough, harrow, seeder • On irrigated land: irrigation equipment and material on (e.g., hoses, pumps, reservoirs). Specific to each field

Table 41

<table>
<tr><th colspan="2">Agricultural lands</th></tr>
<tr><td colspan="2">Scale: Naryn</td></tr>
<tr><td colspan="2">Name of the measure: Agroforestry models combining walnut trees, fruit trees, fast growing trees (hedgerows), native bushes, hay production and agriculture in SFF and private lands</td></tr>
<tr><td>Description of the measure</td><td>Main inputs</td></tr>
<tr><td>Agroforestry models combine annual with perennial crops. They intend to create a complex environment which provides multiple benefits to the plot owner and is more resilient to extreme climate events. In the Kyrgyz Republic, agroforestry systems typically produce food products (e.g., crops, fruits, berries), fodder and timber (construction and fuelwood). Considering the important grazing pressure in the Kyrgyz Republic, agroforestry fields need to be fenced, at least until a living fence can be established. Haymaking is an important benefit and incentive in the first 5 years if the area is not used for crop production. A combination of haymaking, crops, fruits, and timber trees gives the highest benefit.

The objective of agroforestry is:
▪ Landscape restoration
▪ Timber production (construction and fuelwood)
▪ Fruit and crop production
▪ Income generation
▪ Enhanced biodiversity

Expected benefits:
▪ Fruits, berries, crops
▪ Hay
▪ Timber and firewood
▪ Biodiversity
▪ Soil protection, less erosion
▪ Carbon sequestration
▪ Natural capital increase</td><td>▪ Seedlings / saplings / seeds / cuttings of the distinct species include in the system
▪ Labour
• Plantation
• Watering (if needed)
• Maintenance (incl. pest management)
• Fence installation and maintenance
▪ Equipment/material
• Fencing material or other type of enclosure
• Irrigation equipment and material (e.g., hoses, pumps, reservoirs)
• Machinery (e.g., tractor, etc.)</td></tr>
</table>

Table 41

Pasture lands	
Scale: **National**	
Name of the measure: **Temporary grazing ban in degraded areas in all pasture types**	
Description of the measure	**Main inputs**
Degraded pastures in KG still can (enough seed bank in soil) recover if grazing is banned for some time (the period length is defined based on the plant community in the chosen ecosystem). The economic return from degraded pastures is lower compared to the healthy ones. However, pasture users are rarely motivated to stop grazing for some time due to the following reasons: ▪ It is the pasture they traditionally use, and they consider it as inherited from their parents ▪ Transporting livestock to other remote pastures incurs substantial costs ▪ There is no guarantee that a user who stops temporarily grazing livestock on a plot will not lose his right to use it in the future **Expected benefits:** ▪ Improved biomass (productivity, biodiversity, carbon sequestration etc.) ▪ Improved weight gain of grazing livestock ▪ Improved soil stability, reduced soil erosion	▪ Transport cost to other pasture area ▪ Higher cost of pasture ticket if the pasture where the shepherd moves belong to another Ayil Okmotu

Table 41

Pasture lands	
Scale: **National**	
Name of the measure: **Access to remote pastures through infrastructure improvement (e.g., watering points, bridges, roads, etc.)**	
Description of the measure	**Main inputs**
Pasture infrastructure (roads, bridges, water points) has been steadily degrading since 1991. Since the establishment of pasture committees in 2009 and the collection of a user fee by these committees, more investment is allocated to constructing and repairing infrastructure. International development projects have also been financially supporting these activities. Still, these efforts do not cover all needs and some remote pastures are still hardly accessible. Improving access to these remote pastures through infrastructure improvement would help destock livestock from over-grazed and degraded pastures. **Expected benefits:** ▪ Improved biomass in near-village pastures and other degraded pastures ▪ Improved weight gain of grazing livestock ▪ Improved biomass (productivity, biodiversity, carbon sequestration etc.) ▪ Better epizootic conditions due to cleaner water in watering point (concerns water points improvement only)	▪ Labour • Construction of infrastructure (depends on each case) ▪ Equipment/material • Construction materials (cement, pebbles, sand, re-bars, I-beams, square hollow steel sections, structural channel, plastic pipes etc.). The quantity and quality of material depends on the selected infrastructure

Table 41

Pasture lands	
Scale: **National**	
Name of the measure: **Rotational grazing, grazing schedule in summer and winter pastures for increasing productivity and improving palatability**	
Description of the measure	**Main inputs**
This is a similar measure as temporary grazing ban in degraded areas in that the main goal of the rotation is to provide a sufficient period for pasture vegetation to recover after a limited grazing period (i.e., not after year-long or seasonal-long grazing). An additional benefit of rotational grazing compared to grazing ban is that it can improve the harvest efficiency (i.e., to have a greater forage production that in a no-grazing situation): "Harvest efficiency of season-long continuous grazing is about 25% and usually 30-35% for rotational grazing when both are moderately stocked". More details here. **Expected benefits:** ▪ Improved biomass (productivity, biodiversity, carbon sequestration etc.) ▪ Improved weight gain of grazing livestock	▪ Labour More working hours (labour) for herding ▪ Equipment/material Optional: Fencing material (permanent or temporary) to subdivide the pasture into several paddocks ▪ Other costs To delay grazing in spring pastures, it is necessary to feed the livestock in stables for longer time which means more forage should be stored/purchased

Table 41

Protective lands	
Scale: **National**	
Name of the measure: **Riverbank protection and gully stabilization through green infrastructure (plantation of adapted grass, bush, and tree species)**	
Description of the measure	**Main inputs**
Riverbanks are sensitive to erosion, especially in mountain areas where the hydrological profile of rivers is characterized by high seasonal water and recurrent floods. The root system of trees, bush, and herbs play a significant role in stabilizing riverbanks. Unstable riverbanks are at risk to be heavily eroded during high water periods and to reject in the water course various material (e.g., soil, pebbles) that can create additional damages downstream (e.g., sedimentation, degradation of infrastructure). Gullies are created by water runoff on bare soil or soil with limited vegetation cover. They are an important source of soil loss. Green infrastructure aims at stabilizing riverbanks and gullies using a mix of living plants combined with natural materials such as geotextile and wooden structures. Some examples of wooden structures are palisade, check dams, crib walls.	Labour, equipment, building material and further maintenance depend on the type of infrastructure.

Table 41

Protective lands	
Scale: **National**	
Name of the measure: **Riverbank protection and gully stabilization through grey infrastructure (gabions, check dams)**	
Description of the measure	**Main inputs**
Grey infrastructure aims at stabilizing riverbanks and gullies using mineral materials such as gabions, concrete, rocks etc.	Labour, equipment, material for building and further maintenance depend on the type of infrastructure.

Source: original elaboration for this publication

Annex 9. Sensitivity analysis for CBA tables

Table 42: Discount rate sensitivity analysis in restoration models

#	Land type - activity - model	Discount rate	5%	8%	11%	14%
1	Forest - Afforestation -Walnut	NPV	$21,060	$13,680	$8,934	$5,820
		IRR		31%		
2	Forest - Afforestation - Pistachio	NPV	$1,591	$633	$17.48	$383
		IRR		11%		
3	Forest - Afforestation - Spruce	NPV	$1,797	$1,821	$1,814	$1,788
		IRR		-9%		
4	Forest - Reforestation - Riparian Forest	NPV	$6,164	$3,174	$1,474	$489
		IRR		16%		
5	Forest - Assisted Regeneration - Walnut	NPV	$15,536	$10,054	$6,539	$4,242
		IRR		31%		
6	Forest - Assisted Regeneration - Pistachio	NPV	$2,079	$2,207	$2,248	$2,239
		IRR		-4%		
7	Forest - Assisted Regeneration - Spruce	NPV	$3,230	$2,959	$2,744	$2,567
		IRR		Not calculated		
8	Agricultural lands - Watering improvement	NPV	$5,909	$4,324	$3,224	$2,440
		IRR		49%		
9	Agricultural lands - No tillage	NPV	$5,164	$3,447	$2,264	$1,428
		IRR		23%		
10	Agricultural lands - Crop Rotation	NPV	$1,454	$2,398	$2,846	$3,007
		IRR		2%		

#	Land type - activity - model	Discount rate	5%	8%	11%	14%
11	Agricultural lands - Agroforestry	NPV	$2,462	$1,600	$998	$567
		IRR		20%		
12	Pasture - Grazing ban	NPV	$1,705	$923	$437	$129
		IRR		16%		
13	Pasture - Remote pasture access	NPV	$2,158	$1,268	$711	$355
		IRR		19%		
14	Pasture - Rotational measures	NPV	$2,157	$1,256	$690	$327
		IRR		19%		
15	Protective lands - Green	NPV	$925,078	$727,581	$589,082	$489,049
		IRR		Not calculated		
16	Protective lands - Grey	NPV	$923,992	$726,255	$587,604	$487,476
		IRR		Not calculated		

Source: original elaboration for this publication

Table 43: Sensitivity analysis to cost increase in forestry models

#	Model		No change	10%	20%
1	Afforestation - Walnut	NPV	$13,680	$13,445	$13,210
		IRR	31%	29%	28%
2	Afforestation - Pistachio	NPV	$700	$398	$163
		IRR	11%	10%	9%
3	Afforestation - Spruce	NPV	$1,821	$2,056	$2,291
		IRR	-9%	-9%	-10%
4	Reforestation - Riparian Forest	NPV	$3,174	$3,017	$2,859
		IRR	16%	16%	15%
5	Assisted Regeneration - Walnut	NPV	$10,054	$9,964	$9,874
		IRR	31%	30%	29%
6	Assisted Regeneration - Pistachio	NPV	2,207	$2,516	$2,687
		IRR	-4%	-5%	-6%
7	Assisted Regeneration - Spruce	NPV	$2,959	$3,268	$3,577
		IRR	Cannot be determined	Cannot be determined	Cannot be determined

Source: original elaboration for this publication

Table 44: Discount rate sensitivity analysis in agricultural lands

#	Land type - Activity - model	Discount rate	5%	8%	11%	14%
1	Agricultural lands - Watering improvement	NPV	$5,890	$4,309	$3,212	$2,430
		IRR		49%		
2	Agricultural lands - No tillage	NPV	$5,164	$3,447	$2,264	$1,428
		IRR		23%		
3	Agricultural lands - Crop Rotation	NPV	$1,448	$2,393	$2,842	$3,004
		IRR		2%		
4	Agricultural lands - Agroforestry	NPV	$2,568	$1,684	$1,066	$623
		IRR		21%		

Source: original elaboration for this publication

Table 45: Sensitivity analysis to cost increase in agricultural lands models

#	Model		No change	10%	20%
1	Agricultural lands - Watering improvement	NPV	$4,324	$3,904	$3,627
		IRR	49%	41%	36%
2	Agricultural lands - No tillage	NPV	$3,447	$3,006	$2,565
		IRR	23%	20%	18%
3	Agricultural lands - Crop Rotation	NPV	$2,39183	$2,920	$3,442
		IRR	2%	1%	0%
4	Agricultural lands - Agroforestry	NPV	$1,600	$1,327	$1,053
		IRR	20%	17%	15%

Source: original elaboration for this publication

Table 46: Discount rate sensitivity analysis in pasture models

Land type - Activity - model	Discount rate	5%	8%	11%	14%
Pasture - Grazing ban	NPV	$1,705	$923	$437	$129
	IRR		16%		
Pasture - Remote pasture access	NPV	$2,158	$1,268	$711	$355
	IRR		19%		
Pasture - Rotational measures	NPV	$2,157	$1,256	$690	$327
	IRR		19%		

Source: original elaboration for this publication

Table 47: Sensitivity analysis to cost increase in pasture models

Model		No change	10%	20%
Pasture - Grazing ban	NPV	$923	$787	$650
	IRR	16%	14%	13%
Pasture - Remote pasture access	NPV	$1,268	$1,142	$1,016
	IRR	19%	18%	16%
Pasture - Rotational measures	NPV	$1,256	$1,137	$1,019
	IRR	19%	17%	16%

Source: original elaboration for this publication

Table 48: Discount rate sensitivity analysis in protected land models

Land type - Activity - model	Discount rate	5%	8%	11%	14%
Protective lands - Green	NPV	$925,078	$727,581	$589,082	$489,049
	IRR		Cannot be determined		
Protective lands - Grey	NPV	$923,992	$726,255	$587,604	$487,476
	IRR		Cannot be determined		

Source: original elaboration for this publication

Table 49: Sensitivity analysis to cost increase in protected land models

Model		No change	10%	20%
Protective lands - Green	NPV	$727,581	$726,703	$725,826
	IRR	Cannot be determined	Cannot be determined	Cannot be determined
Protective lands - Grey	NPV	$726,255	$725,244	$724,234
	IRR	Cannot be determined	Cannot be determined	Cannot be determined

Source: original elaboration for this publication

Annex 10. Assumptions for the carbon sequestration models

Table 50: Afforestation / reforestation with pistachio, walnut, and almond

Aspect	Assumption in model
Description	Plantation of tree seedlings on land where there were no trees before (afforestation) and where there used to be trees (reforestation). It can also include fencing and other grazing protection, as well as irrigation where needed.
Baseline scenario: Initial land use type	Degraded land (as per IPCC 2006/2019)
Land use after intervention	Planted temperate mountain systems (as per IPCC 2006/2019)
Implementation phase / capitalization phase (years)	3 / 17 years
GHG emission balance (tCO_2e/ha/yr)	-18.3

Source: original elaboration for this publication

Table 51: Afforestation / reforestation with spruce and juniper

Aspect	Assumption in model
Description	Plantation of tree seedlings on land where there were no trees before (afforestation) and where there used to be trees (reforestation). It can also include fencing and other grazing protection, as well as irrigation where needed. Spruce and juniper forests are predominant in higher altitudes, why boreal dry climate is assumed.
Baseline scenario: Initial land use type	Degraded land (as per IPCC 2006/2019)
Land use after intervention	Planted boreal mountain systems (as per IPCC 2006/2019)
Implementation phase / capitalization phase (years)	3 / 17 years
GHG emission balance (tCO_2e/ha/yr)	-9.2

Source: original elaboration for this publication

Table 52: Afforestation / reforestation in riparian forests

Aspect	Assumption in model
Description	Plantation of tree seedlings and cuttings along mountain rivers. Species that are adapted to riparian areas like poplar and willow will be used. Poplar sequesters more carbon than other tree species, so the forest type "Temperate mountain systems" is used (without "planted"), to correspond for slightly higher GHG sequestration. The measure can also include irrigation where necessary, fencing and pest management.
Baseline scenario: Initial land use type	Degraded land (as per IPCC 2006/2019)
Land use after intervention	Temperate mountain systems (as per IPCC 2006/2019)
Implementation phase / capitalization phase (years)	3 / 17 years
GHG emission balance (tCO_2e/ha/yr)	-18.6

Source: original elaboration for this publication

Table 53: Assisted natural regeneration in pistachio, walnut, and almond forests

Aspect	Assumption in model
Description	Assisted natural regeneration involves various activities that aim at supporting the growth of young trees and bushes in existing forests, like enrichment planting, sowing, watering, or grass removal. This model is a restoration approach for degraded forests. There are various degrees of forest degradation within the country although there is no official data available. Based on expert estimates, an average degradation level of 50% is assumed, like forests of neighboring country Tajikistan. Over the modelling period of 20 years, a decrease of degradation level by 30% is assumed.
Baseline scenario: Initial land use type	Temperate mountain systems (as per IPCC 2006/2019)
Degradation level in baseline scenario	50%
Degradation level after intervention	20%
Implementation phase / capitalization phase (years)	3 / 17 years
GHG emission balance (tCO_2e/ha/yr)	-5.7

Source: original elaboration for this publication

Table 54: Assisted natural regeneration in spruce and juniper forests

Aspect	Assumption in model
Description	Assisted natural regeneration involves various activities that aim at supporting the growth of young trees and bushes in existing forests, like enrichment planting, sowing, watering, or grass removal. This model is a restoration approach for degraded forests. There are various degrees of forest degradation within the country although there is no official data available. Based on expert estimates, we assume an average degradation level of 50%, like forests of neighboring country Tajikistan. Over the modelling period of 20 years, we assume a decrease of degradation level of 30%. Spruce and juniper forests are predominant in higher altitudes, why boreal dry climate is assumed.
Baseline scenario: Initial land use type	Boreal mountain systems (as per IPCC 2006/2019)
Degradation level in baseline scenario	50%
Degradation level after intervention	20%
Implementation phase / capitalization phase (years)	3 / 17 years
GHG emission balance (tCO_2e/ha/yr)	-1.1

Source: original elaboration for this publication

Table 55: Agriculture – efficient use of water resources

Aspect	Assumption in model
Description	Irrigation is not commonly applied in the Kyrgyz Republic. A range of water management practices can help in using water more efficiently than most farmers conventionally do. This involves technical interventions like short furrow irrigation or drip irrigation as well as non-technical measures like water measuring and leaving crop residues. To maintain soil moisture, less tillage will be used. Due to the manifold measures in this scenario, the model has been made for 100 hectares to allow for estimates on the share of individual measures: Water use efficiency on cropland: 80% Recovering of non or badly used soils for agriculture: 10% Fruit production on dry land with irrigation: 10% The 100-ha model allows also for differentiation of irrigation techniques. We assume the following: Surface with IRRS: 80% Trickle: 20% Fertilizer use will not change in this scenario.

Aspect	Assumption in model
Baseline scenario: Initial land use type	Annual cropland – Full tillage, medium C input, residues exported (as per IPCC 2006/2019) Degraded land (as per IPCC 2006/2019) Degraded land (as per IPCC 2006/2019)
Land use after intervention	Annual cropland – Reduced tillage, medium C input, residues retained (as per IPCC 2006/2019) Annual cropland – Default crop, reduced tillage, medium C input, residues retained (as per IPCC 2006/2019) Orchard – Agroforestry system: Orchard, reduced tillage, medium C input, no residue burning (as per IPCC 2006/2019)
Implementation phase / capitalization phase (years)	1 / 19 years
GHG emission balance (tCO_2e/ha/yr)	-0.7

Source: original elaboration for this publication

Table 56: Agriculture – no tillage / minimum tillage

Aspect	Assumption in model
Description	No/minimum tillage crop cultivation means direct sowing without ploughing and harrowing the soil. With direct sowing the soil is less disturbed than with ploughing and a permanent plant cover is maintained. Direct sowing is possible on irrigated and rain-fed land, and installation of an irrigation system is assumed (although irrigation systems does not cause any difference in the carbon balance). Green manure as part of residues should be retained to maintain permanent soil cover. An estimate of 15% fertilizer reduction is applied, from initially 138 kg/ha to 117 kg/ha. The amount of pesticide used in the first years is assumed to make no notable change in terms of carbon emissions over the whole project period.
Baseline scenario: Initial land use type	Annual cropland – Full tillage, medium C input, residues exported (as per IPCC 2006/2019)
Land use after intervention	Annual cropland – No tillage, medium C input, residues retained (as per IPCC 2006/2019)
Implementation phase / capitalization phase (years)	1 / 19 years
GHG emission balance (tCO_2e/ha/yr)	-0.3

Source: original elaboration for this publication

Table 57: Agriculture – introduction of crop rotation and cover crops

Aspect	Assumption in model
Description	Cover crops (green manure) are planted to cover the soil rather than to be harvested. Mostly they are ploughed under after some time and act as green manure or better mulched or even better used as cover crop in direct seeding / no tillage systems. The use of cover crops will increase carbon input. Neither fertilizer use nor irrigation will significantly change in this scenario.
Baseline scenario: Initial land use type	Annual cropland – Full tillage, medium C input, residues exported (as per IPCC 2006/2019)
Land use after intervention	Annual cropland – Reduced tillage, high C input (no manure), residues retained (as per IPCC 2006/2019)
Implementation phase / capitalization phase (years)	1 / 19 years
GHG emission balance ($tCO_2e/ha/yr$)	-0.1

Source: original elaboration for this publication

Table 58: Agroforestry – walnut / fruit

Aspect	Assumption in model
Description	Agroforestry models combine annual with perennial crops. In this model, walnut and fruit trees are planted in the agroforestry type "orchard." The plots will be set up on former grasslands. Due to the high soil carbon stocks, transforming grasslands into other land uses results in carbon emissions rather than sequestration. The overall emission balance would be positive. We use the sequestration of (tree) biomass without counting in effects on SOC because we assume that SOC stock stays stable in both baseline and project scenario. Instead of chemical fertilizers, some manure will be applied. Tillage will be reduced, and drip irrigation installed.
Baseline scenario: Initial land use type	Grassland (as per IPCC 2006/2019)
Land use after intervention	Agroforestry: Orchard – Reduced tillage, medium C input, no residue burning (as per IPCC 2006/2019)
Implementation phase / capitalization phase (years)	3 / 17 years
GHG emission balance ($tCO_2e/ha/yr$)	-1 (without SOC)

Source: original elaboration for this publication

Table 59: Agroforestry – poplar

Aspect	Assumption in model
Description	In this model, poplar trees are planted in the agroforestry type "Short Rotation Coppice." The trees will be harvested in the year 20 for timber and firewood usage. The plots will be set up on former grasslands. Due to the high soil carbon stocks, transforming grasslands into other land uses results in carbon emissions rather than sequestration. The overall emission balance for this model would still be negative, but we use the sequestration of (tree) biomass without counting in effects on SOC because we assume that SOC stock stays stable in both baseline and project scenario. Instead of chemical fertilizers, some manure will be applied. Tillage will be reduced, and drip irrigation installed.
Baseline scenario: Initial land use type	Grassland (as per IPCC 2006/2019)
Land use after intervention	Agroforestry: Short rotation coppice – Reduced tillage, medium C input, no residue burning (as per IPCC 2006/2019)
Implementation phase / capitalization phase (years)	3 / 17 years
GHG emission balance (tCO_2e/ha/yr)	-2.4 (without SOC)

Source: original elaboration for this publication

Annex 11. Readiness assessment

Political leadership

The State Forest Service is the national focal point for the Bonn challenge and all processes related to FLR. SFS prepared the country's FLR pledge in 2018 and participated at the Astana roundtable. The areas of forest and pasture proposed for restoration were compiled from existing government reforestation / afforestation programs and from projects of international cooperation organizations or development banks funding restoration activities. These government and international cooperation programs had their own timeline and allocated resources, which were already secured at the time when the pledge was prepared.

After the Astana roundtable, no specific roadmap for fulfilling the pledge was developed, nor was a specific mechanism set up to monitor the implementation of the pledge by different partners. At the political level, there was no follow-up meeting with other key national partners, particularly with the Pasture Department responsible for restoring 150,000 hectares of pasture. This lack of initial coordination limited the emergence of a political process around forest landscape restoration in the country.

Since 2018, there has been a high turnover of directors of the State Forest Service. Some of the new managers had limited knowledge about FLR and the Bonn challenge, which prevented a continuous political dialogue on land degradation and restoration.

Managers at SFS also mentioned that since 2018, there has been no reporting requirement set by the Bonn challenge secretariat, not by regional initiatives related to it (e.g., ECCA 30) or by supporting organizations like UNECE. This did not encourage the Agency to actively coordinate restoration efforts.

Today, there is no political leadership on FLR in the country and the number of decision makers aware of the pledge of the Kyrgyz Republic is limited to a few managers at SFS. The recent restructuring of the government, with the Pasture Department and SFS being now both included in the Ministry of Agriculture, opens new avenues for close cooperation.

Policy and legal framework

Enabling policy environment

As outlined in the inception report, several national and sector strategies set out objectives and activities that are in line with FLR priorities. In the forest sector, the main policy document is the Concept of Forest Sector Development 2040 which aims at the sustainable management of forests to ensure the economic well-being of the population, social prosperity, and environmental sustainability.

In the pasture and agricultural sectors, the recently updated NDC is the new main policy document guiding the development strategies of these sectors. A more detailed Strategy on Agricultural Development of the Kyrgyz Republic for 2021-2025 is under development.

There is therefore a solid policy framework based on which FLR measures can be promoted and implemented in all relevant sectors. Nevertheless, national partners underlined the poor integration of these national strategies and the lack of clear policy for coordinating international processes involving several governmental organizations.

Legal framework

From a legal point of view, the sustainable use of natural resources and the restoration of degraded lands is under the responsibility of different stakeholders, acting at different scales.

Forest lands: SAF is responsible for sustainable forest management, for increasing forest cover and for ensuring forest regeneration. It is also in charge of monitoring and controlling the use of forest and pasture resources within the State Forest Fund, and of limiting soil erosion (Forest code, 2013). National partners pointed that the Agency has the required legal means to implement its functions, including measures related to forest landscape restoration. They however outlined several legal loopholes (e.g., unclear legal provisions about pasture management in the SFF), which sometimes prevent an efficient implementation of restoration efforts. Another important aspect to take into consideration is that an important part of the Kyrgyz Republic's forests (walnut, almond, and pistachio forests) is leased on a long-term basis to private tenants, to members of local communities. These tenants endorse the formal responsibility to sustainably use forest resources on their plot and ensure their regeneration. There are legal provisions through which forest management units can terminate a lease agreement in case there are signs of degradation resulting from unsustainable management. However, such decision is difficult to enforce due to the sensitive socioeconomic context in rural areas. This jeopardizes the ability of SFS to effectively control forest degradation and efficiently implement in areas that are leased out.

Pasture lands: Since the 2009, the law "on pastures" has decentralized functions and responsibilities for pasture management, use, improvement, and monitoring to pasture committees at municipality level. Pasture committees are under the general steering of the Pasture Department of the Ministry of Agriculture which defines pasture management policies for the country. However, the PD has limited legal possibilities to influence the work of pasture committees: the law "on pasture" specifies that government institutions should not intervene in the activities of PC, including on the way they allocate their annual budget. According to representatives of the Ministry of Agriculture, the result is that pasture committees spend their financial resources on activities that are not the most needed to restore pasture resources.

Agricultural lands: The law on the conservation of soil fertility in agricultural lands from 2012 regulates land use and management practices with impact on fertility, soil conservation and other negative impacts. It introduces legal, organizational, and financial measures aimed at preventing soil degradation in the country.

National and regional partners mentioned several legal issues connected to financing restoration measures. They are developed in the next sub-section.

Financing instruments

Forest lands: 90 million KGS are allocated annually to reforestation and afforestation activities. This budget allows the plantation of 1,100 hectares per year. However, since 2017 the forest sector has not received more than 50% of this planned budget. The first reason was the introduction of a new budget code in 2017 which, due to some gaps in disbursement procedures, prevented a full allocation of the state budget. In 2020, the COVID-19 pandemic drastically reduced the state budget and only 20% of the expected funds were allocated to forest plantations. In the meantime, SFS reported in the same years 2,500 to 3,000 hectares of annual, thereby exceeding by up to 300% the initial plan. This, according to SFS, was possible thanks to the additional funding received from international cooperation projects financed by the World Bank, FAO and GIZ. The forest plantations planned within these projects were included in the country's pledge. These projects are either closed (FAO), or going to close (World Bank, GIZ) in 2022-2023. Two new projects with objectives to restore large areas of pasture and forest lands are expected to start in the coming years, financed by GCF-FAO ($50 million including $30 million grant money) and IFAD ($9 million). For example, the latter project sets out an objective – and $4 million – for restoring upstream forests, which is of high relevance for the Naryn River Basin.

SFS representatives indicated that forest management units have a certain flexibility in reallocating part of their financial resources to restoration measures, if this is included in their program-based budget which is developed one year ahead. Interviews with forest management units do not confirm this statement, but rather that their proposals for budget reallocation are usually not approved.

Beyond the general lack of funding from the state budget, SFS representatives underlined the seasonal character of forest restoration measures, implying a timely transfer from the state budget to forest management units. Recurrent delays prevent an efficient implementation of these measures.

Private investments are also increasing, often building on approaches and models piloted in the frame of international cooperation projects. Cost-efficient forest plantation and restoration models are now being upscaled by small-scale tenants (1-5 ha), in walnut, pistachio, and almond forests. Larger-scale investments in high-productivity fruit orchards (up to 30 ha) have gained greater attention, specifically in low-productive lands where irrigation is available.

Pasture lands: At the national level, the Pasture Department does not have a budget for pasture restoration since pasture management and use has been delegated to pasture committees.

Along with these responsibilities, PC must collect use fees among their members. This fee, set by the municipal authorities within the limits set by law, is low, e.g., §$1 per sheep head for a grazing period of 5-6 months. The accumulated budget is meant to cover administrative costs (salary, transport costs) and activities aimed at improving pasture conditions. This budget does not cover all the needs. For example, a typical pasture committee of Naryn province interviewed during the assessment reported an annual budget of $5,900. After deducting administrative costs, only $1,200 is available for infrastructure improvement. This is a real limitation towards the implementation of restoration measures. One of the interviewed pasture committees stressed that the lack of financial resources prevents building key infrastructures which are a prerequisite to pasture restoration, e.g., a bridge to destock livestock from degraded pasture, or a water point on a remote pasture where no water is available otherwise.

Meanwhile, pastures lands have been the focus of several investment projects in the last years, financed by the World Bank and IFAD. Selected pasture committees received machinery (e.g., loaders, graders), equipment, fencing material etc. This had a visible impact on the ground with improved access infrastructure and the enforcement of seasonal grazing bans through large-scale fencing. For example, one of the interviewed pasture committees fenced 7 kilometers thanks to IFAD financing, thereby excluding summer grazing, and enabling the restoration of 40,000 hectares in summer.

Pastures located in the SFF (34% of the country's total pasture area, or 3 million ha) are managed by the State Forest Service. However, pasture management not being a formal responsibility of SFS, this land is not actively managed but rather seen as a source of income. Would a forest management unit want to improve infrastructure to access pasture, the budget framework does not allow for budgeting such expenses, which needs to be included in other forest-related budget lines, for example improvement of firefighting infrastructure.

Agriculture lands: Credits for agriculture machinery, inputs (fertilizers, pesticides, seeds) are available from commercial banks. There are also specific credit programs subsidized by the government.

Technical feasibility of restoration measures

Forest lands: Forest management units show diverse technical capacities, in relation to the equipment they own and have access to through leasing. Most equipment left from the soviet period is not functional anymore and FMUs nowadays primarily depend on investments to procure machinery, such as cars, tractors etc. which they need in their daily activities. In this respect, FMUs, having received support in the past years from FAO and World Bank possess most of the machinery they need to implement the prioritized restoration measures. FMUs which did not benefit from these projects can procure services from private companies for, for instance, infrastructure construction. However, this mechanism is not as versatile as owning its own machines.

Pasture lands: The situation with pasture committees is like that of FMUs, with even more significant differences between PCs which received project support (from IFAD and World Bank) and those which did not. Nevertheless, pasture committees are under political pressure from their members and the local authorities, and they manage to mobilize technical means to implement – at least basic – measures. For example, some pasture committees rent machinery from the local or district administration. Others design low-cost activities and outsource their implementation to private contractors (some examples observed in the field are building check dams on temporary rivers to improve water retention). This type of low-cost measure typically needs to be repeated every year.

Synergies between forestry and pasture sectors: During field visits, several examples of large-scale restoration measures showed clear linkages between the ability of PCs and FMUs to coordinate their efforts and mutualize their technical resources, and the success of their restoration efforts. This observation also applies to non-infrastructure activities which are technically easier to implement if a local agreement is reached. For example, in Naryn province, a PC and the local FMU agreed on a specific period (June-November) during which livestock should not enter a specific valley. Both stakeholders pooled their resources to have people permanently on the ground controlling the full enforcement of this agreement.

Regardless the availability of external resources, local interview partners underlined that restoration measures can only be successful where their implementation follows a systemic approach, underpinned by strong local political decisions and a clear agreement with users. An example of this is the agreement reached in a village of Naryn province about the introduction of a grazing ban in a specific area during summer months. Shepherds agreed to this only after they were promised better access (improved bridge) and living conditions (shepherds' huts) on remote pasture. This agreement was formalized in a local decree and is being successfully enforced.

Agriculture lands: Among the prioritized measures in the agriculture sector, the effective use of water resources and crop rotation/ cover crops are known practices which do not bring about technical difficulties. Their further dissemination primarily relies on financial resources available (e.g., water-saving irrigation systems) and on improved knowledge among land users (e.g., cover crops). No- and limited tillage is the measure which has the biggest technical limitations in the country. Currently, there are only three no-tillage seeders in the country, none in the Naryn and Toktogul provinces. They were procured as part of cropping experiments and are not available for lease. The implementation of no-tillage agriculture thus relies on the import of additional machinery in the country.

Knowledge and skills

National level

The level of knowledge of national level partners about the concept of FLR can be improved across all sectors. As already described, this is due to a lack of coordination between relevant ministries and a lack of political leadership of SAF on the topic. Nevertheless, experts of the Ministry of Agriculture (Pasture Department and Plant Production Department) have good knowledge of modern soil and pasture restoration practices. Numerous trainings and exchanges with other countries have increased the general understanding of ministry staff about soil management, efficient use of agricultural inputs etc. Nevertheless, specific skills are missing, for example how to implement a modern pasture monitoring system leading to clear recommendations for sustainable management. Such skills are available among NGOs and international organizations but are not yet being applied by government institutions.

The situation in the forest sector is different and most of the activities planned at central level are still guided by concepts and practices dating back to the Soviet period. A strong focus is given to afforestation, although new plantations (especially spruce plantations in the Naryn River Basin) offer limited economic and social benefits. At the same time, little attention is given to the sustainable management and regeneration of existing forests, while several studies highlight a low regeneration rate and over-aging of existing stands caused by unproper management and overuse. The numerous projects and exchanges implemented in the sector over the years did not lead to any notable change in this regard. It can be partly attributed to the fact that there is no clear definition of forest degradation in the country which limits the awareness of ministry-level experts about this phenomenon. There are ongoing discussions within SFS about defining clear criteria for forest degradation and this will hopefully trigger changes in the responses given to degradation in the future. UNECE (United Nations Economic Commission for Europe) has also started training central Asian policy makers on sustainable forest management indicators, which is particularly relevant to promote the implementation of restoration measures.

Local level

Forest lands: Local foresters possess basic knowledge about the establishment of forest plantations and have the required capacities to perform their day-to-day activities. However, like at the national level, most knowledge is outdated. It results in the production of low-quality planting material, in an average low survival rate of forest plantations and on a lack of attention to more urgent issues like forest regeneration. This situation is difficult to revert to as there is no dedicated training center in the forest sector which could be used as an entry point to introduce modern forest management practices. This is exacerbated by the high turnover of foresters at the local level which makes knowledge management even more difficult. Academic courses on forestry are offered at the Kyrgyz National Agrarian University but due to low wage levels, most graduates do not work in the sector. Many local foresters – particularly the young generation – learn on the job and have no forestry degree.

In terms of knowledge related to degradation, the attention of local foresters is directed to eroded areas, and to areas where there are signs of illegal cuttings. To a lesser extent, poor forest regeneration is also regarded as a sign of degradation. Knowledge of unsustainable forest structure (e.g., overaged forest) is missing. In terms of response to degradation, foresters are limited to outdated technologies which have proven to be inefficient in the new land use setting that followed the end of the Soviet Union. During field work, unrealistic restoration planning was also observed in one of the visited FMU, where foresters plan to strengthen an eroded riverbank of the Naryn river through standard tree planting. Given the hydraulic characteristics of the Naryn river, this obviously cannot lead to any result. This situation again reveals the low level of knowledge about restoration measures.

Several FMUs were trained in pasture monitoring and in assessing pasture health using the Grazing Response Index. However, it needs continuous training and resources, as well as several years of field implementation before this knowledge can be anchored at FMU level.

Pasture lands: For pasture committees, the most evident sign of degradation is an increase of bare soil and associated soil erosion. Experienced pasture committee leaders and pasture users can also assess degradation based on shifts in vegetation patterns.

An important observation from field work is the frequent reference to climate change as a key factor of pasture degradation. Pasture committees often refer to a decrease of precipitations in the lowlands, impacting close-to-village pastures. The past years have indeed been characterized by summer droughts with 2021 being the worst of all.

District-level pasture management bodies and pasture committees start to openly talk about the need to shift from livestock quantity to quality. It is a new tendency showing a change in their mindset which can be attributed to a mix of their own field observations (livestock productivity decreases in degraded areas) and awareness raising by NGOs and international organizations.

In terms of restoration measures, pasture committees have good knowledge about the positive impact of seasonal or pluri-annual grazing bans. They understand that having enough fodder in winter is critical which implies increasing the productivity of haymaking fields by banning livestock from close-to-village pastures in late-spring and early-autumn. Likewise, improving pasture infrastructure is one of the most cited restoration measures by PCs which shows good knowledge about the necessity to distribute the stocking rate between close-to-village and remote pastures. Rotational grazing is less known, and PCs and pasture users are not familiar with the indicators and thresholds to determine the timing and proper implementation of this mechanism. In general, the knowledge of pasture committee representatives regarding degradation and restoration seems sufficient. This is however jeopardized by the high turnover of pasture committee leasers.

Socio-cultural aspects

During the interviews, several questions were meant to clarify whether certain socio-cultural patterns can be either an enabling, or a limiting factor for the large-scale implementation of restoration measures in the country.

Forest lands: Regarding forest restoration, it was found that there is a continued conflict between forest management units and pasture users related to illegal grazing in forest plantations which sharply reduces their survival rate. Even in cases where plantations are fenced there are reported cases of pasture users damaging the fence to let their livestock in. This type of local conflict can be a serious limitation to successful forest restoration.

Most Kyrgyz forests are overgrown. Their regeneration implies specific sylvicultural operations, including sanitary cuts and thinning. While thinning is prohibited by law for high-value tree species (walnut, juniper), sanitary cuttings are still possible. However, social media influencers and environmental activists have in the past years publicly accused forest management units of illegal wood harvesting. One of the forest enterprises interviewed acknowledged that since these publications, they have halted even sanitary cuts to avoid being the target of any further accusation.

Pasture lands: As indicated in above, pasture committees can allocate their budget in a flexible manner, in line with the pasture management plan developed with pasture users. It means that the decision of financing one or the other measure is partly driven by the pressure put by pasture users on the head of the committee. The Pasture Department stressed that in some cases, financial resources were allocated to activities that were politically important at the local level, but had limited impact on pasture restoration (e.g., improving road infrastructure within a settlement, instead of access roads to summer pastures).

On the positive side, several pasture committees see a tendency towards shepherds returning to remote winter farms which were partly abandoned at the end of the Soviet Union. Where this is not practiced yet, PC encourages shepherds to resettle in these farms to destock close-to-village pastures.

Agriculture lands: Some of the prioritized restoration practices in agriculture, for example no-tillage, require purchasing new equipment which is currently not available for lease in the country. The associated costs are too high for an average farmer but given the country's experience with collectivization, farmers are not ready to pool their resources and invest collectively in this kind of equipment.

Annex 12. Climate financing tracking

Financial support tracking under the former SAEPF

The functions of the former SAEPF (State Agency for Environmental Protection and Forestry) are now split between SFS and the Ministry of Natural Resources, Ecology and Technical Supervision. SAEPF was regularly collecting information on forest and biodiversity development projects from development partners and project implementation units under SAEPF (e.g., World Bank PIU (Project Implementation Units) on Integrated Forest Ecosystem Management Project). There was also a Monitoring Commission under SAPEF which conducted annual meetings with project staff to review project implementation. Data on climate finance flows of environment-oriented projects implemented by non-government organizations are currently not collected, and there are political sensitivities about government agencies requesting such information from civil society organizations.

SAEPF had access to detailed information on public budget financial flows to forest and biodiversity sectors since these areas are within the SAEPF structure. The public budget financial flows were channeled to Leskhozes and protected areas through SAEPF central level economic management department.

Financial support tracking under the Ministry of Finance

The Ministry of Finance collects financial and non-financial performance of ODA projects monthly using a specific form reported by implementing agencies (typically Project Implementation Units). These reports are backed up with quarterly meetings between the Ministry of Finance and project representatives. In-depth meetings are also held annually. Such monitoring is typically backed up with analyses of annual audit reports of projects of international cooperation organizations or development banks (World Bank 2014).

In 2014 the World Bank conducted a Public Expenditure Review which identified the following challenges in public investment management:

- Project monitoring is concerned with financial monitoring and is passive. Except for projects of international cooperation organizations or development banks, monitoring of non-financial dimensions of project progress is not happening, except on an ad hoc basis.
- The financial monitoring system is not capable of tracking changes in i) the disbursement profile of a project; ii) total estimated project costs; and iii) estimated completion date compared to plan.
- Performance monitoring implementation which involves tracking the achievement of the project purpose, i.e., the flow of benefits to the target groups through improved public service delivery (volume, quality, and accessibility of services) resulting from realization of the project, is mixed with ordinary project monitoring.
- Good indicators and a baseline are required in project design for monitoring and tracking progress and later ex post evaluation. There is no ex post systematic evaluation of completed projects to determine whether they represent an efficient and effective use of public resources, either by government, international cooperation organizations or development banks. This evaluation should become increasingly important as the country

moves towards performance-based public management and budgeting.

As for public budget flows, there are codes (7054, 70422) which track expenditures related to biodiversity and forestry in the public budget classification approved by the Decree of Ministry of Finance #161-П Dated December 21, 2017.21F[33] There are currently no budget codes for adaptation or mitigation.

Financial support tracking under the Ministry of Economy and Commerce

According to the recent Government Decree #389 Dated on 19.06.2017, Ministry of Economy and Commerce tracks external technical and grant support. The ministry requests the general information (incl., project title, name of international donor, project scope, objectives and tasks, period, project components and activities, budget and co-financing, beneficiaries, and results with indicators) about the project when it comes for registration from public implementing agencies which receive support. SAEPF therefore had all the information provided to the Ministry of Economy and Commerce about technical and grant support projects implemented by SAEPF. Within the project implementation, public implementing agencies provide information on progress of project activities, their results, analysis, and obstacles related to project implementation and proposals for efficient project implementation to the Ministry of Economy and Commerce on a quarterly basis. After project completion, the implementing agency informs about activities, achieved results, conclusions, and recommendations.

Financial support tracking under the National Statistical Committee

The National Statistical Committee quarterly collects information on FDI directly from enterprises and publishes the aggregated information (e.g., financial volumes, regional distribution) on its website. In addition, NSC (National Steering Committee) reports on implementation of SDG/SEEA initiatives which include inter alia financial support.

Besides, civil society organizations (CSO), including those carrying out activities in environmental protection, report regularly to NSC. However, the level of data aggregation provides information on revenues and use of funds of CSOs. According to the annual report of NSC Enterprise Finances of the Kyrgyz Republic for 2012-201622F[34], the total revenue is 8.02 billion KGS, while the total expenditure is 7.07 billion KGS for 201623F35. The figure for the total number of CSOs is 19.1 thousand registered non-commercial organizations, only 30% of them have reported. 36 CSOs out of 19.1 thousand registered organizations represent the environmental sector. So, it is not feasible to identify the number of financial flows of CSOs in biodiversity and forest development areas. However, the small number of environment-oriented SCOs would suggest that they are not likely to contribute significantly to the total amount of climate-related finance. Given political sensitivities about requesting information from CSOs, it is not a major omission if this source of funds is not currently tracked in the MRV system.

Financial support tracking under the National Bank

National bank supervises financial institutions in the Kyrgyz Republic and regularly collects information about financial operations. It may be possible to track climate finance flows to forestry and biodiversity sectors channeled through financial institutions (commercial banks, microfinance organizations, and credit unions). However, review of NBKR's statistics on its website shows that NBKR does not specify climate related loans issued by financial institutions, and its sectoral breakdown is not specific for forestry and biodiversity. The total

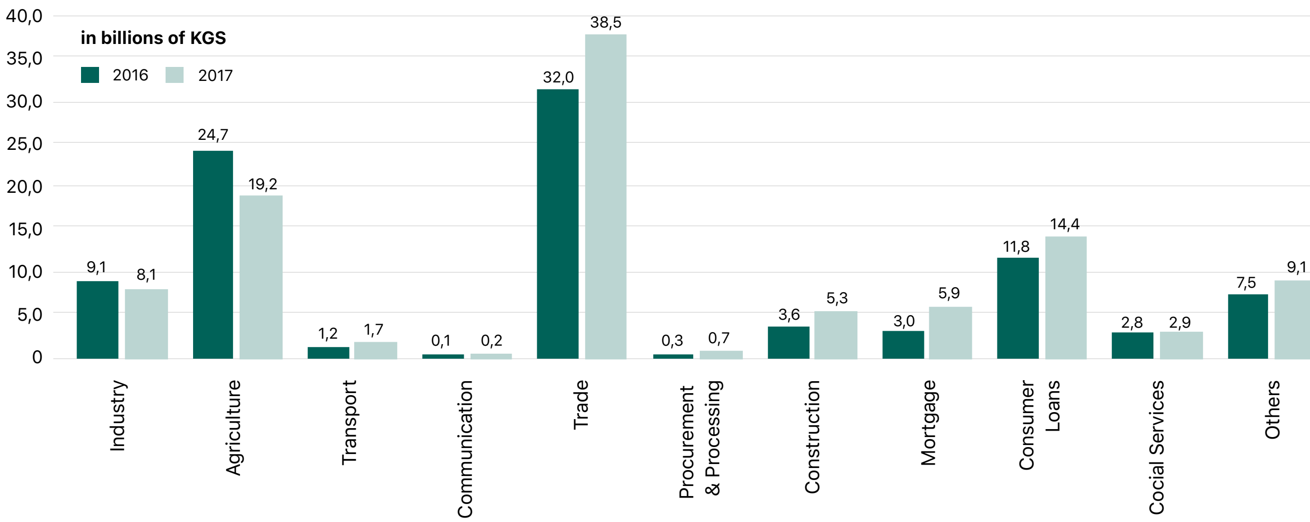
33 This budget classification can be revised and approved at the level of the Ministry of Finance. http://minfin.kg/ru/novosti/byudzhet/byudzhetnaya-klassifikatsiya.html

34 http://www.stat.kg/media/publicationarchive/9fafb93b-d123-461f-a5b8-668576a1a53d.pdf

35 Figures for 2017

amount of the bank loans for 2016 and 2017 are 96.0 and 106.0 billion KGS, respectively. Currently, on NBKR's web-site information is broken down by sectoral areas presented in the Figure 48 below.

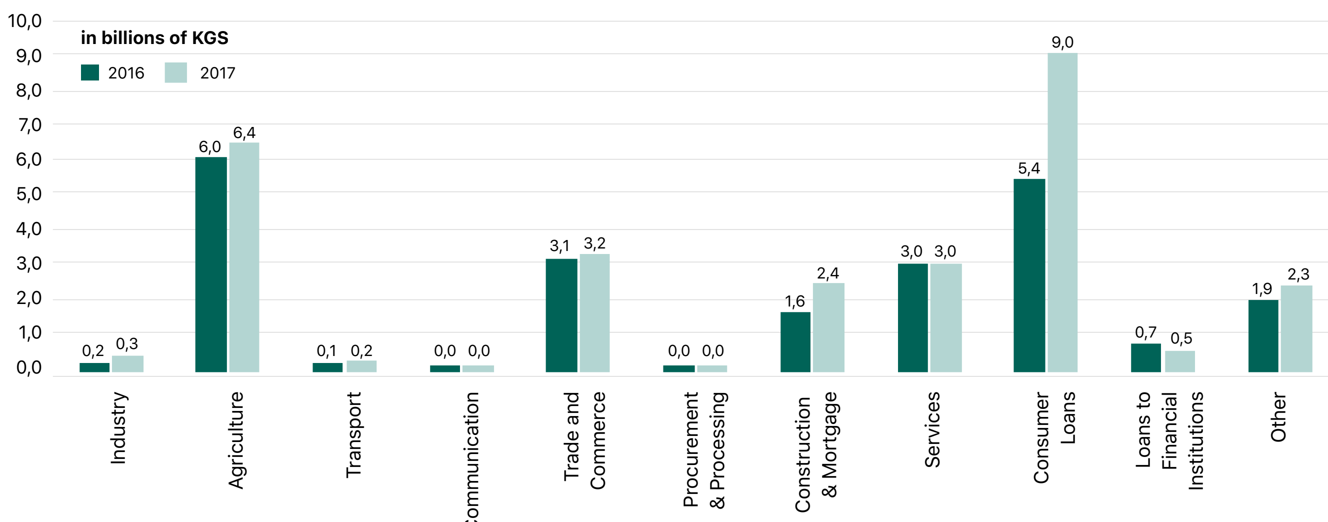
Figure 48: Loans issued by commercial banks in the Kyrgyz Republic, 2016-2017



Source: NBKR, 201724F[36]

A similar situation exists with data disaggregation of financial flows of microfinance organizations and credit unions, i.e., the data is available at similar sectoral breakdown (Figure 49). The total amount of their issued loans is 22.1 and 27.4 billion KGS for 2016 and 2017, accordingly.

Figure 49: Loans issued by microfinance organizations and credit unions in the Kyrgyz Republic, 2016-2017



Source: NBKR, 2017.25F[37]

36 http://www.nbkr.kg/index1.jsp?item=1550&lang=ENG

37 http://www.nbkr.kg/index1.jsp?item=2265&lang=ENG

For now, such sectoral disaggregation of data does not allow to extract the data on climate related financial flows of financial institutions. Nevertheless, SFS and the Ministry of Natural Resources, Ecology and Technical Supervision could consider discussing with NBKR the possibility of collecting information based on mitigation and adaptation targets in biodiversity and forestry sector in future.

Verification of information on climate-related finance: The Ministry of Finance analyzes the implementation of the Public Investment Program while the Chamber of Accounts annually audits the efficiency of use of public budget resources, external credits, and loans, as well as humanitarian aid received by Government.

In 2014, the World Bank stressed the importance of the Chamber of Accounts to lead the evaluation of public investment projects (using risk-based sampling). In 2015, the Chamber of Accounts developed a performance audit methodology for Public Investment Program (PIP) projects and conducted pilot audits with local consultants' support. A performance audit is an independent, objective, and reliable examination of whether undertakings, systems, operations, programs, activities, or organizations are operating in accordance with the principles of economy, efficiency, and effectiveness, and whether there is room for improvement. The methodology is aimed at the introduction of evaluation of PIP projects with the focus on project design, implementation, and sustainability. The methodology provides a qualitative approach for assessing the achievement of project objectives within the project implementation. This can be particularly suitable to assess if the project achieves climate change-related objectives (e.g., afforestation targets).

In addition, the recently established Climate Finance Center has been given the task of conducting verification of GCF-funded projects.

Annex 13. Payment for Ecosystem Services

Ecosystem services valuation and accounting

The term 'valuation of ecosystem services' is not defined under the law (6th report to CBD, 2019). Previously, a range of studies assessed the economic value of ecosystem services at the level of several watersheds and protected areas (CAREC, 2016; UNDP-UNEP, 2017; GEF-FAO, 2018). These studies provide useful information on the type and accuracy of data that is available and can be used in the Kyrgyz Republic for the valuation and mapping of ecosystem services, as well as data gaps that need to be further addressed.

At the national level, GIZ took in 2014 in collaboration with the National Statistical Committee (NSC) and the SAEPF the first steps to support the Kyrgyz Republic develop a System of Ecological Evaluation and Accounting (SEEA). This project focused on capacity development, awareness raising about SEEA among policy makers, institutional support, and the compilation of fast-track forest accounts. In 2015, the UNDP-UNEP Poverty and Environment Initiative together with the Research Institute for Global Change of the Czech Academy of Sciences piloted an Experimental Ecosystem Accounting (EEA) exercise as part of the UN System of Environmental Economic Accounting program. This study focused on a specific forest enterprise (Kyzyl-Unkur) and produced various training materials as well as an implementation guide for SEEA-EEA in the country. Based on this project, the NSC developed a statistical form to gather data from forest users on the types and volumes of forest products they collect. It raised a lot of concerns among communities who feared it could be used to increase tax payments. The introduction of this form was therefore put on hold.

In 2017, the Kyrgyz Republic joined the WAVES initiative of the World Bank. A recent publication (2020) from this project presented the Forest Accounts Technical Report and Data in which provisioning, cultural and regulating ecosystem services of the forest fund of the Kyrgyz Republic are valued as $156.5 million per year. A set of recommendations and tasks ranging from legislative to organizational and methodological aspects was developed to further strengthen forest accounts in the coming years.

Annex 14. Policy Brief

The policy brief has been elaborated as a standalone document, which is presented below.

Policy Brief

FOREST LANDSCAPE RESTORATION (FLR) OPPORTUNITIES IN THE KYRGYZ REPUBLIC

This policy brief outlines the main results of a restoration opportunities assessment (ROAM) conducted in the Kyrgyz Republic. This assessment identifies degraded forest and pasture areas, investigates the correlation between land degradation and sedimentation in Toktogul Reservoir, and offers clear proposals for feasible and effective forest landscape restoration measures in the country, with a special focus on the upstream part of the Naryn River Basin.

The Kyrgyz Republic is one of the countries in Central Asia most vulnerable to climate change. Climate-related disasters combined with unsustainable land use practices already affect the rural population, which depends on natural resources. Land degradation and the consecutive transport of sediments can negatively impact hydropower facilities. In the Kyrgyz Republic, Toktogul hydropower plant, fed by the Naryn river, generates up to 50% of the total electricity production in the country and plays a key role in the country's energy security. The Naryn River Basin is also a key area to tackle land degradation in a sensitive transboundary context.

METHODOLOGY

Priority restoration options were identified in consultation with key national partners and experts (table1). Three restoration measures were prioritized per land use category, as well as two protective measures.

Degraded pasture and forest areas were mapped based on a mix of remote sensing and ground truthing. A **restoration opportunity map** was generated by further subtracting areas where restoration is not feasible or relevant (land above 3,500 m.a.s.l., slopes steeper than 30 degrees, and protected areas). In the Naryn River Basin, an assessment of the capacities and experience of local land managers about restoration interventions made it possible to identify **priority areas for restoration.**

Economic costs and benefits of all restoration measures were compiled in per-hectare models (environmental services included), allowing to compare the long-term economic impacts of different restoration options. Carbon benefits were included in the calculation with a sensitivity analysis of carbon prices.

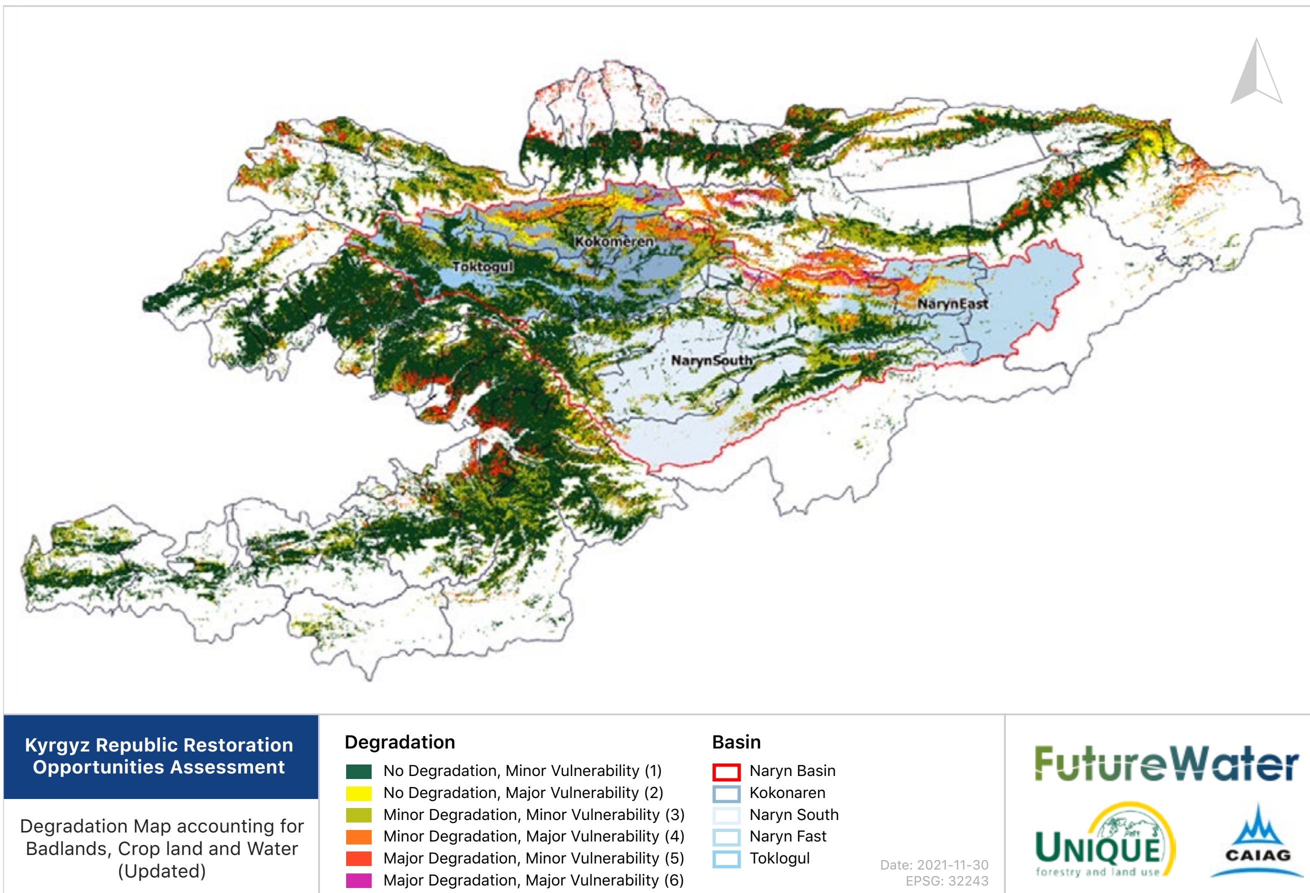
Several **financing options** were reviewed: direct investments by international cooperation organizations and development banks, payment for ecosystem services (PES) and private investments.

A **readiness assessment** examined the existing national and sector policies to identify enabling strategic documents and bottlenecks for scaling FLR. It was complemented by semi-structured interviews with key national and local stakeholders.

FINDINGS

Major degradation hotspots can be observed in the western part of the country and directly to the southeast of Issyk Kul Lake. Within the Naryn River Basin, stretches along the basin's northern edge are also considered degraded as shown in Figure 1 below.

Figure A1: Map of overall land degradation



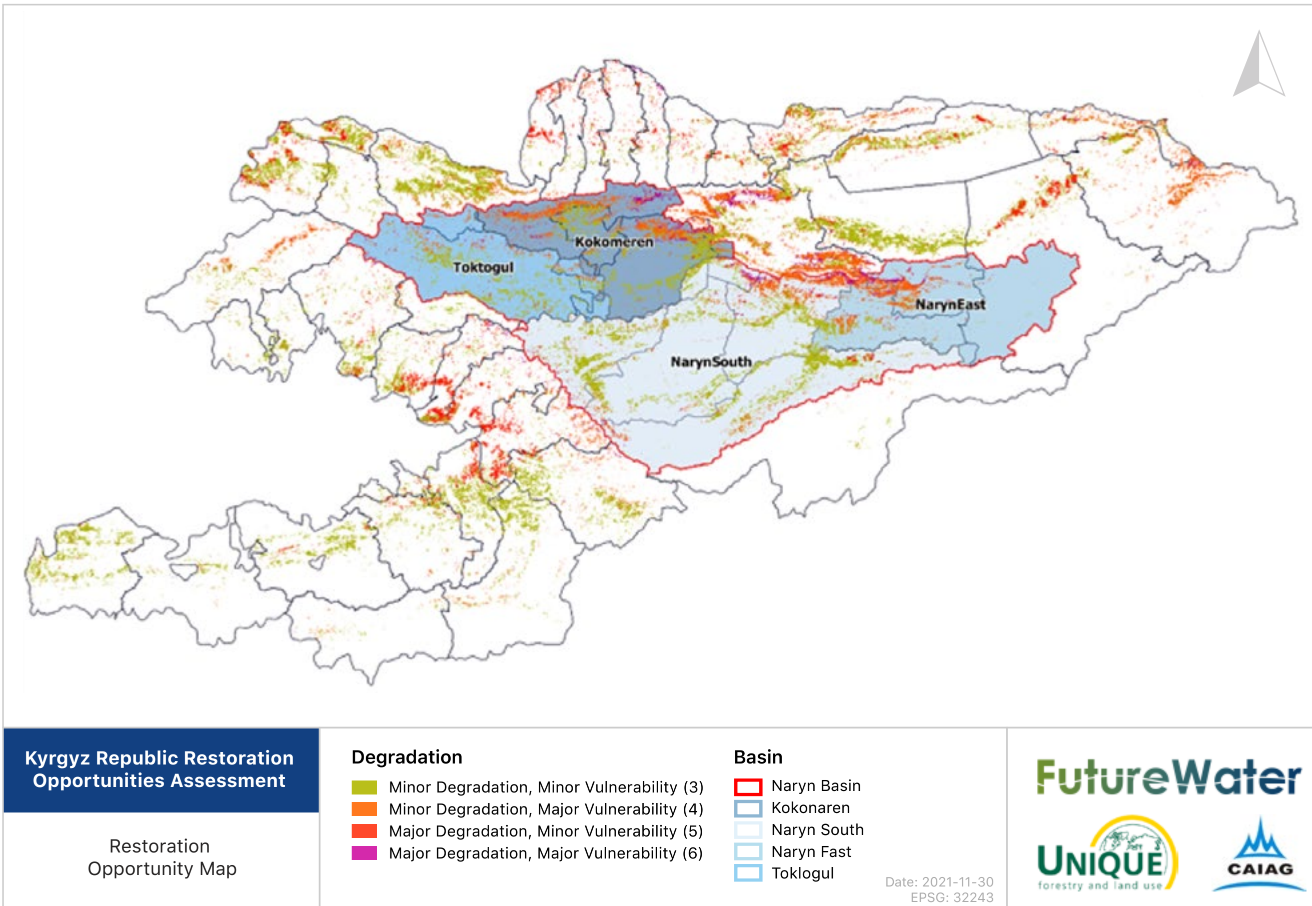
Source: original elaboration for this publication
Note: White areas contain non-forest or pastureland use classes (e.g., high mountain areas, croplands, water bodies)

From these degraded areas, a total of over 1.5 million hectares at national level (8% of the total country area) offer high restoration opportunities. Pastures account for 98.7% of the total and forests only 1.3%.

Areas with high degradation levels and high restoration opportunities were identified within and outside Naryn River Basin. The results are shown in the map of restoration opportunities below (Figure 2). Based on a set of prioritization criteria defined in a workshop, priority areas within the Naryn River Basin where local stakeholders have proven to be active and experienced with restoration were further identified. Four state forest enterprises and 14 pasture committees were given a high priority for restoration in the Naryn River Basin.

Based on this map, restoration investments are recommended on 8,909 ha of forest areas, 39,818 ha of pastureland and 1,300 ha of croplands.

Figure A2: Map of restoration opportunities within and outside Naryn River Basin, constructed from the overall land degradation map with non-feasible areas subtracted



Source: original elaboration for this publication

Most prioritized restoration measures generate economic benefits over the 20-year reference period. Riverbank protection provides the highest benefits, from avoided damage to infrastructure and settlements. Forest restoration and afforestation with nut-bearing trees (walnuts, pistachio) generate high and multiple direct benefits, including nuts and hay. Similar activities in spruce forests do not generate economic benefits due to slow tree growth in mountain conditions. All measures on agricultural and pastureland generate monetary benefits, with improved irrigation and no-tillage taking the first positions. All measures generate high environmental and social benefits. The total up-front costs to finance restoration (1st year investment) in the identified areas amount to over $45.36 million, including $2.28 million to administrate the investments and build capacities of the national partners.

Table A1: Cost-benefit analysis of prioritized restoration measures

Topic	Measures	IRR value. %	NPV Value. $
Pasture management	Grazing ban	16	923
	Access to remote pastures	19	1,268
	Rotational grazing	19	1,256
Afforestation / reforestation	Walnut Forest	31	13,680
	Pistachio	11	633
	Spruce forest	-9	- 1,821
	Riparian forest	16	3,174
Assisted forest regeneration	Walnut forest	31	10,054
	Pistachio forest	N/A	- 2,207
	Spruce forest	N/A	- 2,959
Crop management	Watering improvement	49	4,324
	No tillage	23	3,447
	Crop Rotation	2	2,398
	Agroforestry	20	1,600
Protective lands	Green infrastructure	N/A	727,581
	Grey infrastructure	N/A	726,255

Source: Original elaboration for this publication

There is limited finance available from the State budget to implement restoration interventions. Investments in pasture restoration are more difficult to capture, as they are financed by the local budget. Land users are increasingly interested in investing in restoration activities. This trend concerns agriculture land, less forest land (except in fast growing plantations) where the legal framework makes investments more uncertain. Payment for Ecosystem Services does not offer a high opportunity for financing FLR since there is currently no demand for reduced sedimentation and no additionality (no clear correlation between land degradation and sedimentation).

Thus, **financing forest landscape restoration in the Kyrgyz Republic Requires investments from international cooperation projects or development banks.**

In terms of readiness**, There is a general lack of awareness on FLR at THE political level.** The topic could be more actively lobbied within the government. The coordination of restoration efforts between the pasture and forest sectors could also be enhanced.

Local land users and managers possess good knowledge on pasture degradation and restoration. There are successful examples of cooperation between local land managers to pull resources together and implement restoration interventions in pasture and forest lands with scaling potential. There are fewer experiences connected with the restoration of degraded agriculture land.

There is no institutionalized capacity building mechanism in the forest and pasture sectors, and the further dissemination of knowledge on land restoration is highly dependent on initiatives from international cooperation organizations or development banks.

RECOMMENDATIONS

The following recommendations aim at enhancing restoration readiness and creating an enabling environment for FLR in the country.

Table A2: Recommendations

Topic	Key activities
Political leadership	▪ Create awareness among government officials on FLR and on the opportunities offered by the Bonn Challenge and associated initiatives to leverage funding to implement restoration measures at scale.
	▪ Support inter-ministerial coordination on FLR to align national and sector strategies
Policy and legal framework	▪ Identify avenues for coordination between national sector strategies. Develop specific actions to ensure cross-cutting topics are jointly addressed by respective ministries
Financing instruments	▪ Streamline investments of development partners to the priority restoration measures and areas identified during ROAM analysis
	▪ Scale-up private investments in restoration through specific finance support programs (e.g., subsidies, low-rate credits etc.) and a favorable tax environment (e.g., tax holidays)
Technical feasibility	▪ Upgrade equipment and machinery of local land management institutions (governmental and non-governmental)
	▪ Create awareness among land managers and land users on low-cost and effective restoration measures
Knowledge and skills	▪ Deploy systematic efforts to train land managers and users on restoration practices: • A permanent training center for the forest sector should be established • Current Pasture Department efforts regarding holding online training for sub-national branch offices should be supported through digital equipment improvement.
	▪ Create awareness in the population on land restoration, including on measures like assisted regeneration through thinning and cuttings.
	▪ Set-up a national FLR monitoring system to track progress in achieving the Bonn challenge pledge and steer restoration efforts. In the forest sector, this could be integrated in the Forest Information Management System under development.
Additional studies	▪ Identify the exact locations of restoration measures together with local stakeholders. ▪ Risk of siltation of other HPPs in the Naryn River Basin. ▪ Spatiotemporal modelling for a quantitative assessment of baseline conditions and scenario analyses of different land management and climate change projections. ▪ Studies are required to quantify the impact of fine sediments on the turbine lifespan.

Source: original elaboration for this publication

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