INTRODUCTION

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This book summarizes the main findings of the multidisciplinary research and post-graduate education project “Land use, ecosystem services, and human welfare in Central Asia (LUCA)” (2010-2014) conducted by Giessen University and its partners in Germany and Central Asia[1], funded by VolkswagenStiftung. The project combined research activity and scientific education with emphasis on the intrinsic interaction of people and their environment in the vulnerable region of Central Asia. The principal theme of the project has been the interrelation between ecosystems, land use, and human activity. Ecosystems provide supporting, provisioning, regulating, and cultural services that sustain human wellbeing but that are in turn also affected by human activity. The issue of land use and its natural and socio-economic drivers is of particular scientific interest when analysing the region of Central Asia with its extremely diverse ecosystems and with its societies and systems in transition. The increasing scarcity of natural resources – particularly water and fertile soil – together with conflicts over their use endanger the welfare of the people in the region and potentially could lead to political conflict.

With these issues in mind, a multidisciplinary and cross-national approach has been chosen by Giessen University and its partners to investigate this broad topic while in particular utilizing and enhancing the research capacity of the region. Within several subprojects young academics from Kyrgyzstan, Kazakhstan, Uzbekistan, and Tajikistan have concentrated their PhD research activities on the assessment of past and current land use structures and their interrelation with physical processes of the biogeosphere, economic development, and human welfare. Senior researchers from Germany and Central Asia have guided the research of the PhD students. Capacity building has therefore been an integral component of the LUCA project targeting three areas: the improvement of the methodological expertise of the young researchers, the promotion of multidisciplinary thinking and transnational cooperation, and the (re)connection with the international scientific community. Alongside the

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1 Partner institutions of the project have been: Marburg University, Dept. of Geography (Germany); Helmholtz-Centre Potsdam GFZ, German Research Centre for Geosciences (Germany); Central Asian Institute of Applied Geosciences (CAIAG), Bishkek (Kyrgyzstan); Hydrometeorological Research Institute (NIGMI), Tashkent (Uzbekistan); Academy of Sciences, Institute of Economy and Demography, Dushanbe (Tajikistan); Scientific Information Center of Interstate Coordination Water Commission (SIC ICWC), Tashkent (Uzbekistan); National Space Agency, National Center of Space Researches and Technologies, Almaty (Kazakhstan); Scientific Research Institute of Ecology and Climate, Almaty (Kazakhstan); Agricultural University, Tajik Agricultural Economics Institute, Dushanbe (Tajikistan).

research activities, the project has focussed on education and has conducted summer schools, training courses, a conference, and has facilitated the presentation of research outcomes in international symposia and publications.

This book, organized in two parts, presents abstracts of the research of the subprojects. The first part focuses on dimensions of earth and environmental sciences and demonstrates on how and to what extent (man-made) changes of biogeographic conditions have occurred and how they will influence land use in the future. The study of Duishonakunov/King on a mountain range of Southern Kyrgyzstan measures substantial glacier retreat of more than twenty percent on average as well as changes in permafrost due to climate change over a period of 45 years. This has serious implications for natural hazards and the economic development of the region. Another natural disaster is described in the work of Aslanov et al: the drama of the anthropogenic desertification process of the former Aral Sea. The authors have studied spatial and temporal ways of dust deposition, the composition of the deposited material containing pesticides, heavy metals and salt, and its potential impacts on arable land and human health. The research of Teshebayeva et al deals with the hazard of earthquakes and landslides. The researchers developed a special remote sensing technique for the analysis of such surface displacements in Southern Kyrgyzstan in order to help in the understanding of active tectonic processes and their spatio-temporal consequences. The improvement of irrigation and drainage systems in order to minimize water loss and return flow is the underlying idea of the work of Kenjabaev et al. By modifying a special hydrological model, they were able to predict and compare groundwater levels for various crops in the Fergana province of Uzbekistan and thus assess the efficiency of local irrigation and drainage management practices.

The second part of the book describes project research on socio-economic and institutional aspects of land use and their interrelation with human wellbeing. The working group of Khakimov et al evaluated the macroeconomic drivers of the agricultural sector of Tajikistan and explained that current income growth in the country, mainly caused by a continuously high inflow of remittances, will translate only marginally into an increase in domestic production but will lead to an increase in food imports. The case study of Gojenko et al investigated food consumption in two districts of Eastern Uzbekistan and revealed a considerable level of food insecurity, amounting to forty percent of surveyed households. This showed a direct relationship between the area of household plots, the number and variety of crops cultivated, the number of household members, and the education level of the head of the household. The contribution of Zhunusova/Herrmann investigated the impact of both direct agricultural policies and changing macroeconomic conditions on agricultural incentives in Kyrgyzstan. The authors found out that the production of food crops was preferred over tradable agricultural products due to food self-sufficiency needs, a lack of market access for export products, and a protected home market for importable goods such as energy sources and machinery. A different type of research has been undertaken by the working group of Sabitova et al who looked at the implementation of the Kyoto Protocol in Kazakhstan and its legal implications for land-use, land-use change, and forestry (LULUCF). The argument of the authors is that a domestic emissions trading scheme together with participation in Joint Implementation projects may be employed for Kazakhstan's quantified emissions limitation and reduction commitment under the Kyoto Protocol. The final contribution of Avazov et al looks at the issue of efficient pasture management in Tajikistan's mountains. Applying a bio-economic, linear programming model the authors determine the economic impact of various grazing management strategies. They show how a concentrated pricing will impact on the system by improving inventories over the season and promoting the production of fodder crops to reduce pressure on pastures.

Although each subproject has been very specific in its research question, the overall observation is that land use has been continuously changing in Central Asia, being influenced by and influencing human welfare. Understanding the extent and the drivers of that change is crucial for the further development of the region. The LUCA project has been contributing to this analytical process through its research. Probably the most important outcome of the project has been, however, the enhanced personal and institutional scientific relationships that will sustain further investigations in the future.

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Giessen, in July 2014

Part I:
Natural Resources and Environment

CLIMATE CHANGES IN THE NARYN CATCHMENTS: CONSEQUENCES FOR GLACIERS, PERMAFROST AND THE ECONOMIC DEVELOPMENT IN KYRGYZSTAN

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0 ABSTRACT

The recent glacier conditions in the Naryn catchments were investigated using topographic maps and satellite imagery. The results show, that during the 45-year period 1965–2010, the glacier area decreased in the mountain ranges by 17 to 29%. The glacier shrinkage will affect not only irrigation water availability during summer but also the potential of hydropower stations once numerous smaller glaciers will have disappeared. In addition massive ground ice in permafrost may also melt in a warming climate. This will create natural hazards, especially slope instabilities. Glacier changes may lead to catastrophic glacier lake outburst floods, a common phenomenon in Kyrgyzstan. The effects of climate change on water resources are of paramount importance because of the high dependency of Kyrgyzstan on fluvial water originating from the mountains. Monitoring water resources and planning water use at a balance between water use and water resources belong to the most important issue in this region. In spite of this well-known imbalance, water demand may increase in the future due to food- and energy-security concerns in the region, and this might even lead to severe conflicts among nation states.

1 CLIMATE CHANGE AND WATER AVAILABILITY IN KYRGYZSTAN, AN INTRODUCTION

Naryn basin has the largest river catchment area in Kyrgyz Republic and many mountain glaciers. It is a huge “water tower” for the Kyrgyz Republic and Uzbekistan. Thus, the glacier conditions in the Naryn catchment have a large impact on the available water resources for the arid flat plains below. They provide water for residents, irrigation, and energy in the Kyrgyz Republic but also other parts of Central Asia.

Scientific discussions suggest that, regardless of whether climate change has natural or anthropogenic causes, it will have strong effects on glacier recession, regional hydrological balance, and economic sustainability in arid and semi-arid regions of Central Asia (Alamanov et al., 2006; Fujita et al., 2011). The probable potential effects of climate change on water resources are of paramount importance because of the high dependency on fluvial water originating from mountains. Monitoring water resources and planning water use and the balance between water use and water resources are very important issues in this region because the majority of the water supplied from Central Asian mountains is used within the irrigation zones of the arid flat plains (Report of Eurasian Development Bank, 2009; Agrawala et al., 2001). This study therefore intends to deliver valuable data for estimating the magnitude of glaciological changes and their future effects for the water availability in this region.

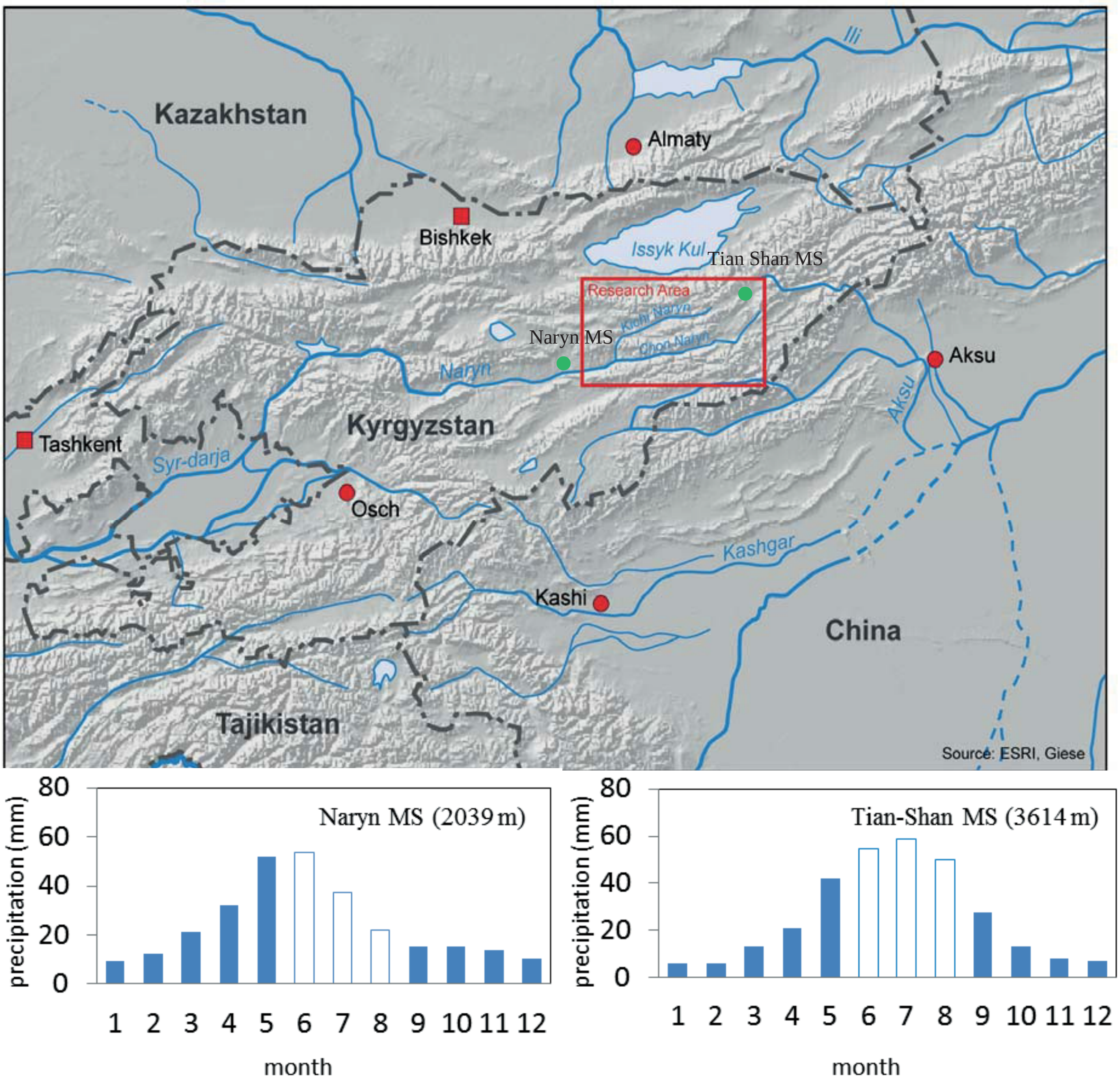
In addition to the glaciological study, the extent of frozen ground and its characteristics are also researched, as the occurrences of widespread massive ground ice in permafrost has to be assumed. This ground ice will melt in a warming climate and thus not only contribute to the water balance. More important, it will create hazards as e.g. slope instabilities by many thawing and freezing (periglacial) processes. At the same time, also glacier changes may create hazards, as e.g. catastrophic glacier lake outburst floods (GLOFs) that are very common and dangerous in Kyrgyzstan. Glacier changes (glaciology) and changes in the periglacial environment (geocryology) are therefore strongly connected by many interrelations. The hazards involved may influence and hinder the development of Kyrgyzstan. Selected glaciological and periglacial aspects will be presented in this paper.

2 THE STUDY AREA

The Naryn basin flow runs from east to west across the territory of Kyrgyzstan, and its length, before merging with the Syr-Darya, is more than 700 kilometers. The major water resources of the Naryn basin are fluvial water from rain and snow and glacier melt in the upstream area. There are 654 identified glaciers in the Naryn basin (Glacier Inventory of USSR, 1973, 1977). We investigated the recent condition of glaciers in the Chon Naryn and Kichi Naryn river catchments in the eastern part of the Naryn basin (Figure 1). These catchments include 69% of the glacier area in the Naryn basin, including 607.9 km2 (10.8% of the basin) in the Chon Naryn and 344.7 km2 (8.9% of the basin) in the Kichi Naryn. The catchments include eight mountain ranges: the Akshyirak, Borkoldoy, Naryn, Sook, Jetim, Jetimbel, Terskey, and Uchemchek.

Two meteorological stations are shown in Figure 1, along with the seasonal variation in monthly precipitation for 1930–2010 for selected stations. The climatic conditions in the upper Naryn basin are very severe, and all locations within it show an average annual air temperature below freezing point. In the lower part of the upper Naryn basin, annual precipitations are 292 mm at the Naryn meteorological station (2039 m) and 311 mm at the Tian Shan meteorological station located at an altitude of 3614 meters (Figure 1, cp. Figure 10 for climate values).

Figure 1: Location of the Naryn basin. The red rectangle shows the study area. Green dots show the locations of the two meteorological stations. Figures at the bottom show the seasonal variation in monthly precipitation for 1930–2010 for selected stations (white bar: JJA).



Annual precipitation is low, and the maximum precipitation occurs during summer (May to August) because of the topographical complexity of the Tian Shan Mountains and the complex interactions between the Westerlies and the Siberian High that affect the precipitation in the Tian Shan Mountains (e.g., Aizen et al., 1995, 1997). The basin has clear cloudless weather with little precipitation during winter, and this allows the use of the Arabel Kumtor, and Chon Naryn catchments as winter pastures. In this paper, local Kyrgyz geographic names are used according to Barataliev (2004) and Barataliev et al. (2004).

3 DATA AND METHODOLOGY FOR GLACIER AND PERMAFROST STUDIES

3.1 Available data and data processing

To clarify recent glacier changes in the two catchments, glacier boundaries were delineated on 1:25,000 topographic maps based on aerial photography collected in the 1960s and with “Advanced Land Observing Satellite” and “Advanced Visible and Near Infrared Radiometer type 2” satellite datasets acquired during 2008–2010. This ALOS/AVNIR-2 (70 × 70 km) data used consists of four bands, three visible (0.42–0.69 µm) and one near infrared (0.76–0.89 µm), and have a spatial resolution of 10 m (JAXA, 2009). We used orthorectified ALOS/AVNIR-2 products by JAXA in this study. To reduce the potential uncertainty in glacier mapping with satellite data, we selected satellite imagery acquired during the glacier ablation period that had minimal cloud cover or nearly cloud-free conditions. The topographic maps were scanned at 700 dpi and were projected by georeference on ArcGIS 9.2.

Figure 2: Extraction of glacier outlines in the Borkoldoy range from ALOS/AVNIR satellite images and topographic maps (1:25,000). Dark-blue glacier outlines of 2010, and white dotted outlines of 1965.