Climate Risk Information for Ecosystem-Based Adaptation to Climate Change in the High Mountainous Regions of Central Asia: Kyrgyzstan and Tajikistan

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Photos courtesy of: Shaun Martin/World Wildlife Fund

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A Project of the Adaptation for Development and Conservation
ADVANCE Partnership
World Wildlife Fund and Center for Climate Systems Research

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About the Institutions

Center for Climate Systems Research

The Center for Climate Systems Research (CCSR) is the home of the cooperative relationship between Columbia University and the NASA Goddard Institute for Space Studies (GISS) and is also a research center of The Earth Institute at Columbia University. CCSR was established with the objective of providing enhanced understanding of the Earth's climate and its impacts on key sectors and systems. CCSR also plays a large role in dissemination of climate change research and information to governments, local and international organizations, educational institutions, and stakeholders.

World Wildlife Fund

For more than 50 years, WWF has been protecting the future of nature. The world's leading conservation organization, WWF works in 100 countries and is supported by 1.1 million members in the United States and close to 5 million globally. WWF's unique way of working combines global reach with a foundation in science, involves action at every level from local to global, and ensures the delivery of innovative solutions that meet the needs of both people and nature.

The ADVANCE Partnership

ADVANCE is a partnership between World Wildlife Fund (WWF) and the Columbia University Center for Climate Systems Research (CCSR) at The Earth Institute. Launched in 2015, ADVANCE facilitates adaptation by providing new ways of generating and integrating climate risk information into conservation and development planning, policies and practice. ADVANCE envisions a future where the world is using co-generated climate risk information based on the best available science to guide conservation, development, and disaster risk reduction to benefit both people and nature.

About the Report

These climate change projections were developed in support of the regional project on Ecosystem-based Adaptation (EbA) to Climate Change in the High Mountainous Regions of Central Asia, implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, and commissioned by the International Climate Initiative (IKI) from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). Representatives from Columbia University's Center for Climate Systems Research (CCSR) involved in this project were present at two workshops in Kyrgyzstan, meeting with local NGO staff members, government officials, and local residents in project areas to help them understand and interpret future climate risks to the region. Additionally, projections were also provided for Darjomj and Siponj villages in Tajikistan, although CCSR did not participate in the local workshops. These workshops were conducted by GIZ and their local partners in the region.

Report prepared by the Center for Climate Systems Research (CCSR) at the Earth Institute of Columbia University for the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). June 2016.

Note: Like all projections, these climate projections have uncertainty embedded within them. Sources of uncertainty include data and modeling constraints, the random nature of some parts of the climate system, and limited understanding of some physical processes. The levels of uncertainty are characterized using state-of-the-art climate models, multiple scenarios of future greenhouse gas concentrations, and recent peer-reviewed literature. Even so, the projections are not true probabilities and the potential for error should be acknowledged.

Introduction

Scientists from around the world agree that global temperatures are rising due to human activities that emit greenhouse gases into the atmosphere. The change in greenhouse gas concentrations not only increases the global temperature, but affects other environmental factors such as patterns of precipitation, heat extremes, storms, monsoon cycles, land ice mass, and river flows.

Climate change will not impact every area of the globe in the same manner, and thus it is necessary to evaluate the projected climate change impacts in specific regions so that decision-makers may plan accordingly. In Kyrgyzstan and Tajikistan, these climate impacts come with possible socio-ecological effects, such as greater (or lesser) snowpack accumulation that will affect water availability, earlier pasture opening and crop planting, or heat impacts on human and livestock health.

Climate risk information can be a valuable resource for stakeholders in the assessment of long-term actions for reducing vulnerability and improving resilience to climate change over the coming century. Collaboration between the scientific community and decision makers in Central Asia is critical to developing the most relevant climate risk information.

In this report, projections for temperature and precipitation are presented for support of the Ecosystem-based Adaptation to Climate Change in the High Mountainous Regions of Central Asia project. The specific locations evaluated are the Bash Kaiyndy project site near At Bashi in the Naryn District of Kyrgyzstan, and the area around Darjomj and Siponj villages in the Bartang Valley of the Tajikistan Pamir region. Future climate projections in both project sites are presented for two future time periods: 2011-2040 and 2041-2070. The methods for how the present and future climate analyses were performed are then discussed. Finally, key lessons learned from CCSR's involvement are also included in this report.

Planning for Uncertainty in Projecting Climate Change

It should be noted that there is a degree of uncertainty associated with predicting future climate conditions, as they have yet to occur (Horton *et al.*, 2015). One of the reasons for this uncertainty is that natural variability of the climate system is largely unpredictable. This includes randomness in ocean dynamics, storm events, solar cycles, and atmospheric patterns that shift in an erratic manner over time.

The second source of uncertainty is human behavior, which is directly related to the magnitude of climate changes. The effectiveness of international climate agreements, the development of new technologies, and cultural and behavior patterns will direct the trajectory of greenhouse gas emissions over time.

A third source of uncertainty is in the global climate models that project future climate patterns. Each of these mathematical models simulates the climate system and inputs how that system will respond to increased greenhouse gas emissions and feedback loops from the interconnected systems that govern weather and climate. These models incorporate these various aspects in slightly different ways, resulting in different outputs for temperature, precipitation, sea level rise, and other variables.

Due to these uncertainties, the climate projections in this report are presented as a range of possible outcomes, rather than a single number for a time period. This is because the analysis uses outputs of 21 climate models, and one single number does not accurately capture the full range of future modeled possibilities. Projections indicate that temperature will increase in both the 2011-2040 and the 2041-2070 timeslices. The range of possible outcomes widens as we approach mid-century, as there's less certainty about emissions scenarios and the resulting warming (in addition to model uncertainty). While temperature change is always projected to increase in these regions, the direction of projected seasonal precipitation change is less defined, with some models projecting decreases in total rainfall and others suggest an increase. In some seasons, such as the spring months, models do show a more consistent directionality over the two timeslices. Stakeholders may find the 2011-2040 more useful for planning, but the later timeslice can help understand the directionality of the changing climate. It is vital to note that these are climate projections (for 30-year timeslices), and that while the long term trend shows a warming climate or a change in rainfall, there will still be year-to-year variability. For example, even though the spring season is expected to become wetter as the century progresses, there will be years with low precipitation and even drought conditions during that time of the year. The risk-based approach to decision making presented in this report can helps to manage through this uncertainty and supports adaptation planning across a range of sectors and applications.

1. Bash Kaiyndy, Kyrgyzstan

1.1 Present Climate

The baseline used for future temperature and precipitation projections at the Bash Kaiyndy project site in Kyrgyzstan represents a combination of station and model values spanning from 1957 to 2005. The project site in Bash Kaiyndy included villages in the valley and adjacent high mountains. Given the significant changes in the micro-climate due to terrain, the project site was subdivided into 'villages' and 'mountain areas' when developing projections. Even this distinction represents a major simplification, given the topographical diversity within both the villages and the mountain areas. Historically in the village areas, the annual temperature is 2.0°C and annual precipitation totals 295 mm. Winter months[*] (November to February) are the coldest in the region, with an average temperature of -12.3˚C and low mean precipitation of 46 millimeters (mm). The spring season (March to May) is warmer with an average temperature of 4.6˚C and receives an average of 105 mm of precipitation. Summers (June to August) have the warmest mean temperature of 14.9˚C and the heaviest precipitation of 116 mm. In the autumn (September to October), the average temperature is 7.6˚C. Autumn has the lowest mean precipitation of all seasons, at 28 mm. Due to a lack of station data, there is not enough information to establish concrete baseline values for temperature and precipitation in the mountain areas of Bash Kaiyndy.

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[*] *Please note that these seasons reflect locally defined seasons, consisting of months which differ from the standard spring, summer, autumn, and winter seasons that are used more widely.*

1.2 Temperature Projections

The major changes projected for temperature in the Bash Kaiyndy region of Kyrgyzstan are outlined in Table 1.a and Table 1.b. Table 1.a shows both the change in temperature from the baseline period and the absolute future estimated average temperatures in the two timeslices in the lower elevation village areas of the project site, while Table 1.b shows only the change factors in relation to the base period for the higher-elevation mountain areas of the Bash Kaiyndy project site. The village areas have weather station data to support the baseline information, thus were robust enough to include the baseline values and future absolute values could be estimated. The mountain regions did not have supporting station data to establish a baseline that is scientifically robust, and therefore concrete baseline and absolute future temperature estimates were not developed for the mountain areas.

In the next several decades, annual temperatures are expected to increase in the area of Bash Kaiyndy by roughly 0.9°C to 1.8˚C above the baseline climatology, and 1.7°C to 4.0˚C warmer in the 2041-2070 time period. The changes are presented in this manner to capture uncertainty and the full range of future possibilities.

Through the year 2040, warming trends are projected to remain consistent throughout the year, reaching up to a 1.8°C increase. From 2041 to 2070 there are greater seasonal differences in temperature increases, with the largest projected warming in autumn, and the upper end of seasonal projections reaching beyond a 4.0°C increase.

While the high elevation mountain regions will remain cooler than the lower elevation village areas, the magnitude of projected changes in temperature in both the mountain regions and villages around Bash Kaiyndy are similar.

One key outcome for the region as a result of temperature shifts is that the increase in spring temperatures could lead to an earlier thaw, meaning earlier pasture opening for herders.

Table 1.a Temperature in Villages, Bash Kaiyndy, Kyrgyzstan. Projected annual and seasonal temperature in the villages of the Bash Kaiyndy project site in Kyrgyzstan in the early 21st century (2011-2040) and mid-21st century (2041-2070) in comparison to the 1980-2005 baseline. Projections show values that represent both the degree change in relation to the baseline (+/-°C) and estimated absolute future average temperature (°C) in each timeslice. The table shows the range of future model outcomes representing the low estimate to the high estimate in each time slice. The low estimate refers to the 25th percentile of model outcomes in greenhouse gas emissions scenario RCP 4.5, and the high estimate refers to the 75th percentile of model outcomes in greenhouse gas emissions scenario RCP 8.5.

Villages	**Baseline** *1980-2005*	**2011-2040** *Low estimate to high estimate*	**2041-2070** *Low estimate to high estimate*
Annual	2.0°C	**2.9°C to 3.8°C**[*] (+0.9°C to +1.8°C)[**]	**3.7°C to 6.0°C** (+1.7°C to 3.9°C)
Winter (Nov to Feb)	-12.3°C	**-11.5°C to -10.6°C** (+0.7°C to +1.7)	**-10.6°C to -8.7°C** (+1.6 to +3.6)
Spring (Mar-May)	4.6°C	**5.4°C to 6.4°C** (+0.8 to +1.8)	**6.0°C to 8.5°C** (+1.4 to +4.0)
Summer (Jun-Aug)	14.9°C	**15.8°C to 16.8°C** (+0.9 to +1.9)	**16.7°C to 19.1°C** (+1.7 to +4.1)
Autumn (Sept-Oct)	7.6°C	**8.6°C to 9.4°C** (+1.1 to +1.8)	**9.6°C to 11.8°C** (+2.1 to +4.3)

[*] Represents estimated absolute future average temperature for the time period

[**] Represents change in temperature from the baseline value

Table 1.b. Temperature in Mountains, Bash Kaiyndy, Kyrgyzstan. Projected annual and seasonal temperature shift in the mountain regions of the Bash Kaiyndy project site in Kyrgyzstan in the early 21st century (2011-2040) and mid-21st century (2041-2070) in comparison to the 1980-2005 baseline. Projections show values that represent the degree change in relation to the baseline (+/-°C) in each timeslice. The table shows the range of future model outcomes representing the low estimate to the high estimate in each time slice. The low estimate refers to the 25th percentile of model outcomes in greenhouse gas emissions scenario RCP 4.5, and the high estimate refers to the 75th percentile of model outcomes in greenhouse gas emissions scenario RCP 8.5.

Mountains	**2011-2040** *Low estimate to high estimate*	**2041-2070** *Low estimate to high estimate*
Annual	+0.9°C to +1.8°C	+1.7°C to + 3.9°C
Winter (Nov to Feb)	+0.7°C to +1.6°C	+1.7°C to +3.5°C
Spring (Mar-May)	+0.8°C to +1.8°C	+1.4°C to +4.0°C
Summer (Jun-Aug)	+0.9°C to +1.8°C	+1.7°C to +4.1°C
Autumn (Sept-Oct)	+1.1°C to +1.8°C	+2.1°C to +4.3°C

[*] Represents change in temperature from the baseline value

1.3 Precipitation Projections

The major changes projected for precipitation in the Bash Kaiyndy region of Kyrgyzstan are outlined in Table 2.a and Table 2.b. Table 1.a shows both the change in precipitation from the baseline period and the absolute future estimated rainfall in the two timeslices in the lower elevation village areas of the project site, while Table 2.b shows only the percentage in relation to the base period for the higher-elevation mountain areas of the Bash Kaiyndy project site. The village areas have weather station data to support the baseline information, and thus were robust enough to include the baseline values, and thus future absolute values could also be estimated. The mountain regions did not have supporting station data to establish a baseline that is scientifically robust, and therefore concrete baseline and absolute future precipitation estimates were not developed for the mountain areas.

There is a wide range of future precipitation outcomes in both the mountain and village regions of the Bash Kaiyndy project site. On an annual basis, projections range from a slight 7% decrease to moderate 20% increase in the village areas and a similar 6% decrease to moderate 21% increase in the mountain regions through 2040 compared to the baseline. In the 2041-2070 time period, the range for projected rainfall change in mountain regions (3% decrease to 32% increase) is wider than for villages (7% decrease to 24% increase).

Across the range of projections, the upper end of percentage rainfall shift in the mountain regions are projected to be slightly higher than village areas, with notable increases expected in winter and spring. This increase in winter and spring precipitation could lead to greater snowpack accumulation and greater spring water availability.

It remains unclear whether summer and autumn precipitation is more likely to increase or decrease in either area. The projections for precipitation in mountain regions of Kyrgyzstan show similar ranges for percentage shifts during the winter and spring seasons, leaning towards an increase in precipitation.

Due to the wide range of possibilities in future precipitation, adaptation measures will need to accommodate the potential for both increasing and decreasing rainfall through mid-century. Even if precipitation increases in the summer season, due to the increased in temperature there will likely be higher levels of heat and dust, leading to water stress on crops and pastures, and impacts on human and livestock health.

Baseline autumn precipitation in Kyrgyzstan is lower than the other seasons, and thus the actual change in precipitation value is also relatively smaller. Through 2070, precipitation is slightly more likely to decrease instead of increase, though the total level of seasonal autumn precipitation is still comparatively smaller than the rest of the year.

Table 2.a. Precipitation in Villages, Bash Kaiyndy, Kyrgyzstan. Projected annual and seasonal precipitation in the villages of the Bash Kaiyndy project site in Kyrgyzstan in the early 21st century (2011-2040) and mid-21st century (2041-2070) in comparison to the 1980-2005 baseline. Projections show values that represent both the percentage change in relation to the baseline (%) and estimated absolute future average precipitation totals (mm) in each timeslice. The table shows the range of future model outcomes representing the low estimate to the high estimate in each time slice. The low estimate refers to the 25th percentile of model outcomes in greenhouse gas emissions scenario RCP 4.5, and the high estimate refers to the 75th percentile of model outcomes in greenhouse gas emissions scenario RCP 8.5.

Villages	**Baseline** *1980-2005*	**2011-2040** *Low estimate to high estimate*	**2041-2070** *Low estimate to high estimate*
Annual	295 mm	**274 mm to 354 mm**[*] (-7% to +20%)[**]	**275 mm to 366 mm** (-7% to +24%)
Winter (Nov to Feb)	46 mm	**47 mm to 58 mm** (+2% to +25%)	**52 mm to 68 mm** (+13% to +48%)
Spring (Mar-May)	105 mm	**105 mm to 126 mm** (0% to +20%)	**109 mm to 138 mm** (+4% to +32%)
Summer (Jun-Aug)	116 mm	**100 mm to 139 mm** (-14% to +20%)	**93 mm to 129 mm** (-20% to +11%)
Autumn (Sept-Oct)	28 mm	**22 mm to 31 mm** (-20% to +12%)	**21 mm to 30 mm** (-26% to +7%)

[*] Represents estimated absolute future average precipitation for the time period

[**] Represents percentage change in precipitation from the baseline value

Table 2.b. Precipitation in Mountains, Bash Kaiyndy, Kyrgyzstan. Projected annual and seasonal precipitation shift in the mountain regions of the Bash Kaiyndy project site in Kyrgyzstan in the early 21st century (2011-2040) and mid-21st century (2041-2070) in comparison to the 1980-2005 baseline. Projections show values that represent the percentage change in relation to the baseline (%) in each timeslice. The table shows the range of future model outcomes representing the low estimate to the high estimate in each time slice. The low estimate refers to the 25th percentile of model outcomes in greenhouse gas emissions scenario RCP 4.5, and the high estimate refers to the 75th percentile of model outcomes in greenhouse gas emissions scenario RCP 8.5.

Mountains	**2011-2040** *Low estimate to high estimate*	**2041-2070** *Low estimate to high estimate*
Annual	-6% to +21%[*]	-3% to +32%
Winter (Nov to Feb)	+3% to +23%	+10% to +48%
Spring (Mar-May)	0% to +20%	+8% to +35%
Summer (Jun-Aug)	-12% to +21%	-18% to +11%
Autumn (Sept-Oct)	-23% to +18%	-23% to +25%

[*] Represents percentage change in precipitation from the baseline value

2. Darjomj and Siponj Villages, Tajikistan

2.1 Present Climate of Tajikistan

Projections for the Darjomj and Siponj villages in Tajikistan are based on a 1980-2005 modeled baseline. The area around the project site averages an annual temperature of -0.6°C and receives 601 mm of rainfall per year. The average winter season (November to February) temperature is -10.5˚C, and the coldest month annually is January with a mean historical temperature of -13.9˚C. The winter months receive an average of 266 mm of precipitation. The baseline spring season (March to May) has a mean temperature of -1.6˚C and receives 249 mm of precipitation. The month with the most precipitation on average is March with 92 mm. Summer (June to August) is the warmest season throughout the year. Temperatures reach an average of 10.4˚C, and the average precipitation is only 46 mm. The month of August historically receives no precipitation. The autumn average (September to October) baseline precipitation is also very low at 40 mm, with a mean temperature of 4.3˚C.

2.2 Temperature Projections

The major changes projected for temperature in the Darjomj and Siponj villages in Tajikistan are outlined in Table 3. The data in Table 3 show both the change in temperature from the 1980-2005 baseline period and the absolute future estimated average temperatures in the two timeslices at the project site.

Roughly a 1.0˚C to 2˚C increase in mean annual temperature is expected in the Darjomj and Siponj villages of Tajikistan through 2040, and a 2.0˚C to 4.4˚C increase in the yearly average is projected through to 2070.

Seasonally, there are no large differentiations in warming trends in the 2011-2040 time period, though increases in autumn temperatures are slightly greater than the rest of the year.

The lower end of the projections for the spring season are cooler than the rest of the year, perhaps only increasing 1.5°C in the 2041-2070 time slice. However, baseline spring temperatures average -1.6°C, and any increase beyond the lower bounds could bring average spring temperatures above freezing.

The autumn season is projected to have the largest increase in seasonal temperatures, rising by up to 5.2°C above the baseline by the year 2070. This is a roughly 1°C greater temperature increase than the remaining seasons and could extend the herding season into later months of the year.

Table 3. Temperature in Darjmoj and Sipoj villages in Tajikistan. Projected annual and seasonal temperature in the Darjmoj and Sipoj villages in Tajikistan in the early 21st century (2011-2040) and mid-21st century (2041-2070) in comparison to the 1980-2005 baseline. Projections show values which represent both the degree change in relation to the baseline (+/-°C), and estimated absolute future average absolute temperature (°C) in each timeslice. The table shows the range of future model outcomes representing the low estimate to the high estimate in each time slice. The low estimate refers to the 25th percentile of model outcomes in greenhouse gas emissions scenario RCP 4.5, and the high estimate refers to the 75th percentile of model outcomes in greenhouse gas emissions scenario RCP 8.5.

Tajikistan	**Baseline** *1980-2005*	**2011-2040** *Low estimate to high estimate*	**2041-2070** *Low estimate to high estimate*
Annual	-0.6°C	**0.4°C to 1.3 °C*** (+0.9°C to 1.9°C)**	**1.3°C to 3.7°C** (+1.9°C to +4.4°C)
Winter (Nov to Feb)	-10.5°C	**-9.6°C to -8.6°C*** (+0.8°C to +1.8)**	**-8.5°C to -6.5°C** (+2.0 to +4.0)
Spring (Mar-May)	-1.6°C	**-0.8°C to 0.3°C** (+0.8 to +1.8)	**0.0°C to 2.6°C** (+1.5 to +4.2)
Summer (Jun-Aug)	10.4°C	**11.5°C to 12.2°C** (+1.1 to +1.8)	**12.4°C to 14.6°C** (+2.0 to +4.2)
Autumn (Sept-Oct)	4.3°C	**5.4°C to 6.4°C** (+1.2 to +2.1)	**6.5°C to 9.5°C** (+2.3 to +5.2)

*Represents estimated absolute future average temperature for the time period
**Represents change in temperature from the baseline value

2.3 Precipitation Projections

The major changes projected for precipitation in the Darjomj and Siponj villages in Tajikistan are outlined in Table 4. The data in Table 4 show both the percent change in precipitation from the 1980-2005 baseline period and the absolute future estimated precipitation in the two timeslices at the project site.

Trends in precipitation change through 2070 are consistent across the seasons and time periods for which projections were made. Based on the projections, it appears likely that annual precipitation will increase overall, up to 20% in the 2011-2040 timeslice, and up to 32% in the 2041-2070 time period.

Winter and spring seasons in the Darjomj and Siponj villages historically receive the largest amount of rainfall, and are more likely to see an increase in precipitation levels as a result of climate change.

It is difficult to conclude whether summer and autumn precipitation will increase or decrease because of the wide range of possible futures in the model outcomes. However, both seasons receive very low amounts of baseline precipitation, thus the difference between the baseline and actual projected precipitation will not be significantly large.

Similar to the wide range in precipitation findings for summer and autumn seasons in Kyrgyzstan, adaptation measures will need to accommodate the potential for both increasing and decreasing rainfall through mid-century.

Table 4. Precipitation in Darjmoj and Sipoj villages in Tajikistan. Projected annual and seasonal precipitation in the Darjmoj and Sipoj villages in Tajikistan in the early 21st century (2011-2040) and mid-21st century (2041-2070) in comparison to the 1980-2005 baseline. Projections show values which represent both the percentage change in relation to the baseline (%), and estimated absolute future average precipitation totals (mm) in each timeslice. The table shows the range of future model outcomes representing the low estimate to the high estimate in each time slice. The low estimate refers to the 25th percentile of model outcomes in greenhouse gas emissions scenario RCP 4.5, and the high estimate refers to the 75th percentile of model outcomes in greenhouse gas emissions scenario RCP 8.5.

Tajikistan	**Baseline** *1980-2005*	**2011-2040** *Low estimate to high estimate*	**2041-2070** *Low estimate to high estimate*
Annual	601 mm	**582 mm to 719 mm**[*] (-3% to +20%)[**]	**591 mm to 796 mm** (-2% to +32%)
Winter (Nov to Feb)	266 mm	**266 mm to 322 mm** (0% to +21%)	**276 mm to 373 mm** (+4% to +21%)
Spring (Mar-May)	249 mm	**245 mm to 292 mm** (-2% to +17%)	**249 mm to 313 mm** (0% to +26%)
Summer (Jun-Aug)	46 mm	**38 mm to 56 mm** (-17% to +22%)	**32 mm to 60 mm** (-29% to +31%)
Autumn (Sept-Oct)	40 mm	**33 mm to 49 mm** (-17% to +23%)	**34 mm to 50 mm** (-15% to +25%)

[*] Represents estimated absolute future average precipitation for the time period

[**] Represents percentage change in precipitation from the baseline value

3. Methods for Developing Temperature and Precipitation Projections

Temperature and precipitation projections were developed using the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) dataset released in 2015[†]. It is comprised of downscaled climate scenarios for the globe that are derived from the General Circulation Model (GCM) runs conducted under the Coupled Model Intercomparison Project Phase 5 (CMIP5) and across two greenhouse gas emissions scenarios known as Representative Concentration Pathways (RCPs). The two RCPs in the dataset are RCP 4.5 and RCP 8.5. The CMIP5 GCM simulations were developed in support of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5). The NEX-GDDP dataset includes downscaled projections from the 21 models and scenarios for which daily scenarios were produced and distributed under CMIP5. Each of the climate projections includes daily maximum temperature, minimum temperature, and precipitation for the periods from 1950 through 2100. The spatial resolution of the dataset is 0.25 degrees, or approximately 25 square kilometers.

The projections were developed for specific sites within each country. In Kyrgyzstan, the analysis was focused on the Bash Kaiyndy project site near At Bashi in the Naryn District. In Tajikistan, the analysis was performed for the area around Darjomj and Siponj villages in the Bartang Valley of the Tajikistan Pamir region. For the analysis carried out for Kyrgyzstan and Tajikistan, two time slices were developed to represent 30-year averages: 2020s (2011-2040) and 2050s (2041-2070). Temperature change factors reflect the change in degrees Celsius for seasonal and annual averages of daily mean temperature in reference to each country's base period. Precipitation change factors reflect percent changes in total seasonal and annual precipitation in reference to the base period. All change factors are relative to 1980-2005 modeled base periods for each country. In the case of Kyrgyzstan, future absolute temperature and precipitation values were computed using change factors relative to the 1980-2005 base period added to 1957-1999 historical seasonal climatic averages for At-Bashi weather station. The absolute values for Tajikistan were produced from the modeled data only.

For Kyrgyzstan, two sets of projections were conducted: one for mountainous regions and another for village areas in the project area. As each grid cell of the model outputs are 0.25 degrees (~25km x ~25 km) in resolution, to process the local climate variables, the mountain projections included 1 high-elevation grid cell, while the village projections average two adjacent grid cells (one including higher elevations, the other mainly at valley bottom).

[†] NASA. 2015. NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP). Available online from: https://cds.nccs.nasa.gov/nex-gddp/ [Accessed: 02/042016]

The low and high estimates were computed to capture a range of possible future outcomes. The low estimate value reflects the 25th percentile among 21 model projections under RCP4.5 and the high estimate reflects the 75th percentile for RCP8.5. Presenting the projections as a range most accurately represents possible future climate conditions for decision-makers and planners applying risk-based approach to climate change adaptation and resiliency.

4. Lessons Learned

While the initial CCSR contribution to the work was largely focused on developing stand-alone quantitative climate projections, interactions with stakeholders ended up yielding additional critical findings, summarized below.

4.1 Adapt climate projections for the specific audience

In Kyrgyzstan, the climate projections were presented to two different audiences, separately. First, a pre-workshop presentation was held for NGO staff members, academics, and local government officials. The focal workshop was particularly for local villagers. Dependent on the audience, the detail of background material and formal scientific definitions had to be altered based on the group's background or the level of technicality expected. Participants at the pre-workshop did not have an adequate knowledge about local conditions, especially with regard to local seasons, which was apparent during the workshop in the villages. For example, the pre-workshop presentation was prepared to be slightly technical and aimed towards a group that was technically more advanced (but not scientific). The emphasis of the main workshop with villagers was to provide the climate projection information to herders in more of a narrative form, in a format that was useful for their livelihoods.

It was necessary to omit more technical details and definitions than expected for the pre-workshop audience. Scientific concepts behind climate change and the processed climate projections often take time to comprehend, and presenting these technicalities in a short time can produce more confusion within the group than clarity. Furthermore, these concepts are often not essential for the application of projections.

For the village workshop, the projections were offered as qualitative uncertainty axes that depicted the expected change (e.g. ranging from less rain to more rain expected). The participants grasped this visualization better and therefore felt more empowered to use this tool in the planning workshop, although the projections were not fully understood.

In summation, it is first essential to consider the project beneficiaries of the projections and what the information will be used for. Secondly, it is important to not over-estimate the scientific or technical abilities of the audience. Lastly, it is often best to ease the scientific detail within workshop presentations for audiences without scientific backgrounds.

4.2 Addressing the complexity of context

Our analysis of the project context changed significantly throughout the process, which made the interpretation and application of the generated climate projections more difficult.

In preparation for conducting workshop presentations in Kyrgyzstan, we relied on a vulnerability assessment to develop an understanding of the ecological and economic context within the project area. During the pre-workshop presentation in Kyrgyzstan we received additional and to some extent conflicting information from local NGO staff members and government officials who were more familiar with the area. With new knowledge we felt that our understanding of the ecological and economic context was accurate. The following village workshop continued to challenge and alter the context further.

It is important to note that context differs between contracted writers, local town officials, farmers, laborers and local herders. An assortment of perspectives is necessary to paint a complete picture.

One such example of conflicting information was the identification of seasons. The seasonal calendar exercise carried out with the community helped identify seasons that were most relevant to the project beneficiaries, which differed from the seasons that were initially selected. This highlights the importance of collecting contextual information directly from project beneficiaries, rather than using regional and national level proxies for local knowledge.

This experience manifest that the appropriate context for climate projections needs to be carefully assessed, and information drawn from multiple sources. In this case, it would have been beneficial to collect the perspectives of local communities before the pre-workshop presentation to achieve the contextual understanding, rather than wait to collect this information in the middle of the process. For example, useful context includes information about:

- Who governs natural resources and land?
- Which ecosystems are used for what purposes, where are those ecosystems situated, who uses those ecosystems, and when do they use them?
- Which NGOs are already active in the region? How might their projects interact with ours in terms of support, redundancy, or contradictory aims?
- What are the perspectives of the community members on climate change to date?

Much of this contextual information was collected at the villages as non-local groups did not have accurate information on the local context.

From the perspective of climate projection development, it is important to operate under a broad understanding of the context so as not to constrain the projections and their usefulness. For example, one beneficial strategy was to bring monthly data to the field to adjust the seasonal distribution.

4.3 Focus on communicating climate impacts and hazards, rather than technicalities

Uncertainty is inherent to all projections, so it does not in itself justify inaction. Global climate model outputs can provide a range of possible outcomes that can be used for adaptation planning. While absolute certainty is not achievable for climate projections, organizations and communities are presently making adaptation management decisions that can be inspired by the best available climate data and scientific intuition. Workshops, and pre-workshop presentations, are generally not a productive forum for technical debates about the caveats and cautions about projections and statistics. These conversations are necessary in an academic and research setting to continuously improve and address the weaknesses of climate models, but if overemphasized may hinder the communication of the best available climate information that may prove useful to decision makers. For example, when presenting climate risk information, it can be powerful to put the information in the context of the impacts that the audience will face, such as the discussion of historical analogs, rather than statistical technicalities.

Conclusion

As a result of climate change, projections show that temperatures are increasing and precipitation patterns are changing in the Bash Kaiyndy project site in Kyrgyzstan and the Darjomj and Siponj Villages in Tajikistan. These changes have implications for livelihoods, such as changing typical patterns of water availability in the spring months, stress on crops and pastures in the summer, and health effects on communities and livestock throughout the year. While engaging with stakeholders through this work, it became apparent that consulting with local beneficiaries, and not just the local NGO and government stakeholders, is vital to building the appropriate contextual information about the local region, such as seasonality, relevant extremes, and perceptions of historical and future climate change.

The activities of this study highlighted how critical it is to know the audience when presenting climate risk information, meaning that the approach taken to communicate the relevant science needs to be determined based on the technical capacity and type of stakeholder. This requires flexibility in the level and types of information shared depending upon how familiar the end user is with the complexities of climate science and climate change projections. Strategies to communicate this level of complexity include presenting qualitative versus quantitative changes in climate, framing changes in the form of an analogy in reference to the way the current climate behaves, and developing scenario axes that visually express the range of possible futures that may arise as a result of climate change.

Many development and conservation activities are dependent on climate variables such as temperature and precipitation. Climate change will bring on new challenges to these activities, affecting people, livelihoods, and ecosystems. Failing to incorporate these changes could lead to maladaptation and inefficient use of resources. Therefore, it is essential to consider climate risk information for future planning. By incorporating climate risk information into ecosystem based adaptation, the GIZ Central Asia Office has taken a crucial first step in understanding the risks that climate change poses to these regions. The analysis and lessons learned in this approach provide valuable insights for how this approach can be replicated in other project sites in the region.