INFORMATION SYSTEMS IN WATER SECTOR OF CENTRAL ASIA: CHALLENGES AND PERSPECTIVES

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ABSTRACT

A water resource planning for the river basins is the most crucial element of Integrated Water Resources Management (IWRM) approach. Development and implementation of the river basin plans enables water management organizations to cope with increasing uncertainties due to climate change, sectoral competition and population growth. Contemporary water management decisions use many sources of information and forms of data. However, the data and information on water sector is often dispersed, heterogeneous, incomplete, and not comparable. New social and political realms require a participatory involvement of the different stakeholders for decision making process in water sector. Thus open source, easy to access information and data management systems are successful. The aim of this paper is to present practical results on improving water management in Central Asia through application of information and communication technologies at the operational level across diverse institutional settings, i.e., transboundary, watershed and national levels of the region. The case study presented is conducted within framework of Transboundary Water Management in Central Asia programme. The programme is the part of the 'Berlin Process', an initiative by the German Federal Government to support the countries of Central Asia in water management and to make water a subject of intensified transboundary cooperation.

INTRODUCTION

Central Asia is a home of more than 55 million people, landlocked region with an extreme continental climate of 10 fold difference between rainfall (150 - 300 mm) and evaporation (1200 - 1600 mm) (Dukhovniy and Sokolov 2003; UNDP 2005; UNEP 2005). In addition climate change impacts have been serious on ice caps in mountains (World Bank 2009). These all make availability of water resources at least contested issue (Abdullaev et al. 2010). Five Central Asian countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) are sharing two large rivers (Amu Darya and Syr Darya) and a complex irrigation system, covering around 8 million ha of irrigated lands (Figure 1).

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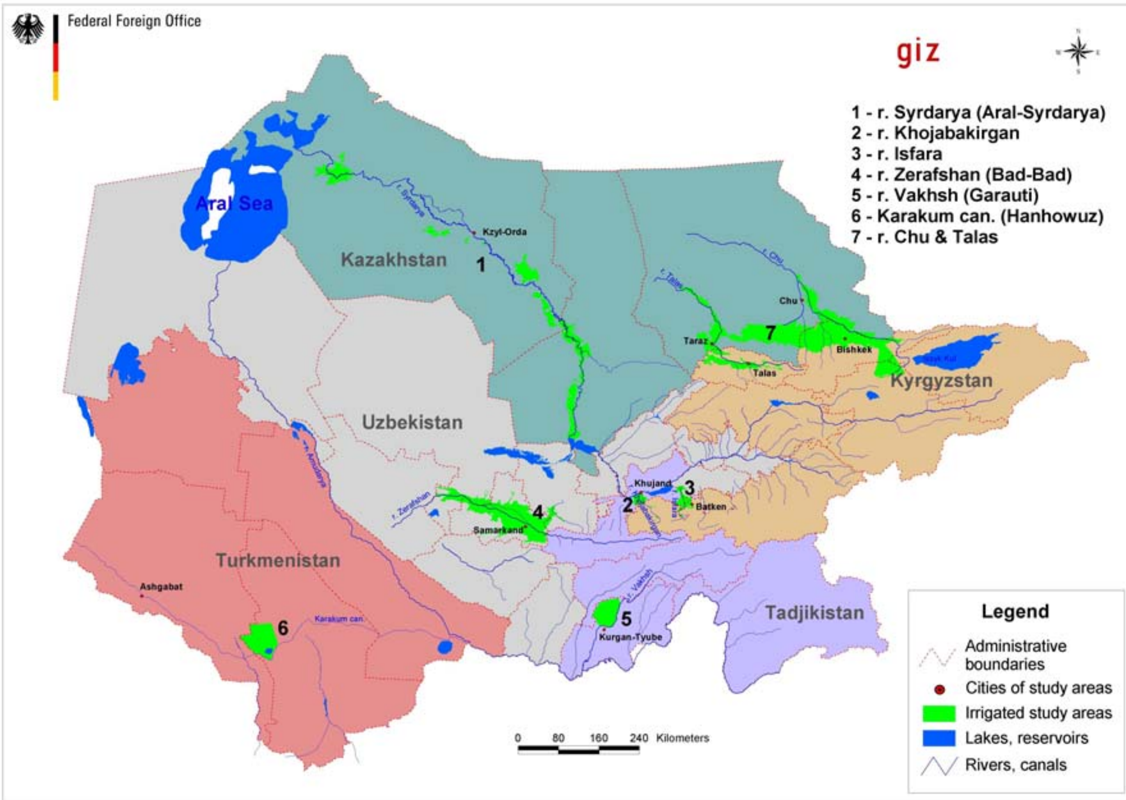

Figure 1. Map of Central Asia and location of intervention pilot areas

Both rivers start in upstream countries with most of the reservoirs and hydropower facilities, yet irrigation is largely practiced in downstream countries (Rakhmatullaev et al. 2010). Previously, this complex system was governed with a single set of policies defined by Moscow. After the collapse of the Soviet Union, states are facing growing tensions over the water resources (Murray-Rust et al. 2003).

During the Soviet times information on water management and use has been handled through administrative reporting system from lowest water management organizations towards higher ones. The soviet legacy in the new Central Asian independent states still practice high reporting requirements and documentation styles, the water sector is not exception. The numbers of reports produced by water management organization (WMOs) were large and mostly in formats which were not accessible or understandable for general public (Murray-Rust et al. 2003). Annual reports have been produced by each WMO and stored in the archives at least for 5 years. Based on annual reports of WMOs and statistical data collected by national departments of the statistics year (annual) books have been published for each soviet republic. The yearly statistics books are composed of data on water resources management: water use per sector, per capita and per administrative units (province).

The water resources assessment and planning, operational decision making in water sector uses the data from different sectors, uses, users and water sources (Biswas 2008). Meanwhile, the crude data are still kept at the lower levels of water management with restricted access to the higher water management hierarchies and to the public. Old ways of collection, storing and processing of the data and information does not work in new context of post- soviet developments such as democracy, market economy declared by Central Asian states (Abdullaev and Rakhmatullaev 2011).

According to Garcia the water governance and management can be divided into three interlinked levels i) constitutional, ii) associative and iii) operational (Garcia 2008). The real-term data are produced at the operational level of water management. At this level, complex interactions between different actors (WMO, Water users associations, farmers, industry, local government authorities, etc.) on water management took place to define water rights (limits), water distribution and water control with application of different water control strategies (Aminova and Abdullaev 2009). Therefore, improving of data management at this level is a crucial precondition for improving of water governance at both in this and higher levels (national and regional) of water management.

The recent advances in information communication technologies (ICTs) and their unprecedented applications in era of globalization have created enormous opportunities for developments of e-government systems around the globe. E-government paradigm is believed to serve as bridge between the governments and their citizens for intensification of dialogue. According to UNDP one of the indicators that can be measured for assessment of governments to use ICTs is e-government readiness index. E-government readiness index is “a composite measurement of the *capacity* and *willingness* of countries to use e-government for ICT-led development” (UNDP 2008).

According to the United Nations statistics, the Central Asian region has made the most significant improvement in e-government development as a region but still a slightly below the world average (UNDESA 2011). Table 1 depicts the statistics of e-government developments and world ranking of Central Asia countries.

Table 1. E-government readiness index and world ranking of Central Asian countries (UN DESA ‘E-Government Readiness Knowledge Base’, 2011)

Country	**E-government readiness index***		**World E-government development ranking**		
	2008	**2010**	**2008**	**2010**	**Change**
Kazakhstan 0.47	43	0.5578	81	46	+ 35
Kyrgyzstan 0419	5	0.4417	102	91	+ 11
Tajikistan 0.31	50	0.3477	132	122	+ 10
Turkmenistan 0.32	62	0.3226	128	130	- 2
Uzbekistan 0.40	57	0.4498	109	87	+ 22
World average	**0.4406**	**0.4514**	**Total number of countries =192**		

*E-government readiness index is composed of i) web measure index; ii) telecommunication infrastructure index; iii) human capital index

Almost all counties except Turkmenistan did progress in implementation of e-government systems with Kazakhstan as a regional leader. Thus it is one of pre-conditions to implement data management interventions in water resources sector of the region.

MATERIALS AND METHODS

Conceptual framework

The ultimate goal of the data management activities is two-fold. The first objective is to provide technical capabilities for improving decision making process at lowest possible water management level (operational) and the second aim is to enable WMOs to carry out river basin plans. Yet few outstanding issues are to be addressed such as water governance and knowledge management. The first issue is related to the accuracy of the data (quality control), the second is absence of the indicators for water management performance assessment and the third issue is concerned with regular and reliable data collection and mining. Data management for IWRM activities was designed with four interlinked intervention pathways: (i) principles, (ii) data, (iii) hardware and (iv)software (Figure 2).

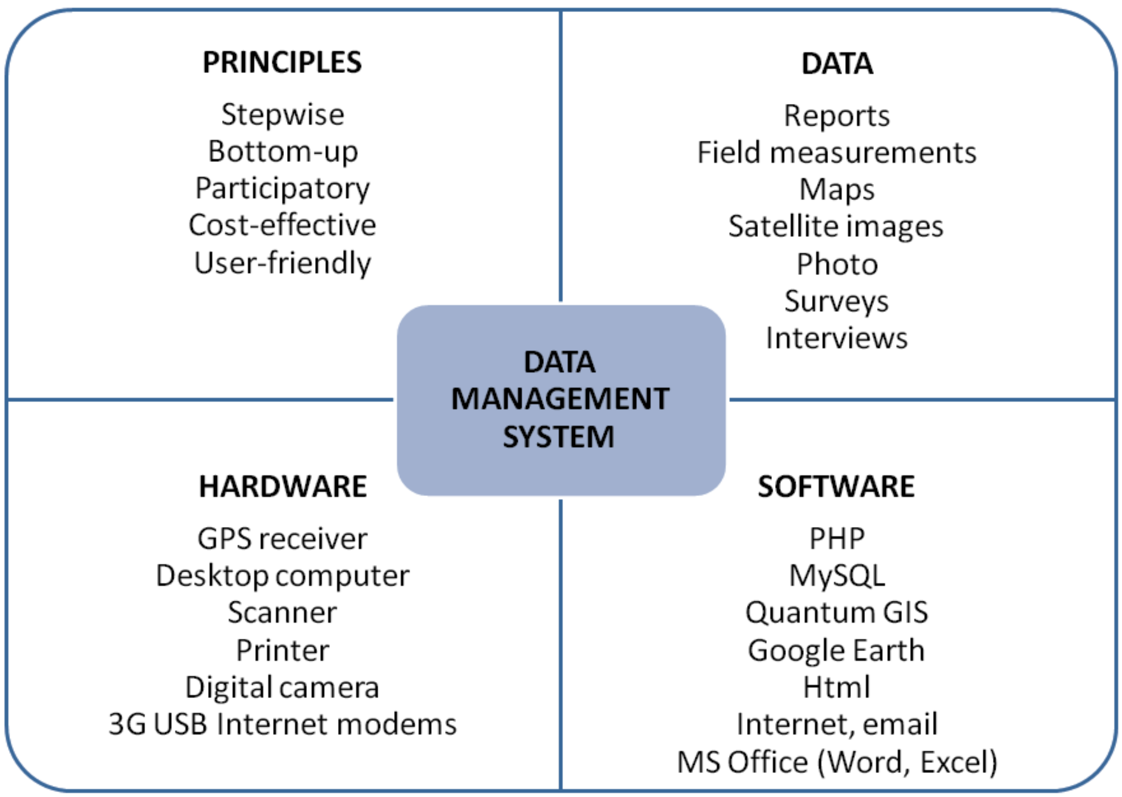

Figure 2. Main components of Data management

Strategic approach

Activities on the Data Management have been designed of a bottom-up approach with full involvement of the partner WMO into the activities from the very beginning (pre-assessment and planning stages). Partner WMO have decided on type, structure, content, interface and format of the Data Management tools which created an ownership of a process by partner WMO.

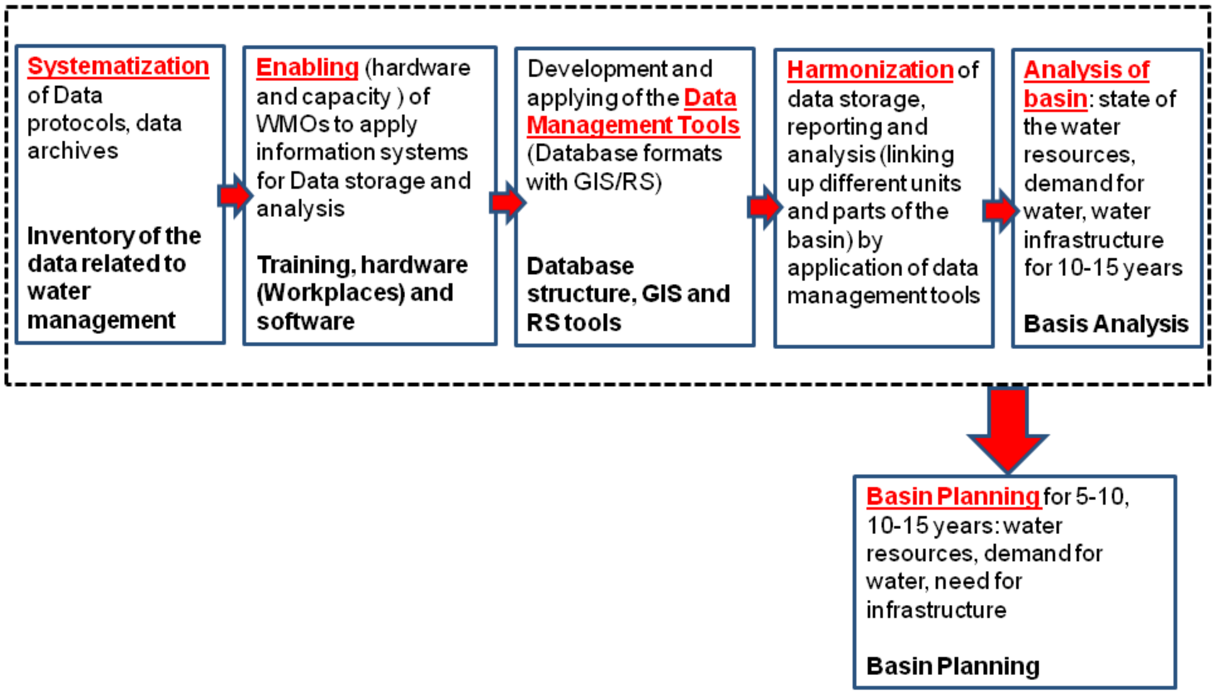

Figure 3. Logical framework of data management activities for river basin planning

Systematization. The initial step was to conduct comprehensive pre-assessment of hardware and capacity building needs of local WMO through baseline surveys and field visits to intervention localities. One of the main aspects was to review the existing data reporting systems and protocols used. In addition, physical infrastructure was also examined for assessing storage, retrieval and communication facilities at place.

Enabling Environment. Special workplaces on data base and GIS/RS were established with providing up-to-date hardware and software to partner WMO at their facilities. Most importantly, those workplaces have been linked with various units of the WMO such as dispatch center, water planning unit and other relevant departments through a local network. These networks helped to improve accessibility and operation, filling data onto the database, i.e., most importantly the transparency of the process.
Implementation of capacity building activities were carried out to educate experts of partner WMOs in all 7 selected sites on data management. The topics of such training series were introductory courses on GIS, GPS, satellite imageries (Google Earth, DEM) and remote sensing tools application in water sector. The partner WMOs have nominated one water professional involved in daily data handling and one expert/scientist from local research organizations or universities (outsiders from water) with knowledge of data management. The capacity building activities continued with a series of on the job trainings in all selected sites. During the on the job trainings, supplemental training needs were indentified, e.g., use of Internet and GPS receivers.

Data management tools. The *Database* has been designed to store and use of the digital data on water resources, use, hydraulic facilities, hydrological conditions, economic and administrative conditions of the location (basin, irrigation system). Datasets are at present available in different formats (MS Excel, Word, Access and etc.), could be transformed into the database by import/export commands or manual typing.The database has been developed using open-source PHP which stands for "*PHP: Hypertext Preprocessor*" script language, is at present commonly used for web based databases (PHP 2011). The foundation platform was MySQL® is a freely downloadable version of the world's most popular open source database (MySQL 2011). It is especially suited for web development and can be embedded into HTML (Hypertext Markup Language). This programme language allows inserting additional tables and updating data base by trained experts of WMOs without aid of programming specialist.

The *Geographical Information System (GIS)* and *Remote Sensing (RS)* tools will allow assessing present irrigated areas, water use situation in different parts of the study areas (basin, irrigation system) (Bastiaanssen 1998). The GIS tools include use of satellite based images, Digital Elevation Models (DEMs), different background maps and coordinates of water infrastructure, recorded through GPS receivers. ArcGIS 9.3.1® (Russian version) used for preparation of raster and vector layers and ERDAS Imagine® program was used for image processing and land use map development. Application of the GIS and RS tools to assess size and location of the irrigated areas is a most important contribution to improve water resources management planning and allocation, especially in Central Asia, where irrigation contributes up to 90% of water use and transboundary conditions.

Harmonization. The measures are focused on development and implementation of the database system architecture with full ownership by local WMO in terms of content, format, and interface. In this stage, WMO partners provided algorithms for reporting on daily water information. User’s manuals on database operation and GIS were developed as supportive documentation for users. Most importantly, the manuals were developed with reflections of end user ideas in non-technical fashion and language. Another paramount issue was to harmonize developed databases for all respective intervention sites in terms of functionalities, modes and structures, i.e., database compatibility in all locations. That is the database structure in different locations could produce comparable reports or indicators that in future data exchange would be possible in future.

Basin plans. The activities were concerned with the filling of the database with retrospective and operational data on water discharge, use, abstractions, population dynamics and irrigation. The last step is to prepare river basin plans based on the stored and generated data.

RESULTS AND DISCUSSION

Political support

The most crucial element for successful implementation of the data management activities is a political support from national water management agencies/ministries in each Central Asian country. Therefore, database concept and structure has been presented to the respective national authorities to gain a political support. This also has been important for the integration of the database into the normal business procedures of the partner WMO. The national authorities of Kyrgyzstan, Uzbekistan, Tajikistan and Turkmenistan have issued support letters to the programme indicating their desire to support the Data Management activities. In 4 above mentioned countries, special decrees were issued by the respective national water authorities declaring to use of the database as a main tool for reporting within their respective hierarchical systems in all states. In Kazakhstan government is funding such program. Moreover, there are attempts by national governments in Central Asia to reduce substantially paper reporting by promotion of electronic reporting.

Database

Architecture. The database structure reflects most of the desires and requirements of partner WMOs on regular reporting. Database allows the production of a selected set of regular reports. In order to ease operation by local experts in their daily work the database made as bilingual, with Russian and a local language as choice. User-friendly interface and easy functioning menu were major requirements to the database from WMO experts. This could avoid costly upgrading of the database. In partner WMOs, soviet time data protocols and formats are used with translation into national languages. This has been achieved through the application of genuine components for databases in all sites (Figure 4).

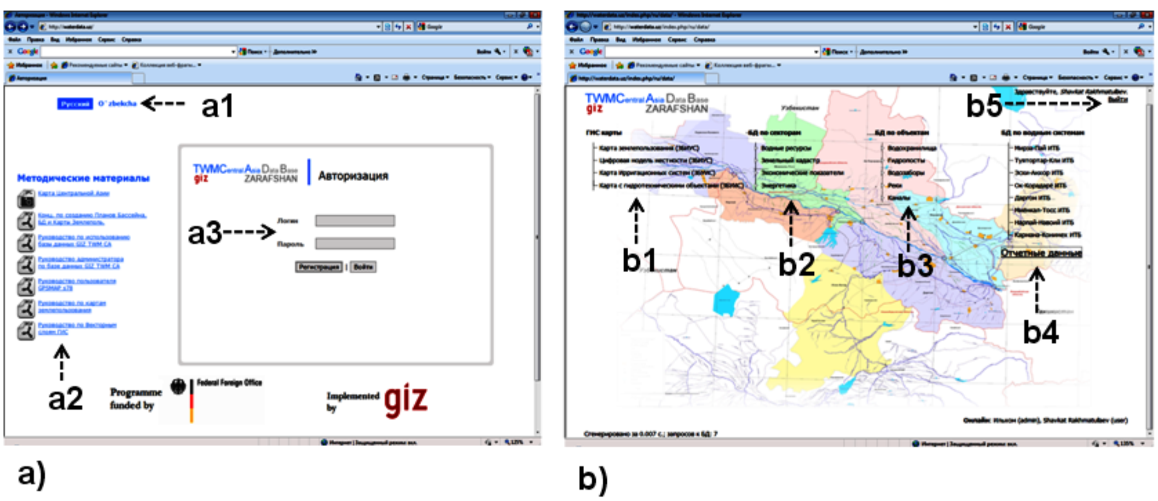

Figure 4. Interface and architecture of database

a) Interface of main page of database; a1 – Language versions; a2 – Help menu; a3 – Login and password;
b) Architecture of database; b1 – GIS based maps; b2 – dataset of sectors; b3 – dataset of hydraulic infrastructure; b4 – reporting forms and protocols; b5 – Administration and management menu

Access/Connection. Access to the database has been one of the crucial issues showing how it will be difficult to convince WMOs to give an open access to the public or to “outsiders”. Only one partner has agreed during the initial meetings to post database onto the internet. After a few rows in the meetings, other WMOs agreed to launch internet database with the provision of access only to their staff from branches/units. Access to the developed database is restricted for only staff of respective WMOs at the moment. One of the reasons is that central server (dispatch center) operator will see who is online and entering data. In addition, the databases are functioning as pilot tests within single WMOs. In four countries from 2012 the database will be used in day-to-day operations. Another concern of WMOs is security reasons.

Administration. Other important issue is ability to administer database itself. The administration menu was incorporated into the database for full control by national WMOs. This aspect played important and trustworthy preconditions for successful implementation. The menu enables WMOs to update, delete or change the structure of database and most importantly to control the access to the database via user registration.

Data compilation. Data bases have been filled by retrospective data of 5 years (2005-2010) and actual data for the 2011 by trained experts of the WMOs. However, it turned to be difficult task to collect long term, retrospective data due to the lost of the paper reports which were stored in unfitting conditions at the offices of district (rayon) and provincial (oblast) water management organizations. This once more confirmed a need for introduction of data management tools to transfer all data into the data bases.

Knowledge Management. The success of the data management activities in long run depends on how expert knowledge transferred from those of trained staff to other personnel of WMOs. The institutional learning is one of important preconditions for successful data management interventions (McDonnell 2008). However, internal structure of partner WMOs at present does not support institutional learning. Therefore, more on job trainings has been planned to contribute into capacity building within WMOs.

GIS and RS tools

Application of GIS tools for water resources management has been quite successful from research and business point of view (Pickles 1995; Bastiaanssen 1998; Ozdogan et al. 2010). However, due to high prices and high learning requirements for GIS tools, their application in practical water management has been limited. However, recent changes in GIS approaches, automation of operations used in GIS, free of charge or low cost satellite images, open source software made GIS tools more attractive for the water sector. The assessment of irrigated areas is important for effective water management for the Central Asian region where irrigation contributes up to 90% of water use (Chemin et al. 2003; Conrad et al. 2007). The irrigated area maps helpful to indentify actually irrigated areas demand for water and water use in specific locations.

Professional GIS/RS consultants have been recruited to produce land use – land cover maps (LULC) for the selected pilot sites. The publicly available data sources have been used for the preparation of the LULC maps. The Landsat-5 satellite images were downloaded from Internet (http://glovis.usgs.gov/) for peak of the growing season (July-

September) of 2009. The processing of the images has been completed by experts with on the job training for staff of WMOs. On the other hand, WMO experts have collected and digitized different maps for GIS layers of irrigated areas such as topographic maps, administrative borders, irrigation system borders, etc. The maps were manually digitized; using as background layer Landsat satellite images (Figure 5).

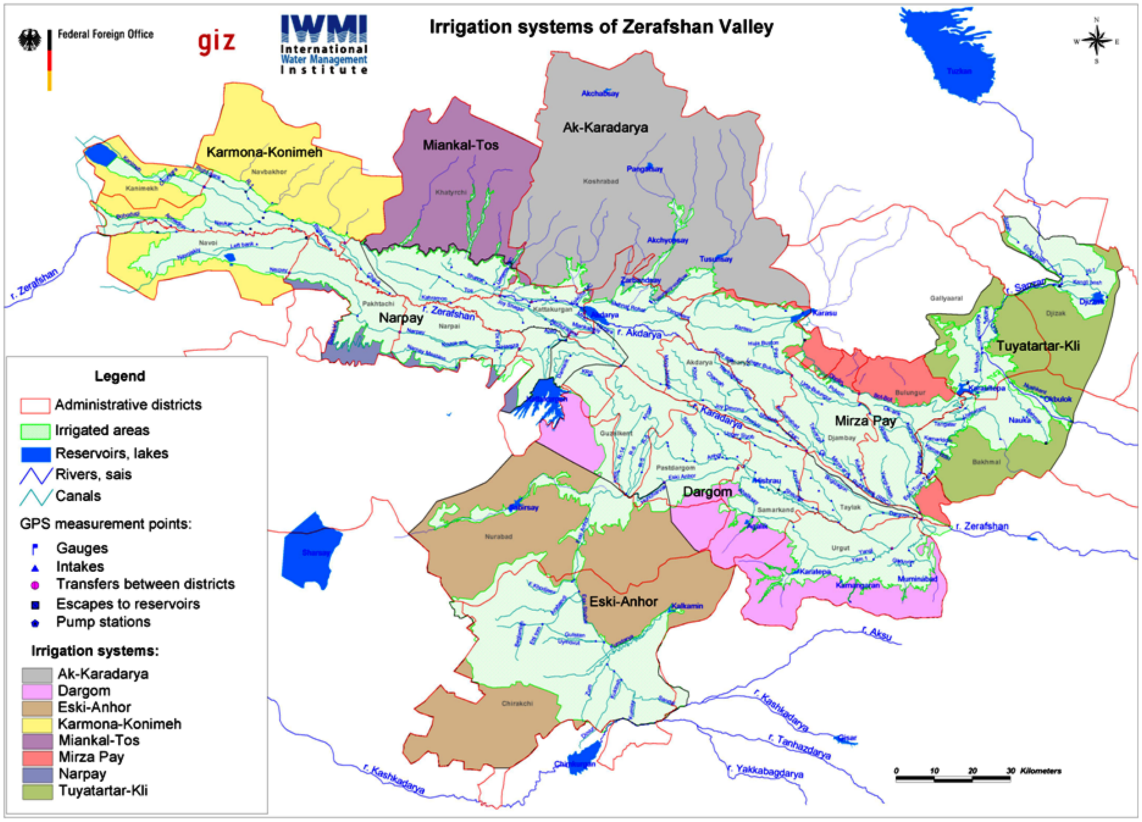

Figure 7. GIS map of hydraulic infrastructure and irrigation districts of the Serafshan River Basin (Uzbekistan part)

The publicly available Aster Digital Elevation Model (DEM) with spatial resolution of 30 meters raster layers were downloaded from Internet (https://wist.echo.nasa.gov/) for all intervention areas. The DEM were used for manual delineation of basin boundaries in the water formation zones (at high altitudes) for study areas. The basin boundaries at low altitudes further corrected with use of the water infrastructure locations. Further, the free of charge products (MOD13Q1) of MODIS satellite images which represent the

Normalized Difference Vegetation Index (NDVI) values (with spatial resolution 250 m and temporal resolution 16 days) were downloaded from Internet (http://glovis.usgs.gov/). NDVI indices were used to indentify land use classes. In situation, when the number of Land Use/ Land Cover classes inside the study areas was unknown, unsupervised classification with predefined number of classes. Unsupervised classification with 16 classes of land use was applied separately to images of each study area. At present Land use and Land cover maps are produced for 4 intervention locations out of 7 (Figure 6).

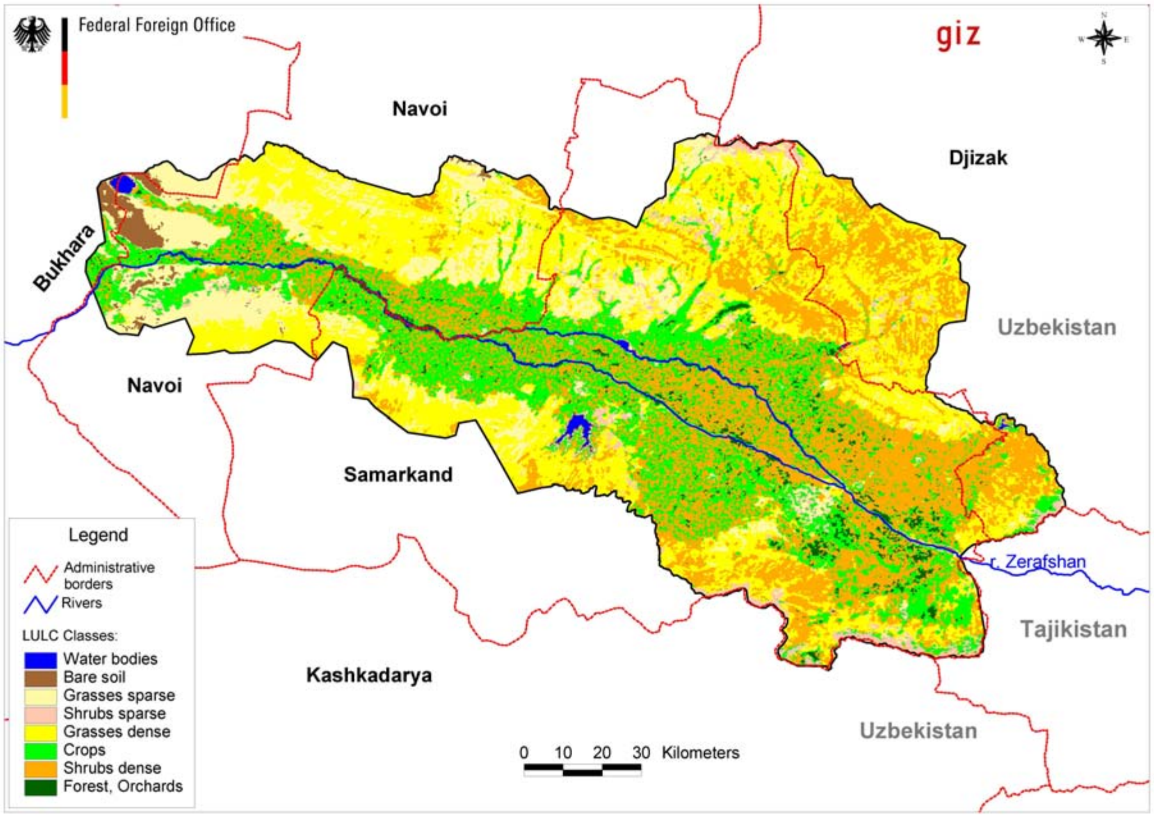

Figure 6. Land Use/land Cover classes of the Serafshan River Basin (Uzbekistan part)

GIS and RS tools are differing from data base due to quite high requirements for the experts who will work with these tools. Without a special training and long term experience local experts cannot produce GIS tools. However, LULC maps are not required to be prepared for each season or year but rather updating it every 4-5 years will be sufficient for basin assessment and planning purposes. Keeping a professional staff with GIS skills is not feasible in current conditions due to the low wages of WMO staff. Therefore, recruiting of a growing number of companies or experts on GIS is an option for updating of the LULC maps. However, in a few Central Asian states National Water Management Authorities are starting to set up GIS units at the national level which can help WMO to produce LULC on a regular basis.

CONCLUSION

Since 1991, independence from former Soviet Union data and information collection, reporting requirements in water sector of the Central Asian countries has not been changed too much from Soviet legacy. The preliminary results of the data management for IWRM activities have shown acknowledgement of the need to use modern information and communication technologies into decision making process and daily operation of national water management systems for sustainable and efficient water management (GWP and INBO 2009). The data previously scattered around different water management levels are gathered and systematized, made accessible for water professionals and decision makers. The water professionals of WMOs are able to produce their regular weekly, monthly and annual reports from the online database.

DM for IWRM activities in selected sites shows that there is DM for IWRM activities are still ongoing and therefore it is action in progress and more learning will be available upon completion of the activities. Yet there are still many challenges on practical application of data management tools in Central Asia, including:

- Diversified understanding of advantages of information technologies across Central Asian staff and decision makers of WMO
- Staff of WMO are generally technically inexperienced on database, GIS and RS tools
- The sub-basin WMO are often geographically dispersed and Internet/Intranet logistics should be carefully examined
- Digital databases should be stored centrally with full access to different users via Internet
- Internet infrastructure is poor for acquisition of large size satellite imaginary.

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