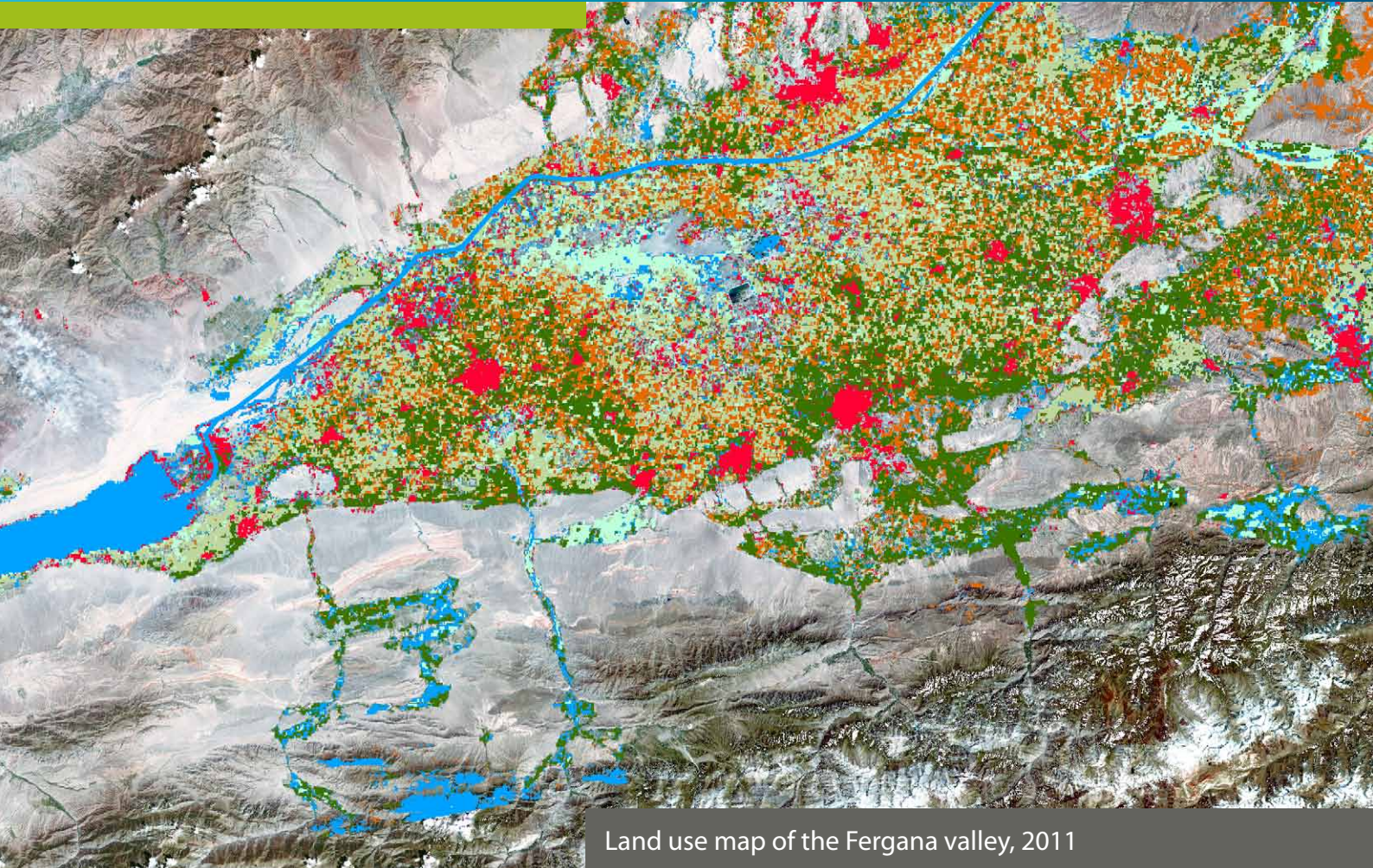


Policy Brief

Issue 01/2015

Informed Decision-Making in Land and Water Management in Central Asia

How Earth Observation Technologies may contribute



Land use map of the Fergana valley, 2011

Introduction

In the context of Integrated Water Resources Management (IWRM), informed decision making requires accurate, timely, spatially extensive, consistent and well understood data sets on climate, water and land resources. Earth observation technologies provide such data sets as well as methods and tools for the generation of high-quality data products to support planning and decision-making. This Policy Brief advocates the use of Earth observation technologies and their integration into operational monitoring and decision-support systems in Central Asia based on examples from the CAWA project.

Key Messages

- ≈ The use of modern Earth observation technologies, both ground-based and space-based, can substantially improve planning and decision-making in water and land management in Central Asia, supporting informed decision-making at local, national and regional levels.
- ≈ This requires short-term investments and a long-term commitment to funding the responsible national and regional institutions.
- ≈ New educational efforts are needed to train specialists, involving regional and national vocational training centers and university education.
- ≈ The global character of and the open access to satellite remote sensing data make them a transparent and low cost data source for use in transboundary river basin planning.

Can decision making in Central Asia rely on existing data?

Facts & Figures

31 million USD are the annual costs for all Central Asian countries together, which are due to various forms and levels of land degradation (estimations based on Sutton et al. 2008).



Salt crusts - an indicator of large-scale soil degradation

Average annual losses caused by weather hazards may be cut by 20-30 % if hydrometeorological information and services are improved. This was shown by economic assessments of the World Bank (2009).



Dried bed of the Toktogul reservoir in summer 2008

Informed decision-making in land and water management requires extensive and reliable data sets to address pressing problems such as food security for a growing population, economic development relying on water and land resources, environmental degradation such as soil salinization, and the protection of the population and economies from damages and losses caused by natural disasters.

Despite remarkable efforts directed to data collection at the mandated state agencies, informed decision making in Central Asia still faces substantial challenges arising from the limited availability and reliability of data sets. These challenges are:

Completeness. Often, datasets are incomplete in space or time, either because data collection has been interrupted or restricted to easily accessible areas or because datasets are not shared between institutions and/or countries. For example, the degradation of the hydrometeorological monitoring in the flow formation zone resulted in less reliable runoff forecasts; in the low lands, well-maintained instruments for channel flow measurements are frequently missing at the levels of water user or farmer associations making assessments of water use impossible.

Data quality. The widely spread poor state of measurement equipment reduces the quality of the measured data. For example, harvest data provided by farmers may be affected by uncalibrated scales, river discharge data by displaced and unreadable rod gauges.

Comprehensive meta-data. Available datasets, e.g. on reservoir volumes or water withdrawals, are usually not well documented. It is unclear how they were generated and processed, and which uncertainties relate to them. Such meta-information is crucial to assess the informational value of the data before using it in decision-making.

Consistency. Changes in and differences between measurement techniques, data processing, or indicator definitions result in data sets, which may not be comparable through time or across administrative boundaries. For instance, changes in the location of meteorological stations may introduce systematic changes in the measured variables, which could be misinterpreted as climate change signal; changes in the definition of the crop type "orchard" may cause a virtual variability in official statistics; water intensive rice is frequently underestimated in official data on area and yield leading to an overestimation of other crops and blurring water demand assessments.

Efficient data formats. Many data sets are still managed in analogous tables, reporting books or analogous maps. This hampers rapid assessments over large areas, e.g. repeated and spatially distributed assessments of land resources or water use efficiency in cropping systems.

Timeliness of information. Data sets are required in time for many decisions, e.g. the seasonal flow forecast is needed weeks before the start of the new vegetation season. Timeliness of information requires real-time data collection, transmission, and processing.

Knowledge. Educational backlogs brought serious shortfalls in basic knowledge and skills in the fields of data handling and processing, geographical information systems (GIS) and remote sensing in many institutions in Central Asia.

New Earth Observation Technologies improve the data basis

Earth observation technologies provide methods and tools to address these challenges. The integration of the new technologies into operational monitoring systems will substantially improve the reliability, timeliness and spatial extent of those data sets on which decision-making relies.

Land and water resources can be monitored using **ground-based** and **space-based** Earth observation technologies. Both approaches complement one another and need to be strengthened in Central Asia.

Strengthen Ground-based Monitoring

In Central Asia, ground-based networks of hydrometeorological monitoring stations are operated by the National Hydrometeorological Services. After the collapse of the Soviet Union, these networks degraded substantially, both in the amount of stations and the condition of the measurement equipment, which led to less information of even poorer quality. The network degradation was particularly severe in the headwater catchments in the high mountain areas of Central Asia, which are acting as the “flow formation zone”, where most of the river runoff is being formed.

Ground-based hydrometeorological observations are essential data sets for water management, particularly in the “flow formation zone”. They are used to derive the weather forecast and the seasonal runoff forecast on expected water availability in the vegetation period, as well as to determine the optimal sowing dates in agriculture. Moreover, they are needed for emergency forecasts and warnings, e.g. on the magnitude and timing of floods and droughts. Thus, they support decision-making at the province, national and river basin levels.

A dense and well-maintained ground-based observational network in the flow formation zone is needed in order to improve the forecasts. The implementation of a multi-sensor approach increases the benefits from the investments into the observational infrastructure and of the operatio-

nal costs. Multi-sensor stations, such as the stations installed in the frame of the CAWa project (see Box 1), may provide meteorological, hydrological, glaciological, environmental, seismological and other data for different users, e.g. Hydromet services, emergency agencies, agencies for nature protection, agriculture and water management organizations, or power suppliers. The operation of such multi-purpose stations relies on trans-sectoral cooperation.

Example 1

Multi-Sensor Monitoring Stations CAWa-Hymet

Within the past decade, a number of international projects have addressed the “observational gap”, among them the CAWa project. Within this project nine automated monitoring stations have been installed in Kyrgyzstan, Tajikistan and Uzbekistan (Schöne et al., 2013). The stations feature independent power-supply by solar panels and a bi-directional satellite communication system for real-time data transmission and remote access to the station. This allows for their integration into Early-Warning systems. Beside standard climate sensors (air temperature and humidity, precipitation, solar and thermal radiation, soil moisture and soil temperature) the stations integrate a range of other sensors, depending on their location, e.g. systems for river discharge and snow measurements, cameras for glacier monitoring, or seismometers. This is called the multi-sensor approach.



The Abramov meteorological and glaciological monitoring station installed in 2011 within the CAWa project.

Integrate Satellite Remote Sensing

During the past decades, satellite technology for monitoring the Earth's surface has been continuously improving. By the year 2030, more than 250 new satellites are expected to be launched for the purpose of civil Earth observation (Wallstreet:Online, 30.04.2014). Current activities in the public space sector like the upcoming Sentinels (EU-Copernicus program) or NASA's Earth Observing System (EOS) missions focus on free data policies opening opportunities for numerous users in the scientific, public and private sectors also in Central Asia. This technology already has shown a great potential for complementing and improving

ground based data acquisition in Central Asia. Modern satellite sensors permit bi-weekly information on crop growth status, early season crop maps (cotton, wheat, rice, orchards, see Example 2), yield estimations (Example 3) and can support assessments of water consumption for crop growth in irrigation systems (evapotranspiration). Monitoring and quantifying crop production can help planners to manage and optimize agricultural production, both at the local, national and even regional scales. For example, regular and area-wide timely information on agricultural production is indispensable for combating

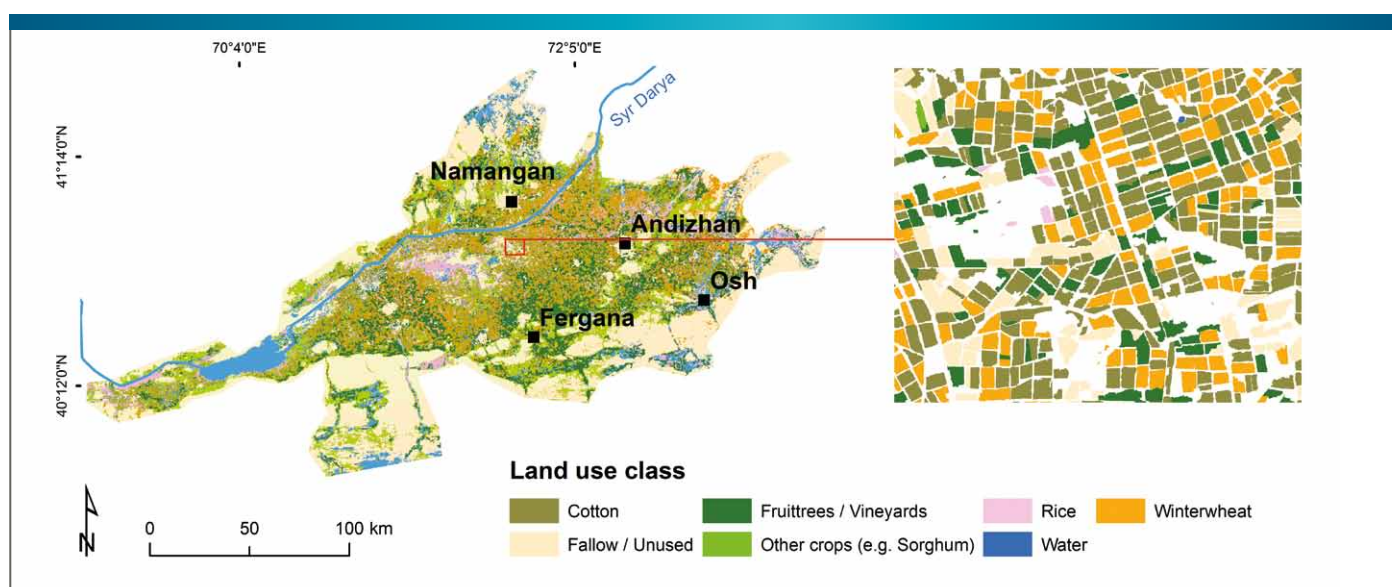
stress on crop production and for securing short-term and long-term stable and reliable supply of food and fiber.

Satellite Earth observation also provides valuable spatial information on water resources in the flow formation zone, in particular water stored in seasonal snow pack and in glaciers. For example, the information from daily snow cover maps computed from freely available satellite data can substantially improve the forecasts of snowmelt start and of runoff during the vegetation period (Example 4).

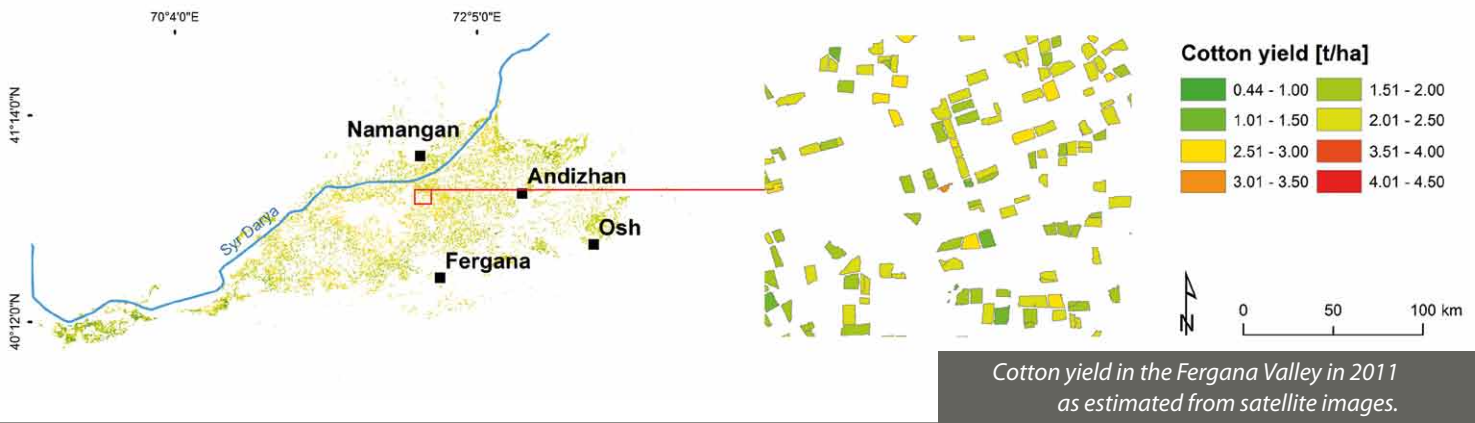
Example 2

Land use maps

Land use maps are produced by means of classification of satellite images. Maps of agricultural land use can be created at the regional level (e.g. for all irrigated land in Central Asia) for major crop types like cotton, rice, or winter wheat (left hand image). The classification accuracy of such maps is > 85%. More detailed crop maps can be produced at the per-field scale in focus regions in order to perform local assessments of crop pattern (right hand image). Multi-annual records of agricultural land use enable planners and decision makers to monitor cropping and rotation patterns, and agricultural diversity in a region. Such maps can be used as input for water demand estimations.



The land use map of the Fergana valley for 2011 shows the main cultivated crops and water bodies.



Example 3

Yield estimation

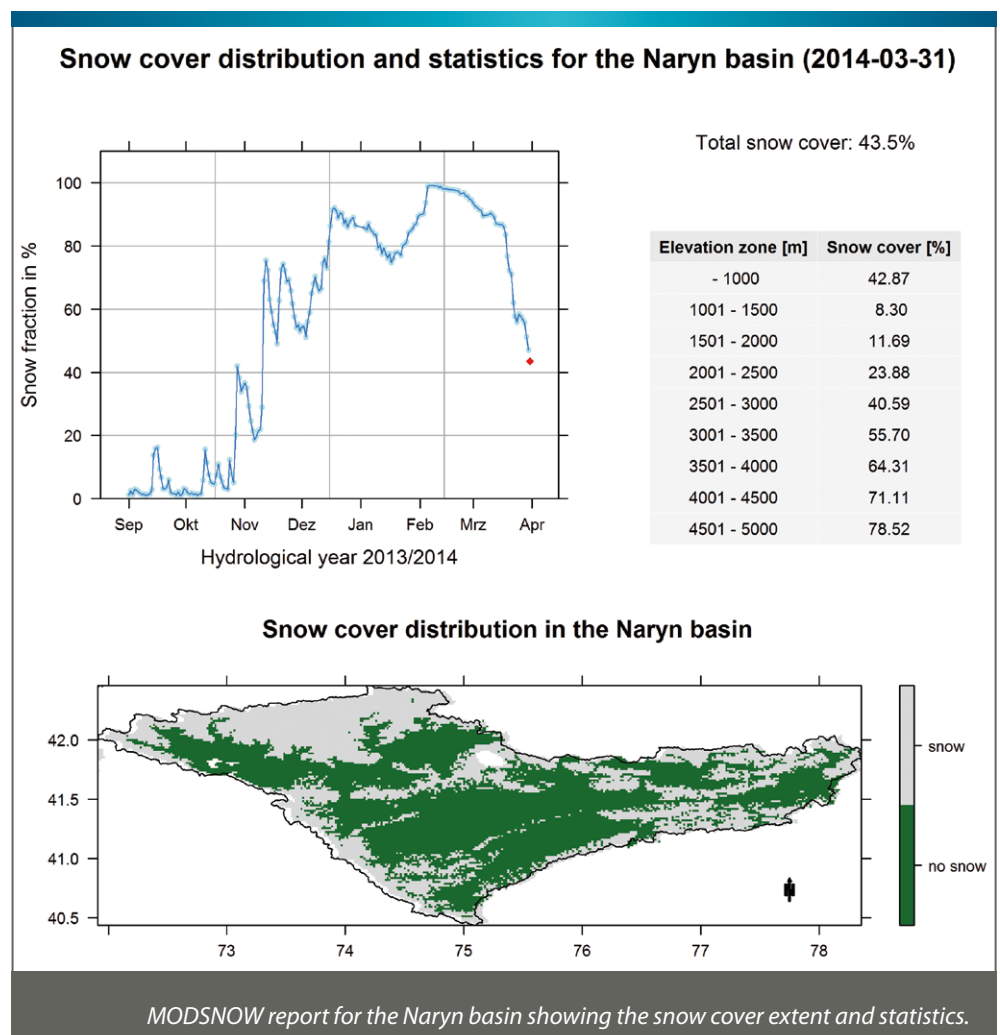
Based on satellite images crop specific yield can be calculated for major crops in Central Asia (cotton, rice, and winter wheat). Depending on the availability of suitable images, regional (left hand image) and local scale (right hand image) analysis of spatial yield pattern can be performed. Multi-annual records of crop yield enable

les monitoring of crop production and to detect areas of suboptimal growing conditions or marginal lands. This is valuable baseline information for planners and decision makers, e.g. for spatial targeting of rehabilitation measures.

Example 4

Snow coverage

The automated MODSNOW tool developed in the frame of the CAWA project produces daily snow cover maps for Central Asian river basins based on freely available satellite data from the MODIS instrument. The main features of the tool are the removal of clouds from the original data sets and the provision of snow cover statistics for watershed areas (Gafurov et al., 2009). By 2014, the MODSNOW tool has been implemented at the National Hydrometeorological Monitoring Services of Kazakhstan, Kyrgyzstan, Uzbekistan, and Turkmenistan, where the snow cover maps improve the predictive power of the seasonal runoff forecast.





Taragay meteo station
in the Naryn basin, Kyrgyzstan

From Data to Decisions

The way from scientific applications of Earth observation towards practical implementation for decision making requires a strong will and substantial efforts from the Central Asian countries.

Infrastructure. To use Earth observation technologies operationally, substantial investments are needed into hardware (e.g. multi-sensor stations, computation facilities) and software, which is partly already available free-of-charge as open-source solutions. Good access to the internet – as it already exists in most capitals of the region – is needed to receive satellite data, which makes special satellite antennas redundant.

Long-term operational budget. The operation of the hardware and communication lines requires a certain amount of operational costs, e.g. for maintenance, calibration of sensors in monitoring stations, internet communication. These costs need to be considered in the budgets of the responsible institutions.

Qualified specialists. Well-trained staff including technicians and specialists in geographic and hydrometeorological fields are required to process and manage the data sets, analyze them, and prepare the relevant high-quality products for decision making. To avoid a “brain drain” these specialists need to be paid appropriately, which requires a sustainable funding of the responsible institutions.

Education. The required knowledge for data processing, analysis and product generation includes the principal understanding of spatial data and the monitored processes, profound knowledge in the use of geographical information systems, and programming skills. This makes the establishment of vocational training facilities and the inclusion of GIS and remote sensing methods into university curricula indispensable.

Data sharing mechanisms. Decision-making in water and land management will always involve different sectors and institutions from one or several countries. Informed decisions which aim at balancing the interests of different sectors rely on shared and transparent data sets. The global character of and open access to satellite remote sensing data, which is not limited in its spatial extent to administrative boundaries, fits well with this approach. Earth observation data and products can be made available to decision-makers from different sectors, at different administrative levels and across boundaries through decision-support and information systems, such as CAREWIB hosted at SIC ICWC. Such systems may be designed in a distributed approach, with decentralized data storage at the data providing institutions but centralized access for the users through a national or regional web interface.

Bibliography

Gafurov, A., Bárdossy, A., 2009. Cloud removal methodology from MODIS snow cover product. *Hydrology and Earth System Sciences*, 13, 7, p. 1361-1373.

Schöne, T., Zech, C., Unger-Shayesteh, K., Rudenko, V., Thoss, H., Wetzels, U., Gafurov, A., Illigner, J., and A. Zubovich, 2013. A new permanent multi-parameter monitoring network in Central Asian high mountains – From Measurements to Data Bases. *Geoscientific Instrumentation, Methods and Data Systems* 2, 97-111, 2013. DOI: 10.5194/gi-2-97-2013

Sutton W, Whitford P, Stephens EM, Galinato SP, Nevel B, Plonka B et al., 2007. Integrating environment into agriculture and forestry. Progress and prospects in Eastern Europe and Central Asia. Volume 1. Washington, DC, The World Bank.

World Bank, 2009. Improving weather, climate and hydrological services delivery in Central Asia (Kyrgyz Republic, Republic of Tajikistan, and Turkmenistan). Report prepared in the frame of the technical assistance project “An action plan for improving weather and climate service delivery in high-risk, low-income countries in Central Asia”, World Bank Russia Country Office, Moscow.

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Picture credits

Title page, pages 4-5: Land use and yield maps by Wuerzburg University, 2013
Page 2: Toktogul reservoir in summer 2008 by CAIAG, 2008; Salt crusts by ZEU, 2010
Page 3 and 6: Abramov and Taragay stations by GFZ, 2011 and 2013
Page 5: Snow cover map by GFZ 2014

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