meeting summaries

NASA LCLUC Science Team Meeting on Land Use and Water Resources in Central Asia

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Rationale for the Meeting

Two key challenges facing Central Asian countries include land degradation and water resource management. Land-cover change, unsustainable land use, and poor management of river waters in the region have created disputes. As the countries of Central Asia are heavily dependent on use of fragile dry lands and limited arable land, land-use change and water management are central issues in the region. A number of regional and international efforts have been made to understand the causes, extent, rate, and societal implications of land-use changes in the region, but these efforts have not been synthesized or framed effectively to address emerging issues.

To help fill this gap, NASA's Land Cover/Land Use Change (LCLUC) program organized a Science Team Meeting focusing on land use and water resources in Central Asia in Bukhara, Uzbekistan, November 7-15, 2013. The Tashkent Institute of Irrigation and Melioration (TIIM) hosted the meeting, which was co-organized by the Monsoon Asia Integrated Regional Study (MAIRS) Program, Global Observations of Forest and Land Cover Dynamics (GOFC-GOLD) Central Asia Regional Information Network (CARIN), and the Northern Eurasian Earth Science Partnership Initiative (NEESPI), with the support from SysTem for Analysis, Research and Training (START). Nearly one hundred scientists attended the meeting, with forty international participants from eleven different countries.

In addition to the science team meeting, there were two other related activities: a LCLUC Leadership Summit (November 7-9) with the TIIM, Bukhara campus (TIIMB) and Samarkand Agricultural Institute (SAI) serving as hosts—see *Leadership Summit* on page 18; and a two-day training session (November 14-15) for students and early-career scientists—see *Training Workshop* on page 19.

The objectives of the science team meeting were to:

- Present the latest research findings that address regional climate, land-use, and water resource issues in Central Asia;
- exchange data, information, and knowledge across the region and with international communities

Group photo of LCLUC Science Team Meeting attendees.

that promote strategies to mitigate food and water sustainability challenges in the region; and
- understand the role, availability, and accessibility of Earth observations for addressing the related science and applications questions, and to strengthen the CARIN.

Opening Presentations

Mukhamadkhan Khamidov [TIIMB—*Rector*], **George Krol** [U.S. Department of State, U.S.—*Ambassador to Uzbekistan*], **Shavkat Khamraev** [Government of Uzbekistan—*Deputy Minister of Agriculture and Water Resources*], and **Saidkul Arabov** [State Committee of Land, Geodesy and Cadaster, Uzbekistan—*Chair*] each gave opening addresses.

Following these remarks came a series of presentations that gave an overview of the LCLUC projects in Central Asia and provided a scientific assessment of land use and water resources in the region.

Chris Justice [University of Maryland, College Park, U.S.] highlighted important land-use and water resource issues in Central Asia. He stated that the institutional and legal frameworks for water-resource management established in the early 1990s in Central Asian countries are not well suited for current national needs, and stressed that subregional cooperation will be essential in resolving transboundary water issues.

Garik Gutman [NASA Headquarters, U.S.] provided an overview of NASA's LCLUC program. Over the fifteen years since it was organized, the LCLUC program has supported approximately 200 research projects that address many regions of the world, including Central Asia. Gutman showcased several of the current NASA LCLUC research projects in Central Asia that examined regional hydrology and glacier dynamics, the role of LCLUC in water budgets and use, land-atmosphere dust interactions, and assessing the vulnerability of the *grain belt* in the semi-arid region. He stressed the need for synergistic use of the data from multiple satellites for LCLUC research, such as those from Landsat, Terra and Aqua [specifically the Moderate Resolution Imaging Spectroradiometer (MODIS)], Suomi National Polar-orbiting Partnership (NPP), and the European Space Agency's Sentinels, scheduled for launch in 2014 and 2015.

Jigauo Qi [Michigan State University, U.S.] presented an overview of the MAIRS program. Stating that Central Asian countries are highly vulnerable to climate change, he stressed the need for interdisciplinary approaches to tackle coupled climate-human-environmental system problems. He highlighted MAIRS initiatives in Central Asia for *Future Earth*, a global platform for international research collaboration on global environmental change and sustainable development. He stated that a dry land working group has been formed and a science plan has been drafted for the *Future Earth in Asia* component of the program.

The Earth Observer is not only the go-to source for detailed updates on important [Science Team] meetings by a wide array of Earth science disciplines incorporating satellite data, but also serves as a vital "corporate memory" for the NASA Earth Science program. I have learned much from the retrospectives of various NASA endeavors (EOS, Landsat, etc.) written for The Earth Observer by Earth science veterans. They have provided rich context for much of what happens in Earth Science Division these days.
*—**Woody Turner** [NASA HQ—Program Scientist for Ecological Diversity and Ecological Forecasting]*

Pasha Groisman [National Oceanic and Atmospheric Administration (NOAA), U.S.] described NEESPI projects in Central Asia, which address land-use and cryosphere changes, hydrological studies integrating LCLUC and climate, and LCLUC studies on drought mapping and monitoring. NEESPI is currently focused on integrated assessments and climate change projections over Central Asia.

Olga Krankina [Oregon State University, U.S.] provided an overview of the GOFC–GOLD program and networks, their structure, organization, and function, including Northern Eurasia Regional Information Network and CARIN activities. She stressed the need for regional cooperation and commitment from individuals and institutions to successfully implement regional network activities.

Alim Pulatov [TIIMT—Uzbekistan, *Meeting Host*] showcased some of the ongoing LCLUC activities at TIIM, with particular emphasis on the Eco-GIS Center, which is involved in geospatial LCLUC studies including water-resource research. He welcomed international collaborations with TIIM on LCLUC research.

Panel Discussions

The week-long meeting featured five different panels with overview presentations, followed by short presentations and extended group discussions. This format facilitated greater interaction among scientists. After these discussions there was a final plenary discussion that focused on data and knowledge gaps, which also identified research priorities for the region. Themes for the panels were:
- Aral Sea basin issues;
- agricultural land use and water resources;
- CARIN priorities for LCLUC research;

- monitoring land use, water resources, fires, and impacts; and
- high-elevation and water-resource research.

Some of the important points captured during the panel discussions and presentations are summarized below.

Aral Sea Basin

The Central Asian Republics depend on the rivers of the Aral Sea Basin for drinking water, irrigation, and hydroelectric power. The river waters in the upstream countries of the Basin (Kyrgyzstan and Tajikistan) are used for hydroelectric power, especially during the winter months, whereas in the downstream countries (Turkmenistan, Kazakhstan, and Uzbekistan), the Basin waters are used for agricultural purposes in summertime. In all countries, the traditional *flood irrigation* method is used, where water is pumped or brought to the fields and allowed to flow along the ground among the crops. Although this method is simple and cheap, more than half of the water is not used by the crops, and is wasted because of losses from evaporation and filtration. These losses, estimated to be about 40%, come from poor development of the irrigation networks and ineffective water management. The regional scientists at the meeting indicated that cotton monoculture is a major factor for water depletion and ecological problems in the region. Multiple crop rotations with legumes should be encouraged, and *drip irrigation* should be used for agro-ecosystem sustainability. They also agreed that replenishing the shrinking Aral Sea to its original state seems almost impossible; however, mitigation measures (e.g., building reservoirs and restoring wetlands) can be undertaken to reduce further degradation. All participants agreed that following the existing international laws on transboundary water issues through regional cooperation is the only way to "solve" the water resource issues in the region. With respect to the geospatial data on the Aral Basin and surroundings, the GIS Center at the Institute of Geography, Karakalpak State University (Uzbekistan), has been involved in creating digital databases on geobotanical aspects, landscape classification maps, protected areas, geomorphology, and other related issues useful for water/natural resource management.

Agricultural Land Use and Water Resources

In Central Asia, more than 60% of the population live in rural areas and work in the agriculture sector. Land suitable for crop production is 20% of the total agricultural land (and as low as 4% in Turkmenistan) and livestock production is important in the region. Cotton and wheat are the dominant crops in Central Asia and these crops rely heavily on irrigation. In Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, 80% of cropland is irrigated, while, in sharp contrast, the percentage in Kazakhstan is only 7%. Most of the agricultural areas in all these countries have been degraded by excessive cotton monocropping. However, the trend is changing, as cotton is being replaced by wheat. The region also produces a wide variety of crops in smaller amounts, including barley, corn, flax, grapes, beets, apples, apricots, and nuts; such diversification is good for the economy. Nonetheless, as a result of years of poor irrigation practices, there are large areas of salinization in the region, and this problem needs immediate attention. Further, diversion of water for irrigation has resulted in severe environmental problems in the downstream areas of the Syr Darya and Amu Darya Basins near the Aral Sea. Efficient water resource management is therefore a priority for the region.

Specific to Uzbekistan, land reform processes after 1991 led to smaller farm sizes, creation of protected areas, fewer pastures, and other changes in the distribution of land use. There is an urgent need to develop comprehensive management plans for ecologically sensitive lands. From the perspective of the international development community, ongoing LCLUC phenomena can be captured using remote sensing data and the patterns can be linked with underlying processes for effective planning and management in Central Asian countries.

With respect to climate change scenarios for the region, the Intergovernmental Panel for Climate Change Fifth Assessment Report shows no improvement in precipitation prediction, and there is a high uncertainty about changes in future precipitation, information that will be critical for agriculture and land-use planning.

CARIN Priorities for LCLUC Research

Scientists from Central Asian countries—including Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan, and the invited representatives from Caucasus (Armenia, Azerbaijan, and Georgia—participated in the panel, identifying priority LCLUC research areas for their respective regions. These included: water, snow and glacier monitoring (quantity and changes); agricultural research for improved crop production, irrigation and water management, and cotton residue treatments; vegetation mapping and monitoring; pests and crop disease monitoring; addressing land-degradation issues; reclamation of saline soils; and monitoring and conservation of critical ecosystems such as lakes and high-elevation forests. To strengthen science and education in Central Asia, the panelists suggested organizing joint international projects as teams, thereby addressing pressing regional LCLUC issues; strengthening collaborative efforts on water resources and management; organizing capacity building and training activities in remote sensing and geospatial technologies; and

forming a regional agricultural network in Central Asia, perhaps either by expanding CARIN to include the Caucasus region or developing a separate GOFC-GOLD network for the Caucasus countries (Georgia, Armenia, and Azerbaijan).

Monitoring Land Use, Water Resources, Fires, and Their Impacts

Participants felt that remote sensing and geospatial technologies are underexploited for LCLUC research in the region, and for operational management of water resources, fires, and environmental management. For example, since Kazakhstan gained independence from the former Soviet Union in 1991, there has been a significant reduction in pasture resources due to increases in livestock-based agricultural practices. Since around 2000, records indicate significant reductions in vegetation cover in pasturelands have resulted in a loss of productivity. Thus, use of remote sensing imagery to map pastureland productivity for decision support can provide useful information. Some international collaborations have resulted in generation of applicable products for the region. **Martin Kappas** [University of Gottingen, Germany] showed regionally calibrated *leaf area index* (LAI) time-series products from NOAA's Advanced Very High Resolution Radiometer (AVHRR) data for Kazakhstan from 1982 to 2010. **Abror Gafurov** [GeoForschungsZentrum (GFZ), the German Research Center for Geosciences] showed advanced snow-cover mapping products using MODIS data useful for hydrological studies.

Fire mapping from MODIS data suggests that Central Asia accounts for only 2% of total global fires. Agricultural residue burning in some northern provinces of Uzbekistan is common and practiced for disposing of wheat residues; however, it is illegal in most cases. MODIS active fire data are used by the Jeyran Eco-Center to monitor local fires in dry land vegetation and to detect illegal agricultural burning. There is an opportunity to develop regional fire products through calibration and validation of global data in dry land areas. Additionally, local participants emphasized the need for capacity building, education, and training in water-resource research and modeling.

High-elevation and Water-resource Research

Over the globe, between 70% and 80% of glaciers are located in high mountain areas, of which 35% are concentrated in Central Asia. More than 60% of the water supply for Central Asia comes from snow-water melt, 20% from glacier melt, 18% from rain, and 1% from other sources. The Central Asian Institute of Applied Geosciences (CAIAG) in Kyrgyzstan is involved in generating regional geospatial datasets useful for water resource research, which includes soil, land use, climate, agro-ecological potential, and water management maps.

The Earth Observer is a great service and resource for the [Earth science] community. It does a great job covering key events and has helpful graphics. The balance of topics and well-written, accessible articles make [the newsletter] a welcomed arrival in my inbox. It's a great way to inform the NASA community about efforts to apply Earth observations as well as to highlight the missions, data, and research that enable applications in the first place.

*—**Lawrence Friedl** [NASA Headquarters—Director of Earth Science Division's Applied Sciences Program]*

CAIAG is also involved in glacier research, conducting meteorological, seismic, and global positioning systems (GPS) measurements in high-altitude glacial regions in Kyrgyzstan. Their research suggests an increase in regional glacier retreat rates from 1970 to the 1990s. For example, in the mountain regions of Akshiyrak, Kyrgyzstan, a relative loss in the area of 13% was observed; similarly, in it was 34% in Djetim, 19% in Borkoldoi, 10% in Nijniy Naryn, and 15% in At-Bashi. The glacier retreat is mostly observed in small glaciers. Integrated meteorological, remote sensing, and instrumentation data suggests that over Central Asia over the last thirty years, snow-covered-areas shrank by 15% and glacier-covered-areas by 10%. Absolute values of precipitation over the whole Central Asia were negative for the last 30 years with the most significant deficit in the alpine regions and Kazakhstan steppes during summer. For the same region, an increase in annual air temperature of 0.68 °C was observed over the last thirty years, and for all of Central Asia, total river runoff has decreased by 4%.

Earth Observations and Remote Sensing for LCLUC Studies

This session took place on the third day of the meeting, and included presentations on potential synergistic use of Landsat and Sentinel data, and potentially merging these data to obtain three-to-five-day coverage, useful for agriculture monitoring. Examples were also provided of remote sensing projects conducted at the University of Würzburg (Germany).

Invited Presentations

In addition to the above panel discussions, the meeting included two invited talks. **Rik Leemans** [Wageningen University, Netherlands] discussed *Integrated Modeling of LCLUC and Interactions*, in which he stressed the need for clear conceptualization, quantification, and validation of all important relationships between LCLUC-vegetation-climate for holistic understanding of societal/policy problems through continuous dialogue with users.

Leadership Summit

As part of the Leadership Summit, the international participants visited different research and educational institutes in the region, with the goal of building collaborations with LCLUC scientists and projects. The scientists from Tashkent Institute of Irrigation and Melioration's Bhakura campus (TIIMB) and Samarkand Agricultural Institute (SAI) organized field trips for the team to familiarize them with the local environment, particularly the dry lands, agriculture, and water resources in the region.

TIIMB has faculty expertise in land management and cadastral studies, geodesy, hydraulic engineering, water management, and hydromelioration. Remote sensing expertise for LCLUC studies is still being developed, and local scientists expressed strong interest in collaboration with scientists, internationally.

SAI, which offers masters' and doctoral programs, was established in 1929 and is one of the oldest and currently the leading educational establishment in agricultural land-use research in Central Asia. The institute has existing collaborations with the U.S. Department of Agriculture (USDA) and Wageningen University (Netherlands). The institute eagerly looks forward to building collaborative research in remote sensing and geospatial technologies linked to agricultural land-use research.

Participants visited the Jeyran Ecocenter, one of the prominent protected natural areas in Bukhara Province in Uzbekistan, and en route had a chance to see local agriculture (dominated by cotton and wheat crops), desert landscapes, and salt-affected dry land areas—as shown in the photos. The field visit included a stop in the Zarafshan River Basin, which was formerly a sub-basin of the Amu Darya Basin, but which connection was lost as increased amounts of water from the river and its tributaries were diverted for irrigation. Local engineers explained that the Zarafshan Reservoir is currently serving nine million people, and showcased how water-use plans are helping basin-wide management of water in the region, including the benefits of recently introduced and expanding drip irrigation.

Xerophyllous vegetation dominated by scrublands and Salsola at the Jeyran Ecocenter in Bukhara, Uzbekistan. **Image credit:** Krishna Vadrevu

Vast areas of salt deposits on the land surface along a road in Samarkand, Uzbekistan. **Image credit:** Krishna Vadrevu

Shahid Habib [NASA's Goddard Space Flight Center] spoke on *Utilizing NASA's Earth Observations for Societal Applications*, which showcased the potential of NASA's remote sensing observations and models for quantifying water balance parameters and hydrological modeling studies.

Conclusion

Common themes that surfaced during the discussions were the need to strengthen regional cooperation to solve transboundary water-use issues in the region, and improve decision-making in the region informed through consensus scientific assessment. Participants identified the need to develop regionally consistent land-use and land-cover datasets. Participants realized that in most Central Asian countries, use of geospatial technologies is limited and that the remote sensing research community is small and mostly engaged in local projects. Thus, pathways from research to operational use and sharing of new techniques and methods should be explored. Some geospatial training capabilities already exist at various research institutes and universities, but they need strengthening. Participants also agreed to work on maintenance, ownership, and governance issues for long-term sustainability of CARIN and its activities. There is a considerable interest from international donors such as the World Bank and USAID, to fund projects over Central Asia on water resources, agriculture, and energy, and in this context, regional scientists could explore such opportunities to address regional-scale questions relevant to all countries in the region. Overall, the meeting was highly successful in addressing LCLUC and water resource issues in Central Asia. Additional information on this and other LCLUC meetings may be found at *lcluc.umd.edu/meetings.php?mid=48*. ■

Training Workshop: Geospatial technologies and models for land and water resources in Central Asia

The TIIM Eco-GIS center organized a two-day training event for students and young investigators. It featured eight international experts from several countries, who served as trainers for the 45 participants. The topics addressed included:

- Introduction to remote sensing data and products;
- hydrological cycle changes over the extratropical land areas;
- the contemporary hydrophysical state of the Aral Sea and its impact on the coastal zones of Kazakhstan and Uzbekistan;
- geospatial analytical methods and critical data/methodological issues specific to Central Asia;
- geoinformatic applications in Central Asia; and
- remote sensing techniques for monitoring land-use and land-cover change, including irrigation and salinity issues in Uzbekistan.

The Earth Observer newsletter provides information about current and recent activities and accomplishments involving the satellites that we operate in the Earth Science Mission Operations Project at NASA's Goddard Space Flight Center (GSFC). This information is appreciated by the operations and ground system teams that work 24 hours a day, seven days a week, to keep the missions safe and providing data to meet science requirements. The newsletter articles and images on the latest accomplishments using data from the Earth-observing missions have inspired the teams and given them a sense that what they are doing is very important and contributes to the success of the missions.

*—**Angie Kelly** [GSFC—Earth Science Mission Operations]*