Zentrum für Entwicklungsforschung
Center for Development Research
University of Bonn

GERMAN-UZBEK
KHOREZM PROJECT

Status Report

ZEF/UNESCO Project Phase III (2007–2011):

Economic and Ecological Restructuring of Land and Water Use in the Region Khorezm (Uzbekistan)

Authors:
Ahmad M. Manschadi, John P.A. Lamers, Christopher Conrad, Asia Khamzina, Bernhard Tischbein, Mehmood Ul Hassan, Nodir Djanibekov, Jennifer Franz, Gerd Rücker, Bernd Kuzmits, Alma van der Veen, Paul L G Vlek

Contents

Introduction

Following the successful completion of the project phases I and II in April 2007, the third phase of the BMBF-funded Uzbekistan project started in May 2007 with the overall aim of integrating the scientific findings and innovations into a comprehensive and interdisciplinary restructuring concept for sustainable improvement of land and water resources in the Khorezm region. This report summarises our concepts and achievements for some of the key components of the current project phase including the landscape segment, drainage experiment, up-scaling from field to regional level, developing bio-physical and socio-economic simulation models, dissemination and policy outreach, and human capacity building and scientific output. More detailed information on these topics will be presented during the mid-term evaluation meetings in Urgench.

Target region and problem setting

The Khorezm district is located in the northwest of Uzbekistan in the lower reaches of the Amu Darya River—the largest former tributary of the Aral Sea. As part of the Turan Lowland of the Aral Sea Basin (ASB), Khorezm is situated about 250 km south of the present shores of the Aral Sea. It covers an area of about 6,800 km^2 of mostly dry arid desert of which roughly 270,000 ha are being used for irrigated agriculture. With an average annual precipitation of 90 mm only, agricultural production and rural livelihood in Khorezm rely entirely on irrigation water supply through a dense network of 16,000 km irrigation channels and 8,000 km drainage water collectors (Fig. 1).

Of the 1.3 million of Khorezm's population, over 70% resides in rural areas and is mostly engaged in cotton, wheat and rice production; and about 27.5% lives below the poverty line of 1 US$ per day. The cash crop cotton is produced in the so-called 'state order' system, by which the government controls the distribution of the crops on the fields, water supply and delivery of other production resources, prices, processing, and export.

Soils are generally low in fertility, cation exchange capacity (CEC) and organic matter content and substantial amounts of chemical fertilizers are used for the cultivation of primary crops. Due to application of large amounts of water during leaching and irrigation events, ground water tables reach critical levels during the cropping season causing secondary soil salinisation and land degradation – a widespread problem in Khorezm.

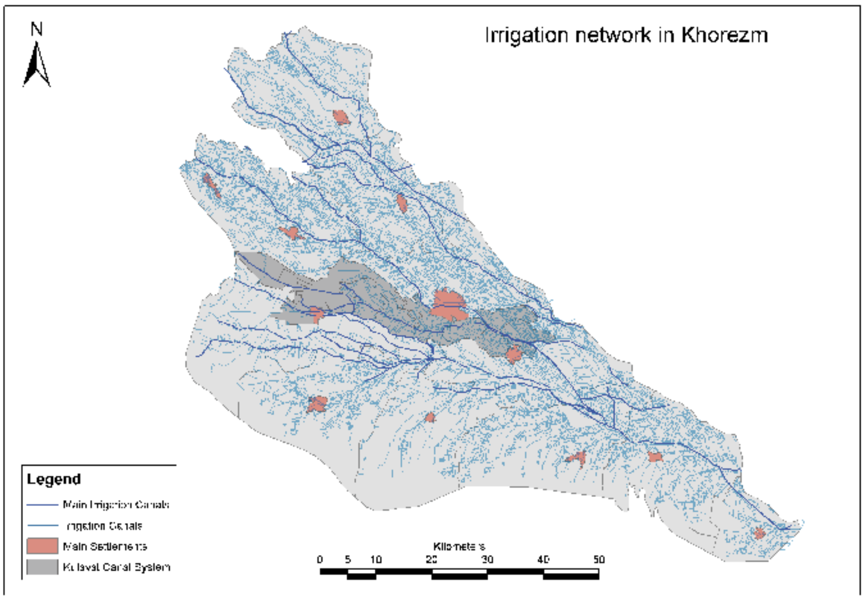


Figure 1: Khorezm map depicting the irrigation network and the boundaries of the Kulavat canal system.

The complex network of irrigation and drainage canals was designed and implemented during the Soviet era to deliver water to large-scale collective farm units based on a centrally organized irrigation water scheduling and delivery system. Land reforms initiated after independence in 1991 have, however, resulted in the disintegration of the large collective and state farms into numerous smallholder farms (17,000 in May 2007). This has led to a serious mismatch between the irrigation water supply system and the actual demand by the new private farmers. The establishment of Water User Associations (WUAs), along the administrative boundaries of the former collective farms, has been an attempt to bridge the gap between the higher-level water providers and the farmers. The WUAs, however, have largely failed to become effective organisations for farm-level water supply management due to lack of human and financial resources.

Thus inefficient use of land and water resources, inappropriate institutional settings and policy frameworks, and underdeveloped agro-processing and service sectors are among the key issues threatening the economic and ecological sustainability of the Khorezm region.

Project goals and objectives

The overall goal of this project is to provide a comprehensive, science-based concept for restructuring of land use and agricultural production systems in the Khorezm region. As Khorezm is representative for lowland, irrigated agroecosystems in Central Asia, innovative technologies and concepts developed in Khorezm will have the potential for up-scaling to other, similar environments. To achieve this goal, research has been conducted on the following key system components: natural resources, production systems, economy and society and institutions (Fig. 2). Simulation modelling is an essential component of the project for integrating the disciplinary scientific findings, up-scaling the results, and predicting the long-term impacts of current and alternative land and water use and management options and policies. The overall restructuring concept will thus be based on (i) recommendations developed with simulation tools for improved land, water and agricultural policies on the national and regional levels; (ii) institutional restructuring for a more sustainable natural resource use; and (iii) developing innovative technologies for enhancing the productivity and ecological sustainability of agricultural systems.

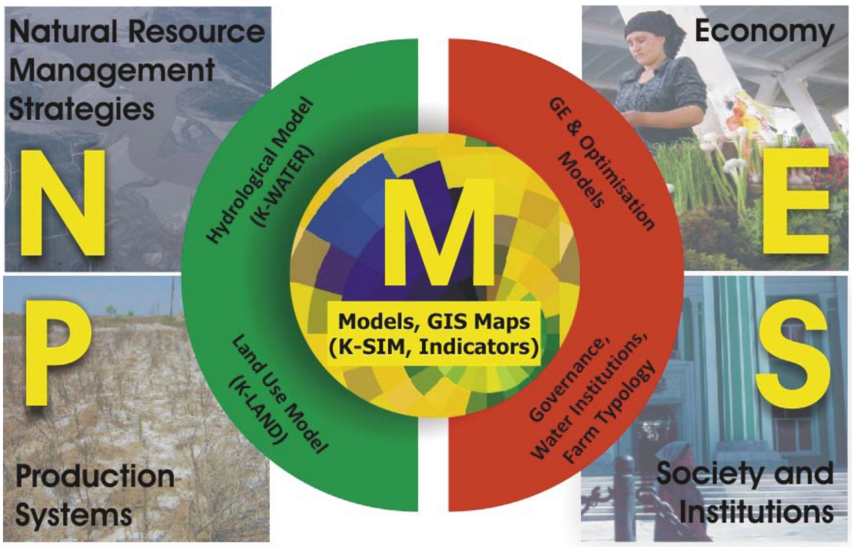


Figure 2: The five thematic areas of research in the Uzbekistan project.

Landscape segment

The project research activities in collaboration with national research and education institutes as well as international partners such as PFU/ICARDA, have resulted in the development of alternative allocation strategies for land and water whereby less productive, degraded land is dedicated to tree production systems. Innovations in crop diversification, conservation agriculture, judicious water and fertiliser use, livestock and fish production, if combined properly on the better land, can compensate for the rested land and increase the economic efficiency of the water and land use. During the next four years, several of these innovations will be tested in preparation for a large-scale adoption on farmers' fields. To verify the interactions and synergies among these innovations applied in concert, a landscape development and restructuring programme has been developed for implementation on the so-called "landscape segment" in Phase III.

The intention of this landscape development study is to verify and quantify benefits derived from the synergetic effects of innovations, analyse the overall effects of improved land and water use, and develop the best management options. In this way, a complete cost-benefit analysis of farm restructuring in terms of direct and indirect monetary terms may also be estimated.

The landscape study will thus mainly focus on the following components:

- Introduction of alternative land uses such as small-scale tree plantations, pastures, and aquaculture (ponds) depending on land suitability to optimize ecosystem services;
- A shift in the state order for cotton as mandated land use to setting the farm-gate delivery levels and allowing for farmers decisions on how to meet these demands;
- Judicious use of water, land and fertiliser resources;
- Production of annual crops under conservation agriculture (CA) for improved water, soil, and salinity management.

The outcomes of these studies will be integrated into best management practices of the landscape management study to optimize agroecosystem production and services using on-farm operational procedures that maximize land and water use efficiency.

At present, the Ministry of Agriculture and Water Resources of Uzbekistan (MAWR) and the Hakimiat (administration) of the Khorezm Oblast have made 75 ha of land available for this research component at the Cotton Research Institute (CRI) in Urgench (Fig. 3). A step-wise approach for restructuring this area will be adopted which is briefly explained in the following.

Preparation:

The entire area of the landscape segment (75 ha) is to be surveyed for water quantity (field and farm-level) and quality (salinity), groundwater table, and soil quality (organic matter, salinity). The survey results will be used as a baseline resource inventory of the area prior

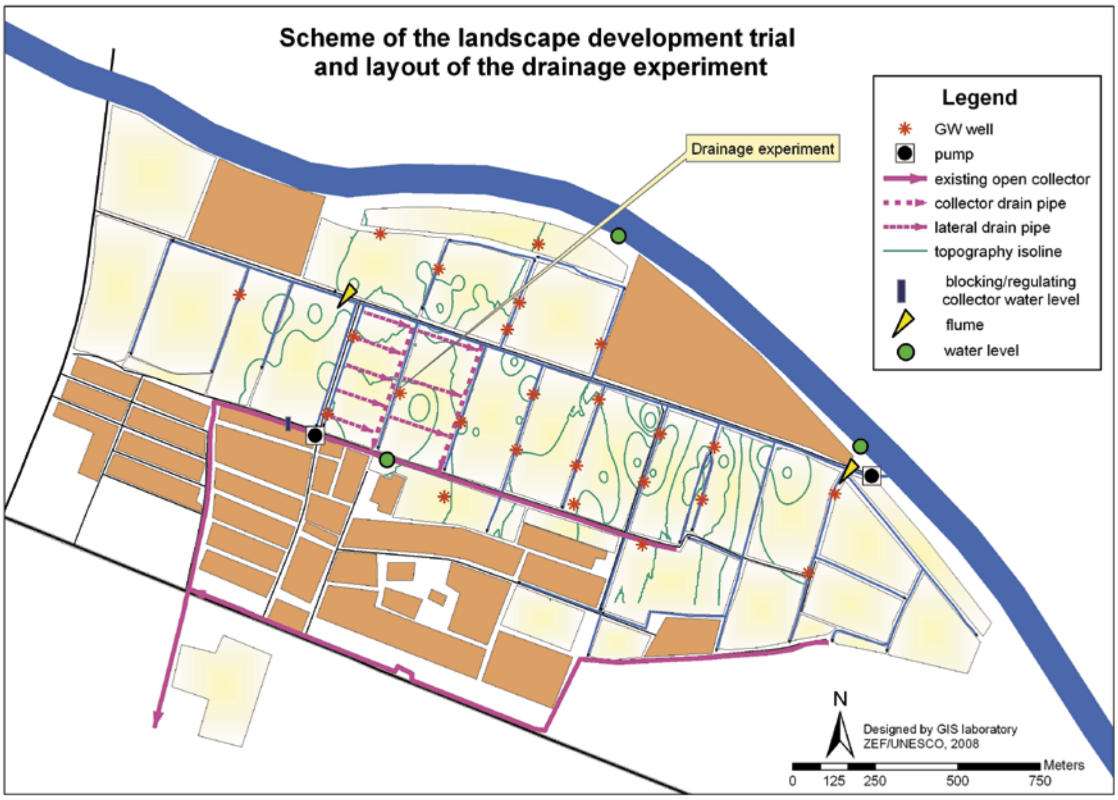


Figure 3. Map of the landscape segment at Cotton Research Institute (CRI) with location and layout of the drainage experiment.

to the implementation of any changes. Furthermore, the instrumentation will be installed for monitoring of irrigation water supply, groundwater and salt dynamics, drainage and biodiversity.

Land allocation:

A land use plan is being developed based on land suitability. Land allocation will be differentiated on the basis of salinity, soil texture and groundwater table and will involve trees, pastures, fishponds and agricultural areas. On the crop fields, a special sequence of activities will be implemented to shift from conventional to conservation agriculture.

- The start is made by deep-ploughing to break up the compacted soil layer;
- Next, a fodder crop (e.g., maize) will be planted for mulch production followed by another ploughing and the cultivation of winter wheat and then a nitrogen-fixing crop (e.g., mungbean);
- After ploughing, the land will be laser-levelled and permanent beds will be prepared;
- Rotation will include cotton-wheat-3rd crop.

For the implementaion of the landscape restructuring programme, the project will build on the existing partnerships with UNESCO, DLR and MAWR and, in particular, with UrDU (State University of Urgench), the local and regional Hakimiat and the Cotton Research Institute (CRI). In addition, strategic partnerships are foreseen with members of the CGIAR-CAC Program in Tashkent such as ICARDA, CIMMYT, and IWMI. This collaboration is governed by an advisory committee consisting of representatives of the partners.

Drainage experiment

Introduction

The groundwater table in Khorezm is generally shallow, fluctuating between 1.2 m during the peak irrigation season in July/August and 2.3 m in February at the end of the non-irrigation period. The shallow groundwater levels are mostly the result of high recharge through irrigation water losses and of low natural groundwater flow due to gentle slopes and deficiencies in the drainage system. Thus increasing the irrigation efficiency to reduce groundwater recharge and improving the drainage system are the key interventions for lowering the groundwater tables and reducing secondary soil salinisation.

Following the advice of the project evaluation committee, we conduct a drainage experiment to (i) investigate the impact of lowering the groundwater table by drainage on the water and salt balance of the root-zone and the effectiveness of salt leaching, and (ii) demonstrate the scope of drainage solutions appropriate to the situation in Khorezm which is generally characterized by severe groundwater outlet problems.

Previous research studies in Khorezm

According to the SANIIRI (Central Asian Research Institute of Irrigation/Tashkent) documentation, drainage experiments with the horizontal piped subsurface systems were carried out between 1968 and 1993 at four locations in Khorezm. Results showed reduction in soil and groundwater salt contents accompanied by an increase in crop yields. However, these studies suggested that a large-scale application of pipe drainage in Khorezm is strongly restricted by severe outlet problems, practical problems to deepen the collectors, high establishment costs, and the difficulty to cope with increased irrigation requirements (the latter resulting from lowering the groundwater contribution to crop water demand). Lysimeter experiments conducted from 1982 to 1986 at the Cotton Research Institute (CRI) demonstrated that maintaining a groundwater level at around 1.5 m below the ground during the vegetation period was optimal.

Concept of the drainage experiment

Based on the results of these drainage experiments, an analysis of the existing drainage network in Khorezm using data of the project's GIS lab, and knowledge and information on the groundwater situation provided by the project partners, we pre-selected, surveyed and assessed 11 sites with respect to suitability for the drainage experiment. Integrating the drainage experiment in the landscape segment at the CRI proved to be the most promising option.

Currently, drainage in the landscape segment is realized by a collector at the southern border (see Fig 3). Levelling along the collector and hydraulic analyses showed that functioning of the collector was strongly limited due to severe outlet problems caused by the presence of pipes and inverted siphons crossing industrialized areas and railways downstream of the segment.

The drainage experiment is being established in the south-western part of the segment (Fig. 3). Due to potential high losses in agricultural areas, drainage by ditches is practically not feasible. Thus the drainage experiment is conceived as a horizontal piped subsurface system consisting of two levels (collector pipes and lateral pipe drains) as shown in Fig. 3. Compared to a one-level system of drainage pipes directly discharging to the collector, this system configuration provides higher uniformity in the lowering of the groundwater, enables associating the individual irrigated fields to the drained area, is more appropriate with regard to the main flow direction of groundwater (from irrigation canal to collector), and matches the regulations on maximum length of collector pipes and lateral drain pipes. As the general outlet problem cannot be solved downstream, the water level in the collector required for free flow conditions for the pipes will be achieved locally by blocking the collector reach at the experimental site against high water level downstream and pumping out the excess drainage water.

The data from the drainage experiment will be used to establish water and salt dynamics (with support of modelling results) influenced by the lowered groundwater table and their effects on crop yields. The results will also facilitate the assessment of leaching effectiveness, quantification of an eventual increase in irrigation requirements, analysis of the functioning of the drainage system, and evaluation of the impact on the crop yield (taking into account the costs of the drainage system).

From field to regional scale – The up-scaling concept

Linking scientific research with the needs of decision and policy makers often involves up-scaling of small-scale observations, experiments and models to larger spatial domains. When data are scaled up, spatial variability and inadequate sampling can lead to significant errors in large-scale averages. Field and farm level mechanistic models are also generally not appropriate when applied to larger areas due to nonlinearities in underlying processes, spatial heterogeneity in bio-physical conditions and socio-economic settings, and interactions between adjacent patches. Therefore, for the purpose of up-scaling of project research results to meso- and regional scales in Khorezm, we have developed a concept based on a number of simulation models and tools targeted at specific spatial and temporal scales. At meso-scale (i.e. farm, WUA, irrigation canal system), the simulation models K-LAND, K-WATER, and K-SIM will be used to address the issues related to tactical and strategic management of land and water resources (Fig. 4). A suite of monitoring systems, land suitability maps, and indicator packages will serve system analysis at the regional level. The project GIS database, remotely sensed parameters, and landscape segment database will provide the required information and data for development and application of up-scaling tools and models. The following is a brief description of our major models and tools for integrating and up-scaling of project research results.

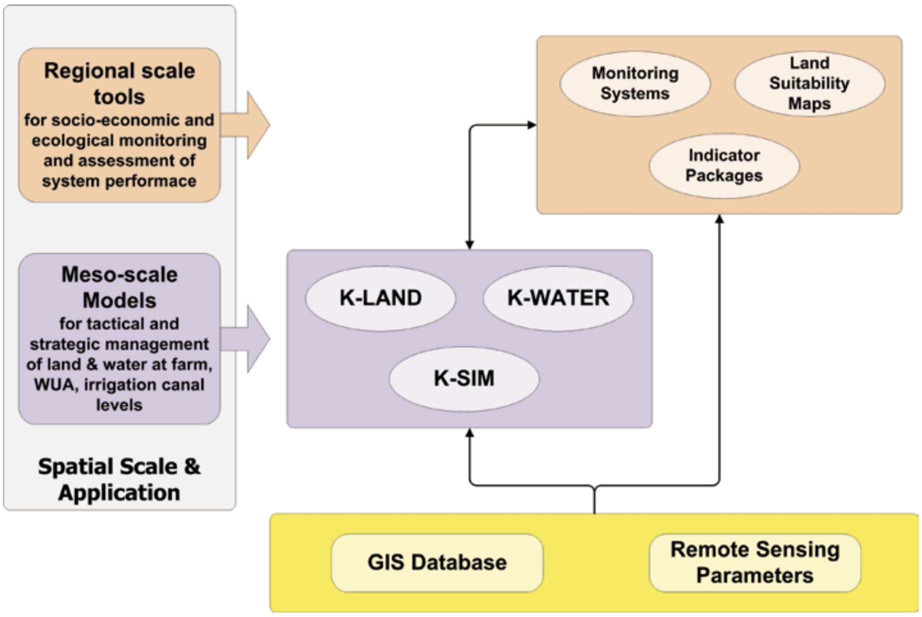


Figure 4. Flowchart of the up-scaling concept.

GIS and remote sensing

Establishment and maintenance of a GIS Centre in Khorezm has been one of the core components of the project. Currently, the GIS-layers in the Central Data Base (CDB) comprise mainly the vector data of the administrative boundaries (fields, WUAs, district, and region), irrigation canal and drainage network, soil characteristics, and climate data. The important regional GIS-raster layers are from satellite image analysis and include the land use, crop yield, leaf chlorophyll status and evapotranspiration. The infrastructural and socio-economic data include among others, roads, machinery and tractor parks (MTPs), commodity prices, and census data. As the only existing GIS lab in the Khorezm region, the project's GIS Centre has been fulfilling demands for spatial data, information and maps, and capacity building not only from the project staff but also from the local scientific community and regional authorities. Since the data for the CDB has been derived from different sources (in-situ measurements, secondary sources, remote sensing), the prime secondary GIS data are being geometrically corrected and updated to match the high resolution satellite reference images which is quite resource consuming. Furthermore, a comprehensive database for the landscape segment is also being developed.

Meso-scale models

K-LAND

The bio-economic model K-LAND aims at providing coupled ecological-economical optimization of land use and crop allocation. The core component of K-LAND is the FLEOM model (Farm-Level Economic-Ecological Optimization Model) which was developed in the project phase II. FLEOM is a stand-alone user-friendly software tool that optimises field-level management decisions on the allocation of crops, water, farm inputs, and labour under a given set of farm-specific production, policy, and ecological constraints and predicts the ecological and economic impacts of respective production patterns. Currently, FLEOM accounts for constraints related to resources (limited land and water), inputs (fertilizer, diesel, labour, credits), policy (land allocation by state order), farm-household (income, availability of credits, food/fodder requirements), and environment (limited allowed soil salinisation and nitrogen leaching). The size of a target area for FLEOM ranges from a single field of 2 ha to an entire WUA of 1,000 ha. Potential users of FLEOM are extension agents, counselling services, WUAs and local water authorities, scientists, and students.

Production decisions in FLEOM are defined as profit maximisation problems with respect to allocation of farm, fields, inputs and resources. The principal component of the model is an economic Linear Programming (LP) optimisation routine written in GAMS (General Algebraic Modelling Software). The optimisation component utilises an extensive agronomic database established via the cropping systems model CropSyst. Initialisation and results of the model are visualised in a GIS-environment (Fig. 5). In addition to the LP approach, FLEOM offers the GIS-based optimisation tool GALLOP (Genetic Algorithms for Land Use and Land Management Optimization).

The following improvements are currently being undertaken to extend the modelling capabilities of K-LAND:

- Multi-year simulations: as the time scale of FLEOM simulations is a single year, a multiple-year feature is being introduced to allow for optimisation over a selected time horizon. This will allow the integration of K-LAND with sub-models for livestock rearing and afforestation.
- Continuous yield functions: the current version of FLEOM utilises the agronomic information in form of input-output tables. Integration of continuous yield response functions instead of input-output tables will allow to observe the optimal crop cultivation practices with respect to field attributes and availability of farm resources when a specific scenario is simulated, an option which is not produced by the CropSyst model;
- Additional land use options (Alternative crops, trees, fodder production): FLEOM currently uses agronomic

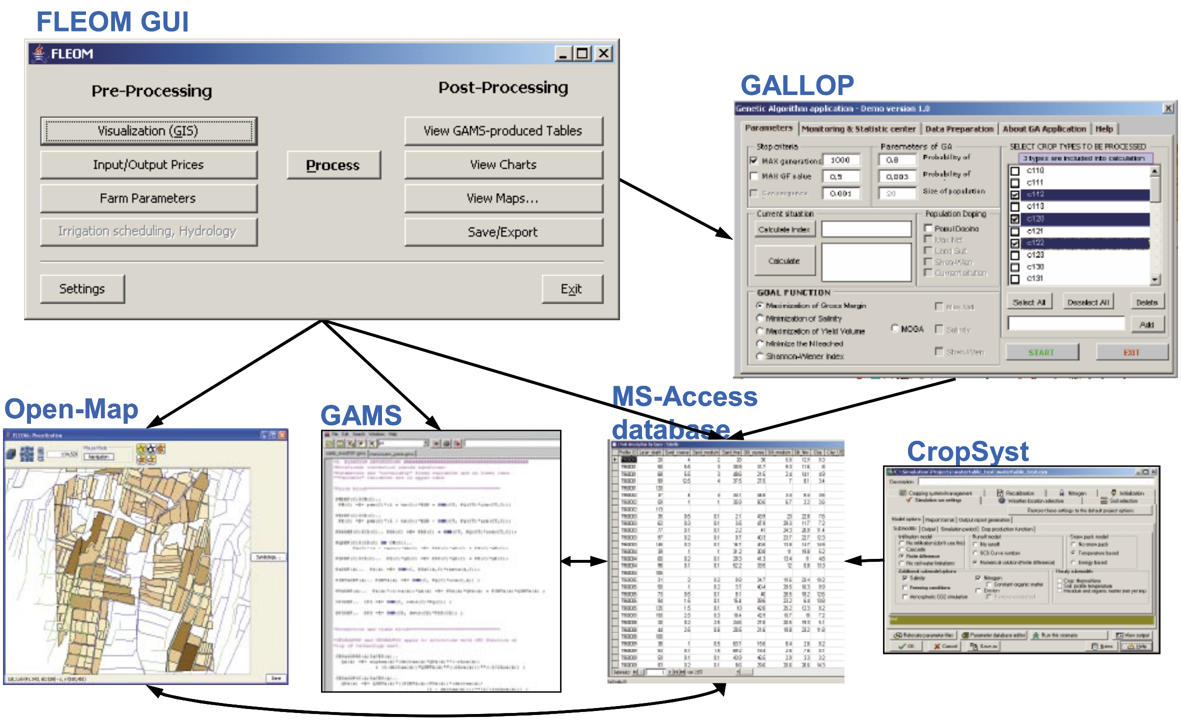


Figure 5. Components of FLEOM and their links

data for cotton, winter wheat and maize only. Field experimentation and modelling work is in progress to include rice, sorghum, and legume crops as well as a bio-physical tree growth component based on Agricultural Systems Simulator model (APSIM) into K-LAND.

- Conservation agriculture practices: the long-term impacts of reduced tillage, residue retention, and crop rotations on soil fertility and crop productivity will be modelled and added to K-WATER.
- Livestock production: as livestock is a major component of farming systems in the Khorezm region, a livestock productivity routine will be integrated into K-LAND.
- Model evaluation: a team of senior scientists and experts will develop a set of simulation scenarios and evaluate the model outcomes prior to release of K-LAND for use by stakeholders.
- Development of a Russian version of the graphical user interface (GUI) of FLEOM.

K-WATER

The K-WATER model is a spatially-explicit irrigation water distribution model which is currently being developed in collaboration with SIC-ICWC (Scientific-Information Center of the Interstate Coordination Water Commission of the Central Asia, Prof. Dukhovny). This hydrological model is designed to optimise irrigation water distribution and enhance water productivity in the entire Kulavat canal system covering 40,500 ha of land stretching along an east-west transect in Khorezm (Fig. 1). The irrigated area fed by the Kulavat network amounts to 22,850 ha, approximating about one-tenths of the total irrigated land in Khorezm. A similar model has already been implemented by SIC-ICWC in the upper Syr Darya System, in the Fergana Valley.

The irrigation network in K-WATER is characterised by a set of canal nodes (hydro-technical structures), reaches (canal sections between two nodes), and outlets (Fig. 6). Water enters the irrigation network from the Shavat canal and flows to hydromodule zones each representing an aggregation of fields planted with the same crop. Crop water demand calculated for each hydromodule zone is then summed up to estimate the total water demand of the area. If water supply is less than demand, water distribution to individual hydromodule zones is proportionally reduced. K-Water will serve canal and WUA managers and farmers as a tool for planning, monitoring, and analysis of irrigation water supply and distribution to improve the transparency and water productivity of the system. While the model will be parameterised for the Kulavad canal system, the generic concept, structure, and design of K-WATER allow application to other canal systems in the Khorezm region.

To extend the use of K-WATER for operational irrigation management, model outputs will be verified and tested against remote sensing parameters such as evapotranspiration (ET) derived fortnightly from MODIS data. Further, remotely-sensed cropping patterns and ET will be integrated to serve for in-season refinement of water distribution. Comparison between MODIS-derived ET and ET estimated by K-WATER will be used to identify field complexes receiving either very high water supply or those suffering from drought stress. Hence, the combination of K-WATER with remote sensing modelling will provide a comprehensive tool for both pre-

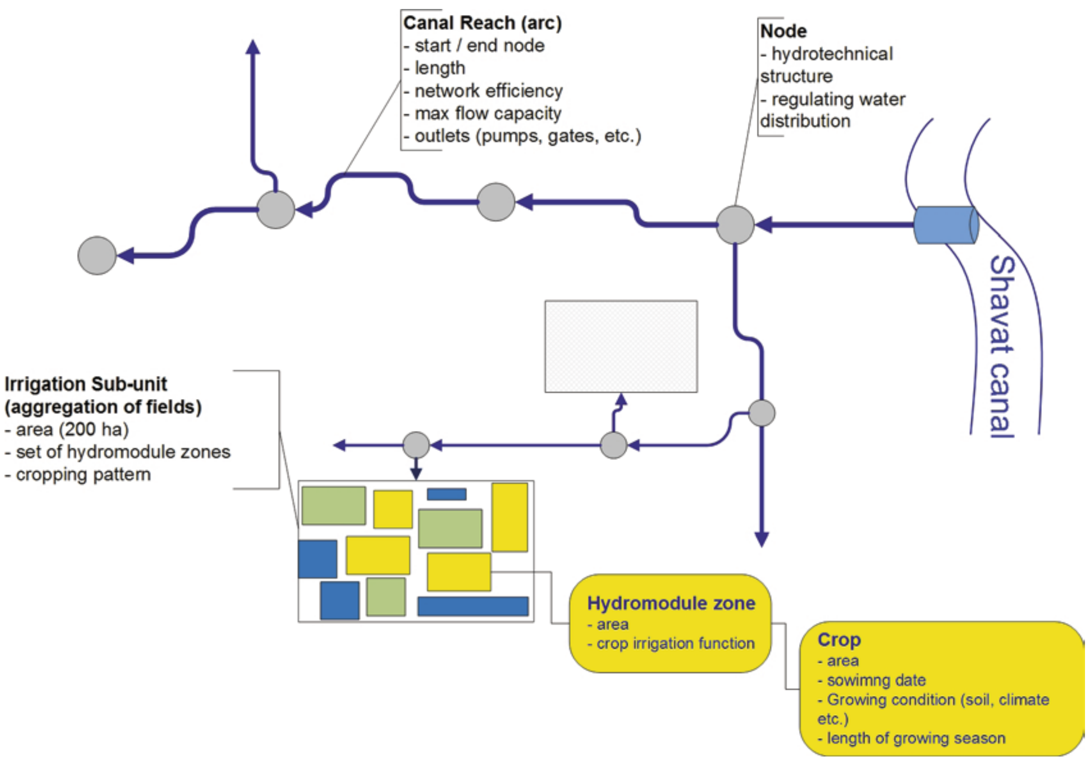


Figure 6. Schematic representation of the spatial hydrological model K-WATER.

season planning of water allocation as well as in-season evaluation and monitoring of actual water supply.

K-SIM

The central objective of the Khorezm project is to develop technologies and approaches for improved and sustainable management of land and water resources. Successful implementation of these innovations at the regional level requires formulation and ex-ante evaluation of enabling policy frameworks and strategies in terms of their long-term impacts on the economic, environmental and social sustainability of the region. The K-SIM model will serve as a dynamic policy information and simulation tool capable of predicting the long-term impacts of agricultural development policies in Khorezm. In policy impact assessment studies, various modelling paradigms have been developed and used including macro-economic models, computable general equilibrium models, optimisation models, system dynamics models, probabilistic or Bayesian network models, and multi-agent simulation (MAS) models. Due to its bottom-up structure capturing micro/macro linkages, interdisciplinary potential, and realistic representation of heterogeneous human agents and their environment, the multi-agent modelling paradigm appears to be the most promising simulation model for policy impact assessment at a regional level. The K-SIM model, therefore, is being developed based on a spatially-explicit multi-agent modelling approach.

K-SIM will rely heavily on the existing bio-physical and socio-economic data and simulation models such as K-LAND and K-WATER in the project. As quantity and timing of irrigation water supply are the major determinants of agricultural productivity and rural livelihood in Khorezm, the K-SIM model will adopt the temporal and spatial resolution of K-WATER for the Kulavat canal system (Fig. 1). The adequate size and the existence of spatial heterogeneity in bio-physical and socio-economic conditions make this study area quite suitable for modelling and scenario analysis of the effects of alternative agricultural policy options in the Khorezm region.

The MAS-based K-SIM model comprises of environment and human systems. The environment is represented at the level of FieldAgent, i.e. congruent land patches with their own bio-physical attributes and ecological response mechanisms to human interventions (Fig. 7). To account for the heterogeneity of bio-physical conditions, each FieldAgent is characterised by a set of state variables corresponding with the GIS raster layers of bio-physical variables (e.g. soil type, land use, irrigation network, etc.). Furthermore, each FieldAgent is owned by a farmer and can be used for producing crops, trees, etc. The quantity and timing of irrigation water to each FieldAgent is provided by the K-WATER model. The productivity of field agents (e.g. crop yields, tree growth and biomass) based on their bio-physical conditions, seasonal irrigation water availability, and management practices will be simulated using the bio-physical sub-models such as the farming systems models APSIM (Agricultural Production Systems Simulator) and CropSyst. The predicted dynamics of bio-physical state variables will then affect the decision making process of farmers with regard to land use and crop/soil management options. The actual cropping patterns and land use practices for the whole study area will therefore emerge from decisions made at the level of individual FieldAgents.

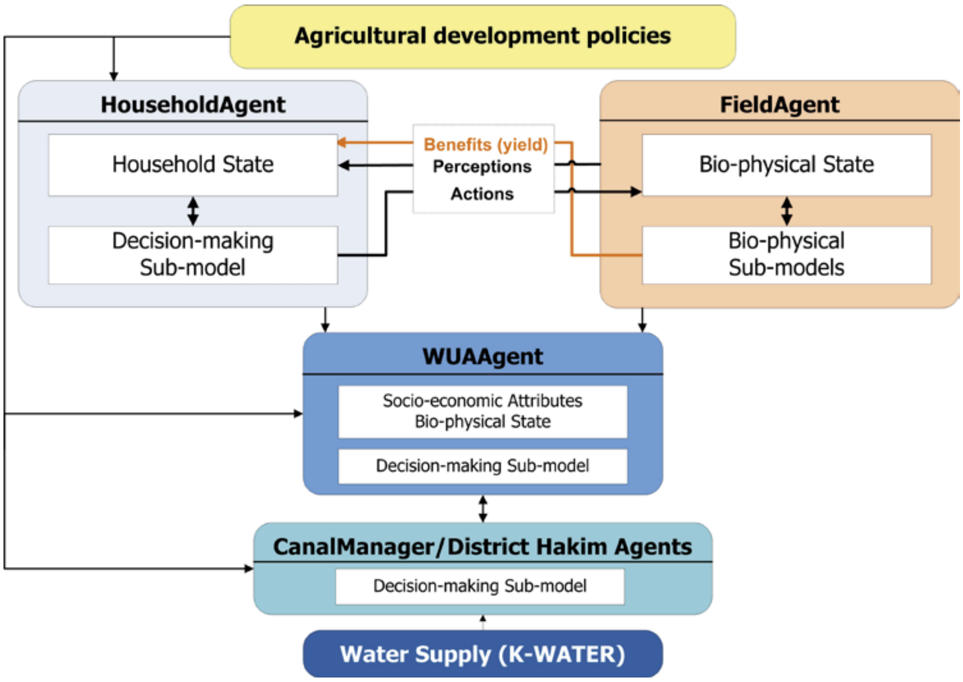


Figure 7. Conceptual framework of K-SIM model.

The human system in K-SIM includes household agents, WUAs managers, Kulavat canal managers, and district Hakim agents. The HouseholdAgent represents heterogeneous farming households with their own socio-economic state and decision-making mechanisms about land use. Some variables describing the HouseholdAgent change as a result of land use activities (e.g. annual income). Seasonal decisions on farm management activities are based on HouseholdAgent profile, outputs from bio-physical models, and information from other household agents. Aggregation of field and household agents form the bio-physical condition, socio-economic state, and geographic boundary of WUAs. The WUAAgent represents managers of WUAs who are responsible for water distribution to end-users (farmers). At the higher hierarchical level, the CanalManager and District Hakim Agents are in charge of allocating irrigation water to the WUAs located along the reaches of the Kulavad canal. Information on the quantity and timing of available water is provided to canal manager agents by the K-WATER model.

K-SIM treats land- and water- use related policies at national and regional levels as external drivers of the system. Policy factors affect the decision making of both human agents at various levels of hierarchy and functional relationships between human and environment. Policy interventions such as changes in production targets, taxation and subsidisation of crops, incentives for alternative land use and crop production practices, and water pricing can be modified by model users to explore the likely impacts of these policy scenarios.

The development of K-SIM will follow a participative modelling approach. Within this setting, the decision makers are integrated in the model development and evaluation process rather than being pure recipients of the simulation results presented by the researchers. An initial meeting with stakeholders to identify their issues, concerns, and needs is planned for September 2008. An interdisciplinary core team consisting of project senior scientists from agronomy, hydrology, economic, and social sciences has been formed to provide input into K-SIM development and evaluation. A ZEF Postdoctoral research fellow (Dr. Quang Bao Le) experienced in MAS will shift to this project from June 2009 for model implementation.

Regional scale tools

Land Suitability Maps

This activity aims at developing GIS- and remote sensing-based land suitability maps for the extrapolation of innovative technologies and development of regional restructuring plans. Spatial extrapolation requires matching the spatially distributed environmental, economic and infrastructure conditions in Khorezm with specific requirements of each technology to identify and demarcate the most suitable sites where the technologies can be applied. A multi-criteria evaluation based on GIS and remote sensing data will be used to analyze the spatial variability and up-scaling of the input data. The project's central GIS-database together with high resolution satellite images on actual land use and infrastructure distribution will provide the necessary spatial data. The resulting GIS maps indicating the spatially explicit suitability of land for various innovations will be integrated into the K-LAND model. We have already developed land suitability maps for tree plantations and fish ponds. These maps are currently being validated and refined using high-resolution satellite images.

Monitoring systems

In order to provide reliable and consistent information on land and water use to regional decision makers and planners in Khorezm, a remote sensing based monitoring system will be established. MODIS data will be used to assess land use, evapotranspiration, and crop yields annually starting from the year 2000. These variables permit quantification of various irrigation performance indicators in 15day, monthly, and seasonal resolution for each WUA within the region. To this end, a small stand-alone software ("Monitoring framework") combining remote sensing parameters and GIS-information is currently under construction.

The indicators comprise crop water deficit, relative evapotranspiration, depleted fraction, and water productivity (yield/water supply). Here, time series of remote sensing observations will allow benchmarking. Afterwards the monitoring system will show trends and anomalies of irrigation water consumption and can be used for benchmarking (Fig. 8).

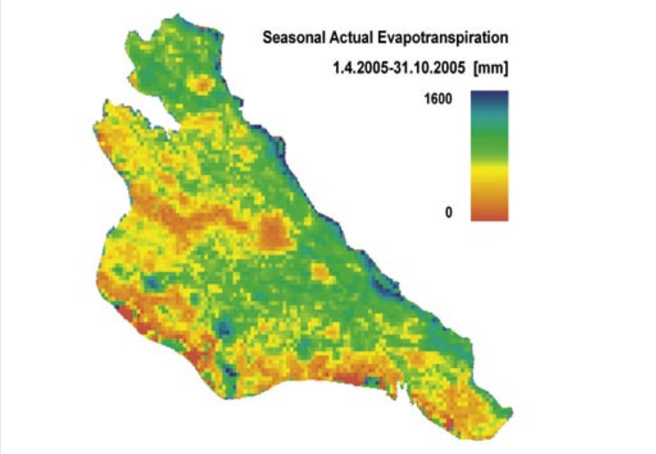


Figure 8: Regional map of seasonal actual evapotranspiration of the vegetation period 2005 based on MODIS remote sensing data (1km ground resolution).

The system therefore has a dual purpose: 1) to contribute variables and indicators to the intended indicator packages (see below), and 2) for strategic and operational irrigation management, and intra-seasonal refinements of K-Water, as described above.

Indicator packages

For supporting large-scale spatial analysis and planning, several key socio-economic and bio-physical indicators will be used. These indicators will help to classify the WUAs into Khorezm-specific types and identify and analyse those that exhibit a relatively better performance - „Best practice" WUAs. This information can be used by, for instance, WUA managers to optimize their own situation, and by regional decision makers to localise WUAs that require specific improvements. Our intended indicator system for the Khorezm region will address the following five central components of the agricultural production systems:

- Irrigation and drainage (e.g. adequacy, uniformity, relative evapotranspiration, depleted fraction, yield per m^3 water, and drainage ratio);
- land use (e.g. long-term sustainability, productivity of the actual cropping system, cropping pattern, and soil bonitet);
- infrastructure (e.g. technical situation of irrigation/ drainage network, machinery, and pump capacity/ cropping area at WUA level);
- economic performance (e.g. irrigation expenses, input and output transportation costs, average farm expenses, crop yields, average income);
- social indicators (e.g. % employee in agricultural sector, fertility rate, health condition).

Methodologically these indicators rely mainly on remote sensing assessments coming from the monitoring system, remote sensing data of higher resolution (Landsat, ASTER, IRS-P6), and the information from secondary data (e.g. KhorStat). At least five time steps (1992, 1996, 2000, 2004, and 2008) will be used for quantifying the indicators and assessing the regional spatio-temporal patterns of land and water use.

Economic analyses

Successful development of a restructuring concept for land and water use in Khorezm requires better understanding of the efficiency and effectiveness of existing markets and infrastructure, and sound analysis of the economic, social, and ecological effects of any proposed liberalisation scenario. To this end, economic research in the project has been concerned with market studies of agricultural commodities, development of a comprehensive database on aggregate parameters of socio-economic development, economic and financial analyses of cropping systems and tree plantations, animal production, and completion of social accounting matrix (SAM) for Uzbekistan and the Khorezm region. We have also developed various models and tools for policy analysis and information including:

- Partial equilibrium model - regional welfare effects of various policies such as liberalisation of cotton markets, introduction of water pricing mechanism, investments into irrigation and drainage network;
- Regional computable general equilibrium (CGE) model;
- Spatial stochastic model of farms - economic effects of introducing no-tillage practices in a group of farms aggregated to a water user association;
- Model of actors and processes for cotton and wheat - regional cotton and wheat value added chains.

The cotton value chain (CVC) analysis, for instance, was applied to obtain a comprehensive picture of the entire state-controlled cotton sector by describing the cotton flows, actors involved and their interrelationships, costs of production, and income distribution along the cotton chain. Results of this study revealed that cotton plays a key role in the regional economy of Khorezm – it contributes as much as 16% to the regional GDP, earns virtually 99% of the total export revenues of Khorezm, and creates value added worth USD 79 million. As only 10% of total fibre output is processed locally, we performed a scenario analysis of various alternative options including improved ginning efficiency and increased local processing of fibre to match the current potential capacities of the textile producers. Results showed that an increased processing of cotton fibre into yarn by only 10% would allow achieving the same regional export revenue while reducing 30 thousand hectares sown to cotton, saving 228 million m^3 of irrigation, and removing about 6 million USD in explicit subsidies. Thus improving the agro-processing industry is one of the key factors for improving the economic viability and ecological sustainability of the Khorezm region.

The on-going economic research in the project includes, among others, analysing the introduction of land and water markets, assessing the food price dynamics in the region, economic analysis of improving irrigation/drainage network and introduction of water saving technologies, multi-year economic analysis of introducing tree plantations on marginal lands, and establishing economically rational practices of fertilizer management for cotton and wheat.

Dissemination and outreach

Too often the knowledge, science and technologies generated by research projects do not become part of the local body of information and consequently are not used by decision- and policy-makers. Developing appropriate pathways for disseminating research findings to national and regional policy-makers, water and land use decision-makers, farmers, local scientific community and media is, therefore, a key component of the project's third phase. The following demonstrates our disseminating and outreach efforts and activities.

Workshops and Field Visits

Wrap-Up Workshop for the first two project phases, Bonn, November 27-30, 2007:
Around 50 researchers from Germany and Uzbekistan as well as representatives of UNESCO elaborated on the research findings and achievements of the first two project phases and discussed the research activities planned for the third phase.

Workshop on Water Rights in Central and South Asia, Bonn, January 24, 2008:
Around 20 researchers – among them staff members of the Uzbekistan project - exchanged ideas on managing irrigation systems in the context of ongoing ZEF projects in Afghanistan, India, Uzbekistan and Vietnam.

Kick-Off Workshop for the third project phase addressing national and regional decision-makers in Uzbekistan, Tashkent, May 27, 2008:
Around 70 participants attended the workshop which was held at the Ministry of Agriculture and Water Resources of Uzbekistan (MAWR). Among the high-ranking speakers at the workshop were the deputy Minister of MAWR, the deputy Minister of Agricultural Research, and the German Ambassador to Uzbekistan. Representatives of the Uzbek parliament, UNDP, and multilateral donor organizations such as the World Bank and the Asian Development Bank were also present. In addition, representatives of the Uzbek research community were participating. The workshop was well received and the project was requested to set up concrete recommendations based on the scientific findings in order to present them directly to MAWR.

Workshop addressing regional and local decision makers, Urgench, May 28-29, 2008:
The workshop that had started in Tashkent (previous section) was continued for two more days in Khorezm. The program included scientific presentations in Uzbek and Russian languages combined with field visits to the project's experimental sites. Here, innovative technologies for improved land and water use such as laser-guided land leveller, hand-held green seeker sensor for nitrogen management and crop yield forecasting, aerobic rice cultivation, and afforestation of degraded cropland were demonstrated.

Communication tools and policy outreach

Science Briefs

In order to reach out to policy and decision makers in Khorezm and Uzbekistan, we have started publishing a series of Science Briefs, called "ZUR" which is the abbreviation of ZEF-UNESCO Rivojlanishlari (Developments). The ZUR Science Briefs present scientific outputs of the project with policy relevance in a simple and concise way (2-3 pages) on a regular basis. So far, we have published five Science Briefs in English and Uzbek (see attached). In addition to the printed version, the Science Briefs are available for download from the project homepage.

Project homepage

To satisfy the increasing demand for information about the project and its results, we are continuously updating and upgrading the project homepage at *http://www.zef.de/khorezm.0.html* with the latest information on workshops, capacity development and other project news. The project is also presented on the IWRM homepage of BMBF under: *http://www.wasserressourcen-management.de/de/167.php*.

Media coverage

The project is regularly visited by representatives of the local press, and the interest of international journalists in project activities and achievements has been increasing. One staff member was interviewed for the online version of The New York Times of June 15, 2008 in an article on "Old Farming Habits Leave Uzbekistan a Legacy of Salt". In summer 2008, a German journalist will visit the project in Khorezm.

Implementing and adapting with stakeholders – Follow the Innovation (FTI)

The research activities in Phase I and II have generated a number of 'innovation packages' that are promising for enhancing sustainable agriculture in the region, improving water management procedures, or provide the necessary policy background for innovations to take a hold. In addition to further testing and refining of these innovative technologies and concepts in researcher-managed settings (e.g. landscape segment), the third project phase will focus on facilitating the implementation of innovative land use and agricultural practices by the relevant stakeholders.

In Uzbekistan, state bodies are excessively involved in decisions at the farm, district, regional and national scales. Hence, farmer's decisions on land and water allocation and management are strongly influenced by the state agencies, e.g. to grow mandated crops using prescribed practices and technologies. This leaves little room for farmers to optimize land and water use or adopt unconventional and innovative agricultural practices.

The project has, therefore, developed a truly consultative, participatory, and trans-disciplinary process that enhances the capacity of partners to innovate named 'follow the innovation'. The ultimate objective is to stimulate adoption of project innovations through an interactive process with the regional and farm-level decision makers. Through iteration, these innovations are adapted to meet stakeholder requirements and constraints. This process is seen as a pre-requisite for out-scaling into the wider area and elsewhere in Uzbekistan and Central Asia. To coordinate and facilitate the FTI process, a senior researcher has been recruited as the FTI facilitator since April 15, 2008.

As an entry point, a series of 5 training workshops have been planned to equip the relevant staff from the project and its key partner organizations with needed knowledge and skills. The first training workshop on concepts related to multi-, inter-, and trans-disciplinarity, and various theories and approaches of innovation adoption and diffusion was conducted at Bonn from February 11 - 14, 2008. Operationalisation of the project's FTI concept and approach was the topic of the second training conducted in Urgench, during June 1-5, 2008.

The most important outcome of the training was the formation of four trans-disciplinary working groups (TWGs) around the innovations: a) afforestation of agriculturally marginal and abandoned croplands; b) improving the performance of WUAs through grassroots-based collective action; c) soil salinity assessment and irrigation scheduling at field level; and d). conservation agriculture, nitrogen management and land laser levelling. These TWGs comprise core and supporting members from

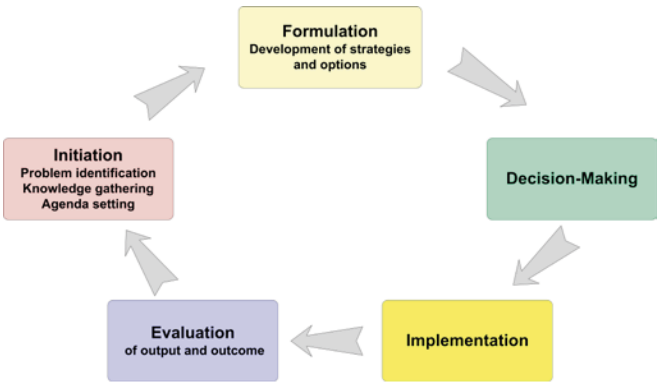
the project and stakeholders. The TWGs have already launched their stakeholder identification and engagement activities, held their first stakeholder consultation and problem analysis workshop, and identified a number of issues where project or partner's innovations could potentially be applied.

While the FTI process has taken off following the second training in June 2008, it will be open for more innovations in the future. Three more training workshops are envisaged in 2008, 2009, and 2010 to focus on monitoring and reviewing the results of the process, identifying further training and skill needs, and equipping the TWGs with necessary skills, tools and methods. These training workshops, of which the next one will take place on November 17-28, 2008 in Urgench, will also be used to learn lessons from the on-going FTI processes and to discuss the launch of more innovations into the FTI process. These processes will be critically analysed to synthesize lessons into peer-reviewed publications, and draw generic guidelines and theoretically informed lessons applicable to the entire Khorezm region and beyond.

Feeding Project Innovations into the governance of land and water resources – 'Spread the Innovation'

The evaluation of the second project phase had identified gaps between the generation of innovative technologies and concepts for improved land and water resource management and the communication of these innovations with national and regional policy makers.

In order to overcome this constraint, we will enter into a policy information process called 'spread-the-innovation' (STI). The ultimate objective of the STI is to inform and influence political reforms towards improved land and water resource use. Together with other project components, such as FTI and K-SIM model development process, STI will tackle all angles of the policy planning circle.



Evaluation of the outputs and outcomes of past reform efforts will be carried out in joint sessions with policy makers and ministry staff. The process starts with the identification of agents for change, i.e. an actor-mapping process to define responsive, reform-minded and influential actors in the decision-making process. Subsequently, the analytical and the practical part of STI will run on parallel tracks. In regular meetings with the agents of change, the sectoral needs and innovation demands shall be determined (perceived needs assessments). In a further step, the structural incentives and impediments for change are to be defined together with the agents of change (incentives mapping). Information on project innovations that meet identified demands will be disseminated in a targeted manner among key actors through personal talks and concise briefing papers that convey tailor-made policy recommendations. Finally, in broader meetings international donors shall be included to jointly discuss the focus of future interventions and incentive structures in the land and water sector.

Ultimately, topic-related networks for innovation shall bring together international organizations, research institutes, local NGOs, governmental authorities and implementing agencies. The STI process will be analytically monitored and evaluated in an action research approach to secure lessons learnt about the structures that foster or impede change. This analysis borrows from the Drivers of Change approach. The STI process will be coordinated by a senior person with profound knowledge of the political culture and decision-making processes in the agricultural and water management sector in Uzbekistan and expertise in donor relations in the Uzbek setting. Ideally, this person is well-established in this realm to ensure access to actors of change. Additionally, this person has the required skills to analytically inform the documentation of the process.

Human capacity building & scientific output

As one of the major internationally-funded long-term research projects in Uzbekistan, we have been able to make a significant contribution toward education and training of young local scientists. Around 80 international scientists are involved in the project. Fifteen PhD students, 51 Master students, and numerous Bachelor students have completed their studies within the framework of the project – the majority from Uzbekistan.

The list of project publications include 37 articles in peer-reviewed journals, 4 edited books, 20 book chapters, more than 70 contributions at international conferences, and 58 scientific articles in Uzbekistan.

The following is a selected list of project's publications in 2008.

Papers in peer-reviewed international journals

Abdullayev, I., Manschadi, A.M., Oberkircher, L., Ataev, J. and Nurmetova, F., 2008 (in print). Conceptualizing Water Research in Central Asia. The International Journal of Interdisciplinary Social Sciences, 3.

Akramkhanov, R., Sommer, A., Martius, C., Hendrickx, J.M.H and Vlek, P.L.G., 2008. Comparison and sensitivity of measurement techniques for spatial distribution of soil salinity. Irrigation and Drainage Systems, 22: 115-126. Available online at: DOI: 10.1007/s10795 008 9043 9

Conrad, C., Dech, S., Hafeez, M., Lamers, J.P.A. and Tischbein, B. (submitted). Remote sensing and hydrological measurement based irrigation performance assessments in the upper Amu Darya Delta, Central Asia. Physics and Chemistry of the Earth.

Franz, J. and Kirkpatrick, C., 2008. Improving the quality of integrated policy analysis: Impact assessment for sustainable development in the European Commission. Evidence & Policy, 4 (1): 171-85.

Kan, E., Lamers, J.P.A, Eschanov, R. and Khamzina, A. (in press). Small-scale farmers' perceptions and knowledge of tree intercropping systems in the Khorezm region of Uzbekistan. Forests, Trees and Livelihoods, 18 (4).

Khamzina, A., Lamers, J.P.A. and Vlek, P.L.G., 2008. Tree establishment under deficit irrigation on degraded agricultural land in the lower Amu Darya River region, Aral Sea Basin. Forest Ecology and Management, 255 (1): 168-178. Available online at: DOI:10.1016/j.foreco.2007.09.005

Khamzina A., Lamers J.P.A. and Vlek, P.L.G. (submitted). Nitrogen fixation by Elaeagnus angustifolia L. in the reclamation of degraded croplands of Central Asia. Tree Physiology.

Khamzina, A., Sommer, R., Lamers, J.P.A. and Vlek, P.L.G. (submitted). Transpiration and canopy conductance of tree plantations on degraded agricultural land in the lower Amu Darya River region of Uzbekistan. Agricultural and Forest Meteorology.

Lamers, J.P.A. and Khamzina, A., 2008. Fuelwood production in the degraded agricultural areas of the Aral Sea Basin, Uzbekistan. Bois et Forets des Tropiques, 297(3): 43-53.

Lamers, J.P.A., Bobojonov, I., Khamzina, A. and Franz, J. (in press). Financial analysis of small-scale forests in the Amu Darya Lowlands of rural Uzbekistan. Forests, Trees and Livelihoods 19 (1).

Lamers, J.P.A., Bobojonov, I., Martius, C. and Khamzina, A. (submitted). Land use polices for marginal land: A financial assessment of tree plantations on degraded lands in Central Asia. Land Use Policy.

Manschadi, A.M., Hammer, G.L., Christopher, J.T., deVoil, P., 2008. Genotypic variation in seedling root architectural traits and implications for drought adaptation in wheat (Triticum aestivum L.). Plant and Soil , 303: 115

Rudenko, I., Grote, U., Lamers, J.P.A. and Martius, C., 2008. Wert schöpfen, Wassersparen. Effizienzsteigerung im usbekischen Baumwollsektor. In: Sapper, M. and V. Weichsel (Eds.): Grünbuch. Politische Ökologie im Osten Europas. Berlin. Osteuropa, 58(4–5): 407–417. Available online at: http://www.osteuropa.dgo-online.org/8.0.html

Ruecker, G., Dorigo, W.A., Grillenberger, J., Kienzler, K., Ibragimov, N., Schmidt, M. and Dech, S. (submitted). Suitability of vegetation indices for monitoring leaf chlorophyll in Uzbek cotton fields using time-series of hyperspectral satellite imagery. Physics and Chemistry of the Earth Journal.

Scheer, C., Wassmann, R., Kienzler, K., Ibragimov, N. and Eshchanov, R., 2008. Nitrousoxide emissions from fertilized, irrigated cotton (Gossypium hirsutum L) in the Aral Sea Basin, Uzbekistan: Influence of nitrogen applications and irrigation practices. Soil Biology & Biochemistry, 40: 290-301.

Scheer, C., Wassmann, R., Kienzler, K., Ibraghimov, N., Lamers, J.P.A. and Martius, C., 2008. Methane and nitrous oxide fluxes in annual and perennial land-use systems of the Irrigated areas in the Aral Sea Basin. Global Change Biology, 14: 1–15. Available online at: DOI: 10.1111/j.1365-2486.2008.01631.x

Scheer, C., Wassmann, R., Butterbach-Bahl, K., Lamers, J.P.A. and Martius, C., 2008 (in press). The Relationship between N_2O, NO, and N_2 fluxes from Fertilized and Irrigated Dryland Soils of the Aral Sea Basin, Uzbekistan. Plant and Soil.

Sommer, R., Kienzler, K., Conrad, C., Ibragimov, N., Lamers, J.P.A., Martius, C. and Vlek, P.L.G., 2008. Evaluation of the CropSyst model for simulating the potential yield of cotton. Agronomy for Sustainable Development, 28 (2): 345-354. Available online at: www.agronomy-journal.org or at DOI: 10.1051/agro:2008008.

Ul-Hassan, M., Shah, T., Rehman, S.U., Tanwir, F., Khattak, M.Z.K. and Lashari, B.K., 2008. Diesel price hike and the energy squeeze on Pakistan's smallholder irrigators. Journal of Applied Irrigation Sciences, 43(1):19-40.

Book

Wehrheim, P., Schoeller Schletter, A. and Martius, C., (Eds.), 2008. Continuity and change: Land and water use reforms in rural Uzbekistan Socio economic and legal analyses for the region Khorezm. Leibniz Institute of Agricultural Development in Central and Eastern Europe (IAMO). Studies on the Agricultural and Food Sector in Central and Eastern Europe, Vol. 43. Halle/Saale. Available online at: http://www.iamo.de/dok/sr_vol43.pdf

Doctoral Theses

Djanibekov, Nodir 2008. A Micro-economic Analysis of Farm Restructuring in the Khorezm Region, Uzbekistan. Dissertation. University of Bonn, Germany.

Rudenko, Inna 2008. Value Chains for Rural and Regional Development: The Case of Cotton, Wheat, Fruit and Vegetable Value Chains in the Lower Reaches of the Amu Darya River, Uzbekistan. Dissertation. University of Hannover, Germany.

Scheer, Clemens 2008. Biosphere-atmosphere-exchange of C and N trace gases and microbial N turnover processes in irrigated agricultural systems of the Aral Sea Basin, Uzbekistan. Dissertation. University of Bonn, Germany.

Veldwisch, Gerd Jan 2008. Cotton, Rice & Water: Transformation of Agrarian Relations, Irrigation Technology and Water Distribution in Khorezm, Uzbekistan. Dissertation. University of Bonn, Germany.

Facts & Figures

Project duration: 2000-2011
Main donors: German Federal Ministry for Education and Research (BMBF); German Academic Exchange Service (DAAD).

Main partners

United Nations Educational, Scientific and Cultural Organization (UNESCO); German Aerospace Center (DLR); University of Urgench (UrSU); International Maize and Wheat Improvement Center (CIMMYT); International Center for Agricultural Research in the Dry Areas (ICARDA); Central Asian Research Institute of Irrigation (SANIIRI); Tashkent Institute for Irrigation and Mechanization (TIIM); Uzbek State Uzgipromeliovodkhoz Institute (UZGIP); University of Würzburg.

Contact

Center for Development Research (ZEF)
University of Bonn
Dr. Ahmad M. Manschadi (project coordinator ZEF)
Uzbekistan Project Office
Walter-Flex-Strasse 3
53113 Bonn
Germany
Phone: +49/228/731917 or 731865
Fax: +49/228/731889
e-mail: khorezm@uni-bonn.de or manschadi@uni-bonn.de

Project Office Urgench
Urgench State University
Dr. John P.A. Lamers (project coordinator Uzbekistan)
14 Khamid Alimjan street
220100 Urgench, Khorezm
Uzbekistan
Phone: +998/362/2262119
Fax: +998/362/2243347
e-mail: j.lamers@zef.uzpak.uz

universitätbonn

UNESCO
United Nations Educational, Scientific and Cultural Organization

German Ministry for Education and Research (BMBF)

IMPRINT

Published by the Center for Development Research (ZEF)
University of Bonn, Germany
Uzbekistan Project Office
phone: # 49 228 731917 or 731865
e-mail: khorezm@uni-bonn.de

Layout: Katharina Moraht
Printers: University Press Bonn
August 2008

www.khorezm.uni-bonn.de