

# Climate Change Trends, Impacts, and Adaptation in Kara Kulja District, Southern Kyrgyzstan

Conference "Mountains and Climate", Bishkek, December 10-11, 2012

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**Abstract.** Climate change impacts are key drivers in resource availability yet national climate change information is limited and local information is nearly non-existent in Kyrgyzstan. While the country's rural mountainous communities are increasingly familiar with the flooding, heat, winds, and drying associated with regional climate change trends, they lack locally relevant, science based information for adaptation efforts. This climate change analysis aims to fill this information gap in Kara Kulja district in Osh oblast. The research combines climate science, meteorological data (1940-2010) from two weather stations, hydro data (1970-2010) from two rivers stations, and community focus group discussions in all sub-districts to identify climate change trends, impacts, and adaptation measures. The purpose of the analysis is to generate locally relevant information for use in designing adaptation plans and activities that reduce climate change vulnerability.

Findings demonstrate that the multiple data sources closely align. There are significant trends in temperature, precipitation, and river flow and associated impacts. All villages in the region have suffered losses related to increasing magnitude and frequency of flood and/or drought and drying conditions. With little to no understanding of climate change, many people have begun adaptation efforts.

*Key words:* climate change, climate change impacts, climate change adaptation, weather trends, Kyrgyzstan, Osh, Kara Kulja

## Introduction

The Intergovernmental Panel on Climate Change (2007) and the Kyrgyz Republic (2009) have determined that existing and projected climate change trends have significant implications for the country's agriculture, water resources, natural disaster occurrence, and public health. Climate change is a key driver of changes in the availability of livelihood resources yet national and regional climate change information is scarce and local information is nearly non-existent in Kyrgyzstan. Rural mountainous

communities are increasingly familiar with the flooding, heat, and drying associated with regional climate change trends, however, they lack the information and resources to address the effects of these new climate patterns. Without adequate information about projected climate change trends and impacts, local vulnerability to climate change impacts will increase.

While information alone is often not sufficient for prompting adaptation, it is an important starting point for informed decision making. The purpose of this research is to collect and analyze locally relevant information for use in designing adaptation plans and activities that reduce community and household vulnerability to climate change in Kara Kulja District of Osh Oblast in southern Kyrgyzstan. The research was conducted as a component of a Mountain Societies Development Support Program (Kyrgyzstan) project to increase community resilience to climate change impacts.

Climate change related weather phenomenon act as additional stressors on human populations and ecosystems. Climate change includes gradual changes in average conditions over the long term, greater weather variability, and changes in the occurrence of extreme events. Climate change is already impacting agriculture, water resources, and the occurrence of non-seismic natural disasters in Kara Kulja district and the impacts are projected to rise over the next century. In Kyrgyzstan, climate change projections include: 1) increased temperature particularly in summer, 2) decreased precipitation in summer and increased precipitation in winter, 3) stronger winds, 4) more frequent, intense, and longer droughts over wider areas, 5) increased frequency of heavy precipitation events, and 6) increased incidents of floods, mudflows, and glacial lake outburst flood (Cruz et al. 2007, Kyrgyz Republic 2009). Each of these climate projections was partially or fully observed in weather data and/or by Kara Kulja residents.

Kyrgyzstan is highly vulnerable to climate change. Fay *et al.* (2010) rank Kyrgyzstan as the third most vulnerable country to climate change impacts in the Eastern Europe and Central Asia region. The research ranks the country ninth out of twenty-eight for the predicted amount of change in climate conditions (exposure), third in the level of likely climate change impact to the country (sensitivity), and twenty-fifth in ability and resources to address climate change (adaptive capacity) (Fay *et al.* 2010). If climate change impacts are not addressed through adaptation measures, these impacts threaten to increase poverty and land degradation in Kara Kulja.

In Kara Kulja, like many areas of rural Kyrgyzstan, most people's livelihoods depend on agro-pastoralism and glacial fed rivers. This heavy dependency on agriculture makes the population even more vulnerable to climate change than the country as a whole. Warming temperatures, drought, heat waves, increased heavy precipitation, and high wind events can dramatically impact crops and livestock. In mountainous Kyrgyzstan, small farmers are often also faced with marginal land holdings, poor access to irrigation, and increasing land degradation. Many households are dependent on livestock and small areas of hayfields and rain fed crops. Drought and drying have particular impact on people dependent on rain fed hay and crops to meet food and fodder needs. Increases in rain fed crop damage and failure in dry years may substantially reduce people's food security, income, and ability to feed livestock through the winter. In addition, decreased water availability can increase conflict over water within or between communities.

Adapting to climate change in Kara Kulja involves building on existing local adaptation measures while also introducing new techniques and technologies to address impacts. Climate change, however, is only one of a range of natural, social, and economic problems that people face. Successful adaptation measures thus focus on climate risk as it relates to household and community priorities such as livelihood strategies, access to water, disaster risk reduction, and the capacity of civil society and government to support communities.

#### *Kara Kulja*

Kara-Kulja district is located in the eastern part of South-Western Kyrgyzstan (Fig. 1). The district includes the Tar and Kara Kulja river watersheds and the Alai-Kuu, Adyshev, Chongboor-Too, and Uzgen mountains of the Fergana range. Elevations range from 1100m to over 4800m. The highest peak of the Fergana range, 4893m, lies in the Alai Kuu range on the district's east border with Naryn. In the west of the district, the Tar and the Kara-

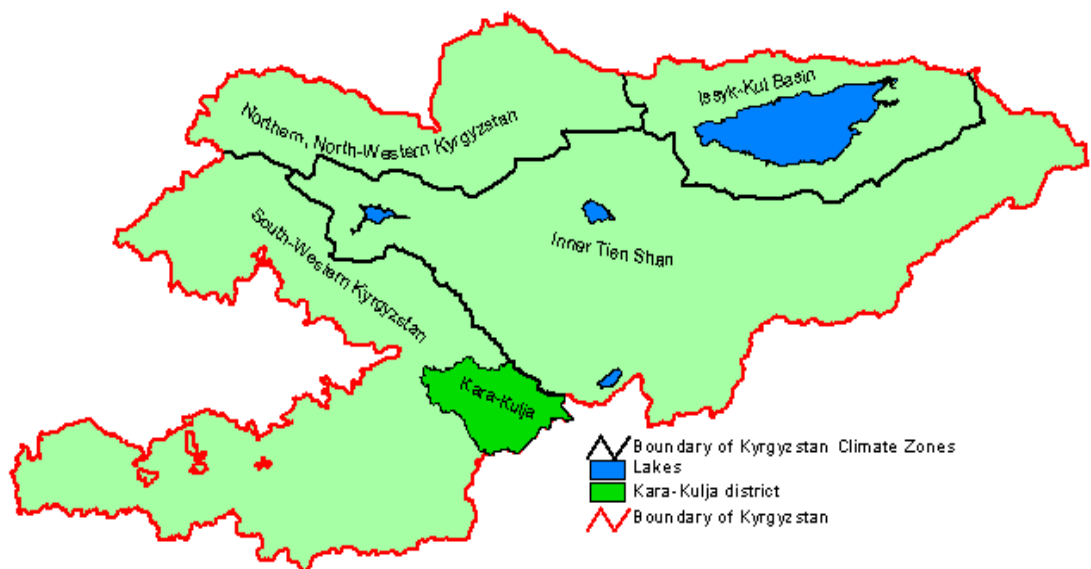
Kulja Rivers confluence to form the Kara-Darya River which flows into the Fergana valley forming the headwaters of the Syr Darya, one of Central Asia's most important rivers.

Kara Kulja's complex physical geography causes large variations in local climatic conditions. There are large inter-annual, annual, and daily temperature fluctuations and a strong temperature gradient associated with elevation. Average annual precipitation in Kara-Kulja district is 355-907mm with precipitation increasing with elevation. The maximum precipitation falls in the spring and the minimum comes in the late summer.

## Methods

Climate change trends, projections, impacts, and adaptation measures in Kara Kulja District were compiled through analysis of climate science, hydro-meteorological, and local observation data (Table 1). Climate trends in the Kara Kulja region are based on government hydro-meteorological data from 1940 to 2010 for two meteorological stations and four weather posts in Kara Kulja region at various elevations, and local observations (Table 2). Hydrological conditions and trends are based on data from two hydrological posts located on the Kara-Kulja and Tar rivers and local observations. Data analysis determined averages, maximums, minimums, and trends for temperature, precipitation, and hydrological characteristics. Discussion of natural disasters (mudflow, avalanche, landslide, rock fall, water-logging) in the Kara Kulja region is based on a literature review, data from the Ministry of Emergency Situations (MoES), and local observation.

Local climate change observations were collected during focus group discussions in all twelve sub-districts of Kara Kulja. Participants identified climate trends, extreme and unprecedented weather and natural disaster events, local impacts from climate trends and extremes, and existing adaptation measures.



**Fig. 1.** Map of Kyrgyzstan and Kara Kulja District with climatic regions (created using the GADM database, <http://gadm.org/>)

Data Type	Data Sources
Climate Science	Inter-governmental Panel on Climate Change, National Communications to the UNFCCC, Climate Change Research and Assessments
Hydro-Meteorological	Kyrgyzstan Department of Hydro-Meteorology: six meteorological stations and two hydro stations in Kara Kulja and Uzgen Districts
Local Observation	Focus group discussions and interviews in all twelve sub-districts of Kara Kulja

**Table 1.** Data sources used in this research

Station, post	Altitude, m	Location
MS Uzgen	1,012	Fergana Valley
MS Kyzyl-Zhar	2,230	Alai-Kuu (Tar watershed)
MP Kara-Kulja	1,300	Kara-Kulja watershed
MP Chalma	1,360	Tar watershed
MP Kurulush	1,540	Kara-Kulja watershed
MP Ak-Tash	1,730	Kara-Kulja watershed

**Table 2.** Characteristics of meteorological stations and meteorological posts used in report (KR Hydro-Meteorological Department data, accessed March 2011).

Climate Change Element	Data Type Used for Analysis
Trends	Climate Science, Hydro-Met, Local Observation
Projections	Climate Science
Impacts	Climate Science, Local Observation
Adaptation Measures	Climate Science, Local Observation

**Table 3.** Data type used for each element of this climate change analysis

Focus group discussion participants varied by area but included heads of Ayil Okmotu, chairs of the Ayil Council, Ayil bashchi, agriculture specialists, members of pasture committees, resident farmers and livestock owners, and aksakals. Data analysis identified focus group discussion themes. The lack of comprehensive weather data in Kyrgyzstan and the potential for significant weather change over short distances in mountainous Kara Kulja emphasized the importance of local observation.

Climate change adaptation best practices and recommendations were compiled through literature review and observation of local context. Recommendations include consideration of existing practices, best practices relevant to the region, and adaptation needs identified by focus group discussion participants.

## Results

The climate analysis results are organized by climate trends and projections, climate change impacts, and adaptation measures.

### *Climate Trends and Projections*

The analysis examined climate trends and projections for temperature, precipitation, wind, river level, and weather variability and extremes.

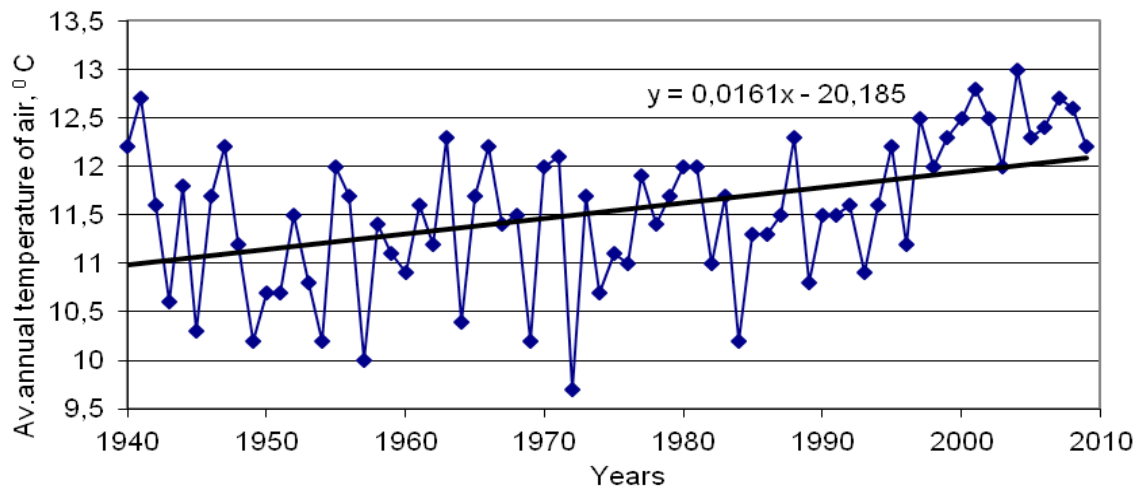
*Temperature.* Local experience and local weather data both showed a significant temperature increase in Kara Kulja. Village residents living below 1500m in particular reported that summers were hotter and there had been unprecedented winter warming with winter rain events in 2009 and 2011.

*"Summers are hotter now and some springs have gone dry." (Karaguz AO)*

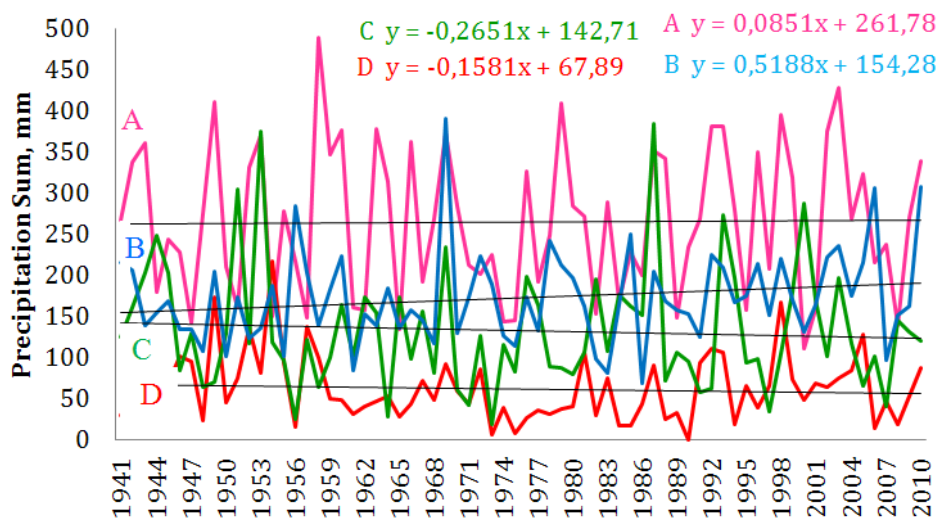
Analysis of local weather data shows a significant temperature increase of 1.1° C during the 70 year period from 1940 to 2010 (Fig. 2). This data also showed a greater increase in winter temperatures compared to other seasons. Average temperature increased in all months of the year with the largest temperature increase in March, November, and December and a smaller increase in May-September.

Climate change projections for Central Asia include warming well above the global mean with an increase of 3.7° C by 2100 compared to an estimated 3° C globally (Christensen *et al.* 2007). Model projections reported in the Kyrgyz Republic's Second National Communication to UN Framework Convention on Climate Change (SNC) call for even higher temperature increases of 4.5-6.2° C by 2100 with spring and summer temperature rising more than fall and winter temperatures.

*Precipitation.* Village residents consistently



**Fig. 2.** Change of average annual temperatures at the meteorological station Uzgen (KR Hydro-Meteorological Department data, accessed March 2011)



**Fig. 3.** Long-term change of seasonal amount of precipitation at MS Uzgen (Hydromet data).

reported changes in the intensity, timing, and type of precipitation. Generally people reported that 1) rainfall had increased in intensity, 2) rain was falling instead of snow (below 1500m), and 3) the timing of rain was less predictable. At lower elevations, people repeatedly reported that rain in the last few years increasingly fell very fast (high intensity) in short 15-30 minute storms rather than more slowly over a few days. During the last two years, people reported heavy snowfall throughout the district. The winter 2009/10 snowfall was very high everywhere and the most anyone could remember in two sub-districts, Oi Tal and Kyzyl Zhar.

*"It used to rain for 3-4 days at a time and the land could absorb the rain. Now it just rains for a half hour very heavy and destroys things." (Chalma AO)*

The weather station data show a small average annual precipitation increase of 12mm at meteorological station Uzgen for the 70 years between 1940 and 2010. Although overall annual precipitation increased slightly, this trend varies significantly by season. Precipitation increased in winter and spring,

36mm and 6mm respectively, while in summer and autumn, precipitation decreased by 11mm and 18mm (Fig. 3). The station data was not able to capture the occurrence of heavy rainfall.

Precipitation projections for Central Asia call for a small overall decrease in precipitation, however the seasonal trends closely match the precipitation data trend from Kara Kulja. Projections are for decreased spring and summer precipitation and some increase in winter precipitation. Predictions for Central Asia include a median change of -3% in annual precipitation by 2100, with +4% in December, January, and February and -13% in June, July, and August (Christensen *et al.* 2007). Precipitation projections from the SNC (2009) showed a possible increase or decrease in annual precipitation although models were consistent in predicting a decrease in summer precipitation and an increase in winter precipitation.

*Wind.* People in Kara Kulja consistently reported that the wind had changed in strength, direction, and timing. Generally people reported 1) stronger winds, 2) higher variability in wind direction, and

3) wind coming throughout the year rather than only in the spring and autumn as in the past. Global weather data also shows a strengthening of westerly winds in the mid-latitudes since the 1960s and this trend is projected to continue.

*“The wind has become stronger and more frequent. It used to only be in spring and fall, now it can come anytime.” (Sari Bulak AO)*

**River level.** Local residents observed extreme and/or unprecedented flooding in various villages during 2005-2010. In some areas, elders reported the highest river level in memory and there was first time flooding in other areas. Local river data shows that from 1940 to 2010 the average annual water flow increased by 5.95 m<sup>3</sup>/s (48.7 mm) in the Tar River and by 9.45 m<sup>3</sup>/s (328.5 mm) in the Kara Kulja River (Fig. 4). Monthly river flow trends for the last forty years (1970-2010) show an increase in flow during all months and a particular increase during the high water period.

The dramatic glacial retreat documented in Kyrgyzstan is projected to continue through this century. Data from the 1960s show that Kyrgyzstan had about 8,200 glaciers covering 8,077km<sup>2</sup> or about 4% of the country (Kyrgyz Republic 2009). The SNC (2009) projects that the glaciated area of Kyrgyzstan will be reduced by 64-95% between 2000 and 2100. Glacial melt is projected to contribute to an ongoing increase in river flow through about 2030 followed by a decrease in river flow as the glacial component diminishes.

**Variable and extreme weather.** Village residents consistently reported that there was increased weather variability and occurrence of unseasonal or extreme weather events. People remember that historically the seasons changed at a more regular time and the weather of each season was more predictable. In recent years there has been extreme or unprecedented flood, drought, and heavy snow. Throughout Asia, the IPCC projects an increase in extreme weather events such as drought, heat waves, and heavy precipitation (Cruz *et al.* 2007).

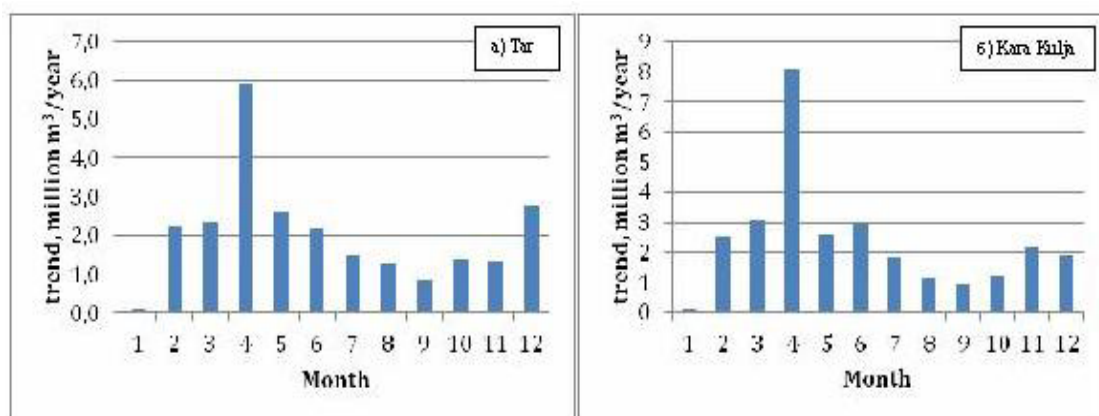
*“When I was a boy, we always knew the seasons, winter was winter and each season had its time.*

*Now seasons are unpredictable.” (Kara Kulja AO)*

**Discussion of Trends and Projections.** Findings demonstrate that local observation, district weather and water data, and the climate change projections for the country and region closely align (Table 4). Temperature is clearly increasing. The precipitation trend of a slight increase and the projection of a slight decrease are contradictory, which may be related to ongoing changes in precipitation over time or the uncertainty associated with precipitation projections in this region. There is agreement among local observation of precipitation trends and climate projections, however, that the frequency of heavy precipitation events is increasing. Local observation, global trends, and climate projections also agree that wind strength is increasing. Increased river flow is also clearly documented although it is projected to decrease after about 2030 when the glacial melt contribution diminishes. It also appears that variable and extreme weather events are increasing as projected.

**Impacts.** The climate change trends and projections documented above will have various impacts in Kara Kulja. Some impacts, such as a longer growing season, may have positive effects in some areas. Many impacts, however, are projected to be negative, such as drought and general drying of rain fed and pasture lands, diminished water availability in summer, increased wind and water erosion, and increased risk of flood, mudflow, glacial lake outburst floods, and potentially landslides. Climate change is also expected to increase the frequency of harsh climate events, such as drought and flooding, thus reducing the recovery time available between occurrences. Some of the impacts described below are already occurring in Kara Kulja and all are likely to gradually increase throughout this century.

**Impacts to water resources.** In Kara Kulja, water resources are critical for agriculture, domestic use, and down-river power generation. Even slight changes in the water regime can negatively impact people and the economy. The increased river flow and heavy precipitation events in recent years have been accompanied by an increase in flood frequency and magnitude causing bank erosion and destroying fields, bridges, canals, and irrigation infrastructure. While flooding and erosion are projected



**Fig. 4.** Average monthly river flow increase in the a) Tar and b) Kara Kulja rivers from 1970-2010 (KR Hydro-Meteorological Department data, accessed March 2011)

Data Source	Precipitation	Temperature	Wind	River flow
Local Experience (Kara Kulja)	↑ heavy precipitation	↑	↑ More variable direction and timing	↑
Hydro-Met Data (Kara Kulja and Uzgen stations)	↑ summer/fall ↓ winter/spring  Overall increase of 12mm (1940-2010)	↑ 1.1 ° C (1960-2010)	No info	↑ 5.95 m <sup>3</sup> /s Tar 9.45 m <sup>3</sup> /s Kara Kulja (1940-2010)
Climate Science (IPCC, GoKR 2008)	↑ heavy precipitation  ↑ summer/fall ↓ winter/spring -3% precipitation (2000-2100)	↑ ~3.7° C (2000-2100)	↑	↑ before 2030 ↓ after 2030

**Table 4.** Climate trends and projections from local people, local weather data, and climate science (KR Hydro-Meteorological Department data, accessed March 2011; Christensen *et al.* 2007; GoKR 2008).

to continue due to heavy precipitation events, overall runoff volume is expected to decrease by 43.6-88.4% by 2100 compared to 2000 levels (Alamanov *et al.* 2006). This decrease is due to an increase in evaporation and diminished glacial melt contribution. The eventual decrease in water resources has significant carry-on impacts for agricultural production and domestic water use. Diminished water availability may increase local conflict over limited water. Additionally, down-river water demands for irrigation and power generation in both Kyrgyzstan and Uzbekistan are likely to increase, potentially putting pressure on mountain communities to improve water management and reduce consumption.

*Impacts to agriculture.* Climate change trends and projections showing warmer and drier summers and diminishing water resources have significant implications for agriculture. Climate variability and extreme events are also important factors for agriculture productivity. Production may be negatively affected by heat waves, drought, heavy precipitation events, spring thaws, and natural disasters and positively affected by a longer growing season and the carbon fertilization effect. In Naryn District most people's livelihoods depend on agriculture that is highly sensitive to climate. The climate change trends and projections showing warmer and drier summers have significant potential impacts for agriculture. Climate variability and extreme events are also important factors for agriculture productivity. Drought, increased intensity of precipitation, heat waves, and high wind events can dramatically impact annual crops and livestock. In addition, decreased water availability can increase conflict over water within or between communities.

The 2007 IPCC report concludes with a high level of confidence that Central Asia is highly vulnerable (highest rating) to land degradation from climate change impacts (Cruz *et al.* 2007). Increased drying and precipitation variability (including drought) are likely to negatively affect pastures and rain-fed crops in particular (Tebaldi *et al.* 2006). In Naryn, most people have already

abandoned previously cultivated rain-fed lands due to low productivity. People remain, however, heavily dependent on pastures. In pastures, projections for reduced summer rainfall and increased temperature during the growing season are likely to cause increased bare ground (Zha *et al.* 2005). An increase in bare ground can lead to increased soil moisture loss resulting in more bare ground and a feedback process that accelerates grassland degradation (Milton *et al.* 1994). Livestock production is particularly sensitive to drought and aridity is already a limiting factor in much of Central Asia (Lioubimtseva and Henebry 2009, Sayoskul *et al.* 2003). Decreased pasture productivity, heat stress, and reduced access to water could cause a reduction in livestock milk production and an increase in some diseases (Cruz *et al.* 2007). Climate change projections for warmer and drier summers are significant for agriculture but climate variability and extreme events are equally or more important factors (Lioubimtseva and Henebry 2009).

A longer growing season and carbon fertilization, however, will likely have a positive effect on pasture and crop productivity. There is disagreement among scientists about whether the positive effects of a longer growing season and carbon fertilization will outweigh the negative effects of drying and the long term decrease in water availability. A longer growing season resulting from warmer temperatures, however, would be particularly beneficial for colder mountain areas of Kyrgyzstan such as Naryn District. And carbon fertilization resulting from the increase in atmospheric CO<sub>2</sub> increases the carbon available for photosynthesis and promotes plant growth. While the real world effects of carbon fertilization under climate change are still being debated, evidence is consolidating around its positive effect on plant growth. Some scientists have projected increased productivity under climate change scenarios for wheat and potato crops in Central Asia given the benefit of carbon fertilization (Kato *et al.* 2012, Sommer *et al.* 2012). This research projects that increased crop productivity from carbon fertilization will

outweigh any negative impacts associated with temperature and precipitation. The International Panel on Climate Change (2007) also concludes that at mid to high latitudes, warming of 1-3° C may have a small beneficial effect on crop productivity even with changes in precipitation. Savoskul *et al.* (2003) on the other hand, note that water shortages may outweigh the benefits of a longer growing season.

*Crops and Hayfields.* In Kara Kulja, about 15,500ha are dedicated to cultivation and hayfields. Rain fed cultivation includes sainfoin, barley, oil crops, spring wheat, and smaller amounts of potatoes and beans. Irrigated lands are mainly used for winter wheat, corn, potato, and smaller areas for vegetables and rice. Rain fed hayfields, composed of native vegetation, are also important and have replaced rain fed cultivation in some areas.

Negative impacts on crops:

1. Increased evapotranspiration rates cause crops to require additional water.
2. Diminished water availability after ~2025.
3. Drought threatens rain fed crops that depend on precipitation and impacts irrigated crops when irrigation sources dry up or diminish.
4. Early crop or tree growth promoted by warming winter temperatures is susceptible to freezing.
5. Longer snow free periods may cause frost heaving of the soil surface damaging overwintering crops.
6. Heavy rain and strong winds cause erosion and crop damage thus decreasing soil fertility and crop yields.
7. The suitability of existing crop varieties and types may change and rain fed cultivation may become unsuitable in warmer and drier conditions.
8. Water-logging, floods, mudflows, and landslides may affect land suitability for cultivation.
9. Warming temperatures can lead to both the spread of disease into new areas and an increase in disease vectors when insects are able to survive milder winters in greater numbers. Alternatively, warm and dry conditions may reduce the occurrence of certain plant pathogens.

Positive impacts on crops:

1. Longer growing season and decreased limitation from cold temperatures promotes crop growth. In many mid and high latitude areas, increasing temperatures may benefit crops, otherwise limited by cold and/or short growing seasons in the current climate. Some scientists project that that moderate warming (up to 2° C) in the first part of this century may benefit crop and pasture yields in temperate regions. Further warming expected for the second part of the century, however, may reduce crop yields.
2. Carbon fertilization resulting from the increase in atmospheric CO<sub>2</sub> increases the carbon available for photosynthesis and promotes plant growth. The carbon fertilization effect is reduced when other growth limiting factors such as inadequate soil moisture or nutrients are present. Cline (2007) estimates that agricultural productivity in Kyrgyzstan could increase by 5-15% between 2003 and 2080 with the effects of carbon fertilization. Productivity would decrease, however, by 5-15% without the effects of carbon fertilization.

*Livestock and Pastures.* In Kara Kulja, livestock graze the district's 318,000ha of pasture and are a critical part of the local economy. While often less sensitive than crops, livestock production is at substantial risk from warming and drying conditions. Livestock take the majority of their annual feed from pastures but rely on critical hay and forage crops to survive the winter. The UNFCCC projects that grassland productivity will decline by as much as 40-90 percent for an increase in temperature of over 2° C in the semi-arid and arid regions of Asia such as much of Kara Kulja's territory (UNFCCC 2007). The resulting reduced food supply may lead to animal malnutrition and death and force livestock owners to destock herds they are unable to feed, usually at low prices. Rebuilding livestock numbers can take years, increasing livestock owners risk to future impacts. Pastures are also more susceptible to overgrazing during drought and dry conditions increasing the risk of land degradation.

Negative impacts on livestock and pastures:

1. Reduced pasture productivity (changes in species composition, decreased biomass, an increase in bare ground, and land degradation) due to drying and erosion from heavy rainfall and strong winds.
2. Drought causes decreased pasture productivity, decreased fodder production, and reduces the water sources livestock rely on.
3. Higher temperatures and milder winters could contribute to the spread of infectious diseases in livestock such as anthrax, brucellosis, and leptospirosis.
4. Increased winter snow raises risks to livestock through reduced grazing on pastures covered by snow for longer periods and snowstorms that threaten unsheltered animals with exposure.
5. Heat stress.

Positive impacts on livestock and pastures:

1. Irrigated pasture and pastures with sufficient precipitation may experience increased productivity due to a longer growing season and the reduced impact of cold temperatures.

*Impacts to natural disasters.* Globally, changing temperature and precipitation patterns are predicted to increase the occurrence of non-seismic disasters such as floods, landslides, avalanches, and mudflows (WMO 2011). Climate change is also expected to lead to an increase in the frequency and severity of drought and heat waves, forest fires, and intense rain storms that can cause floods and landslides (Pollner *et al.* 2008, Chestin and Colloff 2008). Increased precipitation intensity and increased run-off from rapid snow and glacial melt can also cause surface erosion, riverbank erosion and rising groundwater levels. Kyrgyzstan is also likely to experience an increase in glacial lake outburst floods and, in higher elevations, avalanches (Kyrgyz Republic 2009).

In Kara Kulja there is evidence that events associated with climate change (heavy rain, rapidly melting heavy snow, glacial melt) have caused an increase in the occurrence of floods over the last six years. The locally reported increased magnitude, frequency, and in some places, first-time floods have caused extensive damage. These same climate change factors that cause flooding also lead

to slope saturation and increased landslides. While saturation factors may exacerbate landslide occurrence, drying conditions may also serve to alleviate landslides making projections difficult. In Kara Kulja, three separate glacial lakes threaten the areas of Konduk, Kara Tash, and Kyzyl Zhar. The Ministry of Emergency Situations (MoES) ranks the Kara Kulja lakes as moderately dangerous. Although detailed monitoring data is lacking, glacial melt is likely increasing lake levels and saturating and destabilizing the natural dams holding them in place.

*Adaptation Measures.* Climate change adaptation is defined as “measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes” (UNFCCC 2007:10). These adjustments and changes may be proactive or reactive efforts in response to actual or predicted climate change. There is no single solution to adapt to climate change. Rather, adaptation measures include a wide range of approaches and activities that can reduce the negative impacts of climate change when included in overall community and natural resource management planning and implementation.

In Kara Kulja, people are already undertaking autonomous adaptation measures in response to the weather changes they are experiencing (Table 5). People have mainly undertaken climate change adaptation measures in response to drought, flood, and heavy snow. Examples of these measures and the sub-district using them are listed below.

Climate change adaptation in Kyrgyzstan is often similar to non-climate related development and governance activities but with specific attention to how climate conditions have changed and are likely to change in the future. Adaptation activities are distinguished not necessarily by the activity outcome but by the inputs to the process and design, which explicitly consider new conditions associated with climate change. Examples

of adaptation measures include changes in crop varieties or types, improved irrigation, increased storage capacity for crop yields, sustainable pasture management, flood protection, insurance for climate related losses, seasonal forecasting, early warning systems for extreme events, and climate change awareness raising. Adaptation measures at a community level involve various forms and activities (Table 6) and may be initiated by individuals, groups, governments, or other entities.

Although climate science can help us predict future changes, climate change in Kyrgyzstan is notoriously difficult to predict with certainty. Decisions about climate change adaptation must be made in the face of this on-going uncertainty. Adaptation should be guided by an approach of building resilience to impacts associated with a warmer climate, drier summers, and increased variability in weather events (i.e. drought, heavy rain). Climate change in the next 100 years is unlikely to lead to a new stable climate but rather continuously changing conditions. Adaptation is therefore an evolving process that reflects the continuing variation in weather events and impacts associated with climate change. Appropriate adaptation measures depend on the livelihood context (i.e. rural agriculture) and climate change impacts. There is a wide range of adaptation measures and not all are constructive or positive responses to change. Maladaptations include measures such as overgrazing drought-affected pastures or taking more credit than is possible to pay back and thus losing a home to the bank.

Climate change is only one of a range of natural, social, and economic issues that people face. Thus, successful adaptation measures focus on climate risk as it relates to household and community priorities such as livelihood strategies, access to water, disaster risk reduction, and capacity of

Drought	<ul style="list-style-type: none"> <li>• Utilize normally unused remote pastures when forage is diminished during drought (Kyzyl Zhar)</li> <li>• Switch to more drought resistant crops, i.e. from wheat to barley (Kenesh)</li> <li>• Increase planting of sainfoin in order to increase fodder storage (Kashka Zhol)</li> <li>• Change irrigating practices during drought (Kashka Zhol)               <ul style="list-style-type: none"> <li>• Use as little water as possible; irrigate during the night/early morning; recover the water at the far end of the field and direct it to the next field (instead of letting it go back into the river); plant crops that use less water (i.e. no rice)</li> </ul> </li> <li>• Use knowledge of tax law to apply for and receive tax exemption when crops are lost or damaged by drought (Kyzyl Zhar, Kashka Zhol, possibly Oi Tal and Alaikuu)*</li> <li>• Ayil Okmotu does not collect rent for AO lands during drought (Kashka Zhol)</li> <li>• Increased reliance on credit and dependency on remittances (all)</li> <li>• Sell livestock to buy hay (all)</li> </ul>
Flood	<ul style="list-style-type: none"> <li>• Ministry of Emergency Situations is supporting flood protection infrastructure (lower elevations)</li> <li>• Ayil Okmotus have developed emergency response plans</li> </ul>
Heavy snow	<ul style="list-style-type: none"> <li>• Increase fodder storage for longer winters (Kapchegai)</li> <li>• Ministry of Emergency Situations brought food by helicopter when road was closed by heavy snow in winter 2009/10 (Kyzyl Zhar and Alaikuu)</li> </ul>

**Table 5.** Existing adaptation measures in Kara Kulja

\* Tax Code Article 344, paragraph 2. Local kenesh have the right to provide full or partial relief from land tax on agricultural lands for up to three years when a farmer has incurred material losses from and uncontrollable force, force majeure.



civil society and government to support communities. Adaptation efforts are also more likely to be successful when they are coordinated with efforts aimed at poverty alleviation, enhancing food security and water availability, or addressing land degradation. This document is focused on community level adaptation strategies and does not explicitly address adaptation directed at policy or national level efforts.

*Recommendations for Adaptation Measures in Kara Kulja.* Kara Kulja farmers and livestock owners have been adapting to changes in weather and their environment for years. Best practices for adaptation combine climate science and global climate modelling data with local knowledge and adaptation strategies. Based on climate trends and predictions and community priorities and concerns, the following adaptation measures are recommended for small-scale village pilot projects. Village assessments may identify additional worthy adaptation measures. All adaptation measures should be accompanied by work to build community adaptive capacity— the ability to moderate potential damages, to take advantage of opportunities, and to cope with the climate related impacts. Approaches to building adaptive capacity in rural agriculture-dependent communities include information sharing on climate change trends, projections, impacts, and adaptation strategies; capacity building for climate change analysis and adaptation planning; and diversifying income strategies. Community adaptation measures should be implemented in close coordination with the village council, sub-district government, and relevant government ministries.

#### *Recommended Pilot Projects*

1. Implement soil and water conservation techniques in cultivated and pasture land.
2. Increase the use of drought resistant and early maturing food and fodder crop types and varieties.
3. Improve irrigation access and introduce water efficient irrigation practices and technologies.
4. Stabilize and protect riverbanks and flood prone areas with tree planting, flood walls and/or other physical structures.
5. Protect irrigation infrastructure from floods and mudflows.
6. Increase fodder production and storage capacity.
7. Improve food storage and preservation techniques and facilities.
8. Improve access to and use of quality weather forecasting for short-term and seasonal weather.

In addition to assisting communities in climate change adaptation, addressing the root cause of climate change, green house gas emissions, is also important. Reducing carbon emissions from household cooking and heating serves to raising awareness about the causes of climate change, decreases pressure on local fuel resources (often forests and manure), and contributes to global climate change mitigation efforts. Pilot projects may also include improving energy efficiency through improving building insulation or installing energy efficient stoves.

*Soil and Water Conservation.* Soil and water conservation is central to sustainable land management in the context of climate change. Cultivated lands in Kara Kulja experience wind and water erosion, depleted soil fertility, and lack of water particularly in rain fed lands. Pastures also experience wind and water erosion in addition to drying conditions and altered plant communities from over or under grazing. Soil and water conservation techniques aims to improve productivity and prevent land degradation. Strategies encompass a wide range of techniques designed to prevent or reduce soil erosion, compaction and salinity; conserve or drain soil water as needed; and maintain or improve soil fertility. Numerous organizations and efforts have developed successful approaches and techniques for achieving these objectives. The World Overview of Conservation Approaches and Technologies (WOCAT) houses an important knowledge base on many of these strategies.

## Discussion

Kyrgyzstan is already experiencing the impacts of climate change in warming temperatures and increased weather variability. The climate science, weather data, and local observations collected for Kara Kulja demonstrate clear climate trends and impacts. All data sources agreed on multiple temperature, precipitation, and natural disaster trends such as warming temperatures, changing precipitation patterns, and increased flood and landslide occurrence. Other climate parameters and impacts, such as wind events and avalanche occurrence require additional weather data and local experience observations to establish clear trends. Climate analysis is not a one-time assessment but should be conducted regularly to continue to establish key trends, impacts, and appropriate adaptation measures.

This report focuses on climate change and its impacts on residents of Kara-Kulja. However, it is also

Adaptation Forms	Examples
Technological	Drought resistant crop varieties; water efficient irrigation system
Behavioural	Increase fodder production and storage; shift the crop calendar according to new conditions
Financial	Improve access to insurance, credit, and/or savings
Institutional	Establish early warning and emergency response systems
Informational	Improve access to seasonal weather forecasting

**Table 6.** Example of adaptation forms and activities, adapted from Smit and Skinner 2002

important to consider how local actions may exacerbate climate change impacts that might otherwise be mitigated or avoided. Poor agriculture practices or poor land use planning, for example, may contribute to land degradation or cause infrastructure and human life to be unnecessarily vulnerable. The locally identified increase in flash flood occurrence is likely a combination of climate change impacts and poor pasture management practices. While there has been an increase in heavy precipitation events that cause excessive and rapid runoff, this has coincided with a decrease in perennial and annual pasture vegetation due to fuel collection and intensive grazing on slopes proximate to villages.

While climate change impacts are expected to increase, adaptation measures have the potential to significantly improve community resilience to these impacts and, additionally, to reduce the vulnerability of downstream communities throughout the country and region. Adaptation measures for drought, flood, landslide, strong winds, and heavy snow can maintain and even improve crop and livestock production and protect key infrastructure. Soil and water conservation measures to prevent or reverse land degradation are a critical aspect of adaptation. The examples of climate change adaptation presented in this report, however, are unlikely to work if implemented in isolation. The most effective adaptation efforts build on existing adaptation strategies and the priorities for local governance, community development, and sustainable natural resource management.

## Acknowledgements

This research was undertaken as a component of the Mountain Societies Development Support Program (Kyrgyzstan) project, "Increasing rural communities' ability to adapt to climate change in Osh," funded by ICCO and Kerk in Actie.

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