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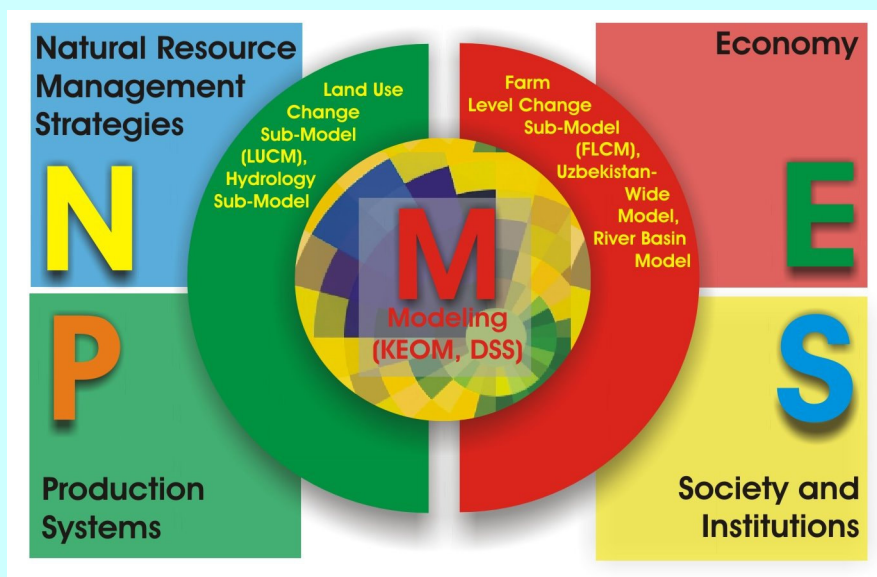


Economic and Ecological Restructuring of Land- and Water Use in the Region Khorezm (Uzbekistan)

A Pilot Project in Development Research

Project Phase II:

**Field Research
and Development of a Restructuring Concept
(2004-2006)**



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Executive Summary

During Soviet times, over 7 million ha of artificially irrigated agricultural land have been created in the Aral Sea Basin (Aral), basically in order to produce cotton. Large amounts of river water have been withdrawn from the main tributaries of the Aral Sea. Following independence in 1992, Uzbekistan has chosen a gradual approach to economic reforms from plan to market economy; however, today's agricultural production systems are in fact still reminiscent of those inherited from the Soviet era. They are characterized by extensive monocultures under heavy inputs of fertilizers, pesticides, and water, the latter being delivered in extensive irrigation systems that are expensive to maintain and in which up to 70% of the water is lost. The so-called "state order" on crops such as cotton, wheat and in part rice, is a system of obligatory allocation of land to the production of these crops, which is imposed via strongly hierarchical and centralized government structures inherited from the former Soviet system. It insures the predominance of cotton production and impedes the transition to a market economy. As it is, the agricultural production is ecologically unsustainable; soil degradation is rampant, water quality is very low, and water losses, in comparison to other arid countries, are extremely high. The system is also economically unstable, as, for example, the wages paid in agriculture are among the lowest in the region. The inhabitants of Karakalpakstan and Khorezm, two districts on the lower reaches of the Amu Darya River, the largest of the Aral Sea's tributaries, suffer most from the accumulated effects of low water use efficiency, soil degradation and salinization, as well as from the economic and administrative legacies inherited from the Soviet era that are leading to poverty and poor health. The critical economic and ecological situation in the Aral region is thus the result of ill-conceived economic policy and weak institutions and administrative measures. Furthermore, the mixture of Soviet, tribal ("clans"), and ethnic cultures adds to the complexity of the problem. Structural solutions will need to be multi-faceted and can only be developed by a truly interdisciplinary approach.

ZEF has therefore designed, in consultation with its partners (UNESCO, DLR, University of Urgench and TIAME in Uzbekistan and many others), an interdisciplinary, application-oriented research program with the aim to provide appropriate regional development concepts based on sustainable and efficient land and water use. The program started in 2001 and is based on an integration of natural resource management, economic studies and studies of institutions. The philosophy is that of a long-term, participatory commitment to deliver de-centralized development options based on a system where markets function and sound ecological principles are adhered to. The program includes a strong human capacity building component, particularly the training of young Uzbek scientists from the Aral who will be the potential future decision-makers in the region.

Recognizing that most of the Aral Sea is lost, the ZEF program assumes that a sustainable restructuring of land and water use in the Aral (1) will have to improve the livelihood of the local population through private farming based on (ecologically, economically and socially) sustainable land-use options; (2) must be based on an efficient use of the existing resources while gradually refurbishing the dilapidated irrigation system. This requires a reduction in cropped land, which we expect to achieve through diversification of land use, utilization of the "service potential" of ecologically sound land-use systems, efficient use of production factors, liberalization of the input and output markets, increase in rural income and careful modification of existing legislation and decision-making systems to enable this process.

In this document we present the proposal for extending ZEF's project on "Economic and Ecological Restructuring of Land- and Water Use in the Region Khorezm (Uzbekistan) - A Pilot Project in Development Research" into its next phase. This project phase, to last from 2004 to 2006, is the second of a total of four phases covering the 10-year program (Phase I: Establishment of central databases and infrastructure; Phase II: Field trials for process understanding, development of a simulation model (KEOM, see below); Phase III: Testing the concept for restructuring land use on pilot farms and developing a Decision Support System (DSS); Phase IV: Adaptation of the concept and its implementation in Khorezm; cf. Table 1).

In Phase I (18 months) the project concentrated its efforts on assessing the state-of-the-art, based on secondary data acquisition, surveys of land use, ecological conditions and current economic, institutional and social/health conditions of the Khorezm region. The project has been firmly established with excellent institutional arrangements, infrastructure and national and local support. Moreover, there is a clear tendency in the country to shift to privatization and liberalization of markets,

so that the BMBF project is drawing increasing attention from various levels of government. It therefore becomes even more important to facilitate this process with sound restructuring concepts. Therefore, **in Phase II, the main aims of the project are (1) to gain the necessary understanding of natural, economic, and social processes that allow the proposition of a alternative restructuring concepts; (2) to develop an Ecological-Economic Optimization Model (KEOM) that will help assess the impact of various restructuring concepts on economic and ecological developments; (3) to develop together with the local land users and with the help of KEOM, a pilot scheme for large-scale privatization of Shirkats (communal farms); and (4) to initiate the development of a Decision Support System (DSS) to aid decision makers in the privatization process and reallocation of land and water resources.**

Thus, the model developed in Phase II will provide the concepts to be tested on the pilot farms in Phase III, when also the DSS will be fully developed.

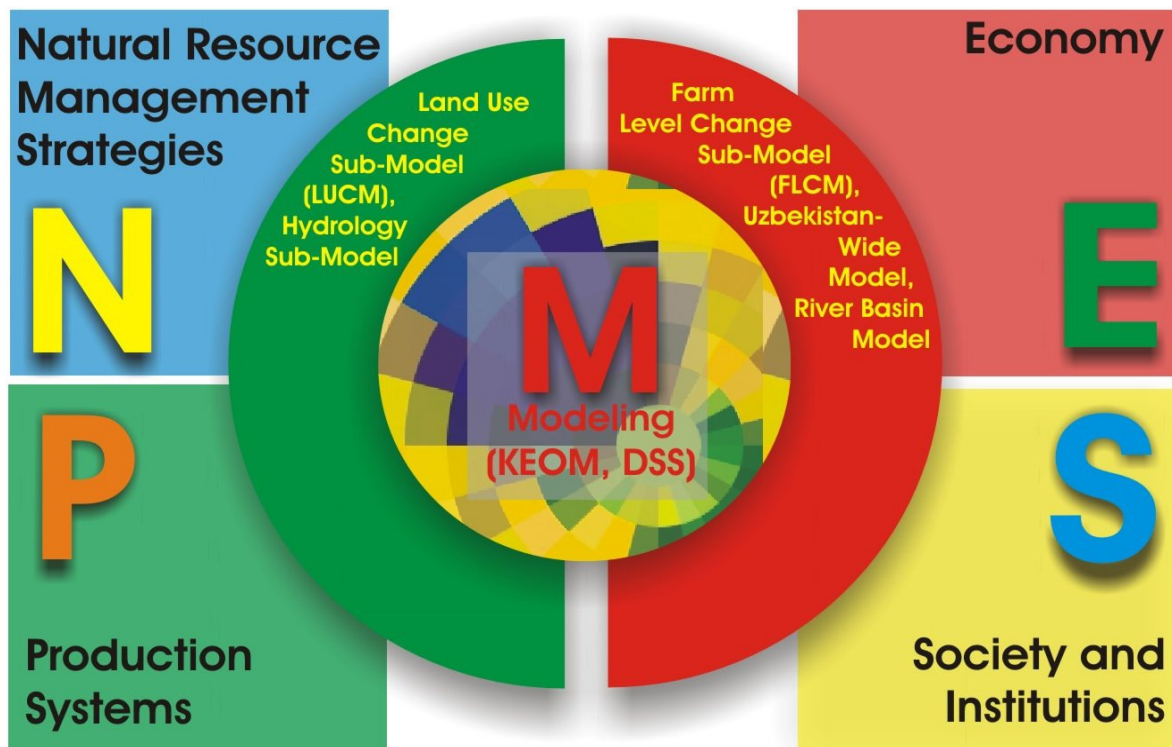


Figure 1: The four project research areas feed through sub-models into the Khorezm Ecological-Economic Optimization Model (KEOM). (The individual studies in the different areas are listed in Table 1)

For this purpose, the project in Phase II comprises research in four thematic areas that will provide the basic data input for the integrative, interdisciplinary KEOM and the pilot farm scheme design (cf. Figure 1). These areas cover: **(1) Natural Resource Management Strategies (N)** targeted at decision makers, in which i) optimal land-use patterns (including the introduction of trees and ponds as alternative land uses with ecological functions) will be determined, ii) ways for an efficient, sustainable management of the two most important resources, water and land, will be elaborated, and iii) indicator functions for a sustainable resource use related to water quantity and quality (salinity in irrigation and drinking water), and soil quality will be established allowing assessment of the success of the restructuring measures to be adopted; **(2) Production Systems (P)** in which i) possibilities for a diversification of crops through the introduction of alternative crops, cropping systems, and rotations will be exploited, ii) possibilities for an improvement of fertilizer efficiency will be studied, and iii) irrigation efficiency on the field level will be addressed to develop recommendations targeted at farmers as the main land users; **(3) Economy (E)** aiming at i) establishing development pathways for transforming the local economy from a centrally-based to a market-oriented system, ii) the acquisition

of primary research data on farm management, market conditions, profitability of diversified crop production systems, expenditures of regulating the economy as well as costs of intergenerational distribution, and iii) a socio-economic assessment of losers and winners of possible reforms, all related to the question of how the land and water use can be improved; and **(4) Society and Institutions (S)** aimed at i) understanding the formal (legal) ways of resource distribution in the state institutions and the newly formed Water User Associations, ii) increasing our understanding of the the informal ways of by-passing these institutions in decision-making, iii) assessing environmental legislation and the legal aspects of land tenancy and land use with the aim of identifying the possibilities for legal, institutional and administrative modifications needed for a land reform, market liberalization and an effective increase in land/resource use efficiency and sustainability. In area S, the project also addresses the question of international competition for water in Central Asia and thus provides the link between the development of water distribution on regional and supranational scales.

The sub-models (representing the thematic components) developed during Phase I and II of the project will be integrated in the central model (KEOM). The model's main purposes are research, planning and teaching; however, it will also provide the basis for a concept to implement changes in land and water use, free of the Uzbek state order, in experimental pilot farms (Phase III). Parallel to this large-scale experiment, Phase III will be dedicated to the participatory development of the Decision Support System.

In short, an improved resource management, the success of which is gauged through monitoring the adequate indicators in area N, is supported by a restructuring of the production systems (P), the economic (E) and the legal/institutional/administrative systems (S), and integrated in the KEOM model and DSS (area M) through which a thorough scenario analysis will lead to restructuring concepts.

In the following, we shortly give justifications for and describe the main content of the single work packages and their interrelationships (for an overview cf. Table 1. The link between research from Phase I and Phase II is shown in Table 8).

Area N (Natural Resource Management Strategies): Resource utilization begins with the allocation of land to various land uses. One alternative land use is the establishment of tree plantations and shelterbelts for biodrainage, organic matter input, improvement of the microclimate through shadow, and tree products such as wood, fruit or fodder. The other alternative explored in this program is the installation of ponds for fish farming in the region. A status quo of land use over the region has been established in a DLR study through Remote Sensing of the Leaf Area Index (LAI), through which, in combination with biophysical parameters, optimum watering will be forecasted for short periods. Given the obvious need to set aside land for ecosystem services necessary for making the environment more viable, the GIS project will be expanded to include a dynamic land-use model that will allow the identification of the regions to be set aside for forests, shelterbelts, and fish ponds. This will be viewed in close connection with the alternative suite of cropping systems. Detailed hydrological and soil quality studies are necessary for achieving vertical drainage efficiency, water-use efficiency and improved ecosystem functioning that will allow assessment of the success of the measures to be implemented through this program. As no reliable information is available in Uzbekistan on the in- and outflows of water in the irrigation systems of the lower Amu Darya River (district of Khorezm), first a sound database for a hydrological budget for Khorezm will be created based on own measurements. Furthermore, the ongoing measurements of a field water budget for cotton will be extended to additional crops and regional up-scaling will be undertaken based on studies of water fluxes on different scales. This will allow the optimization of water allocation strategies. Research on the establishment of tree plantations will be continued. A long-term experimental plantation of tree species under different irrigation regimes will be continued to study growth parameters and gauge the expected ecological effects on soils and water. Mapping of existing tree stands and of indicators showing suitable sites will allow later implementation of the plantation schemes on a larger scale. Another alternative land use that also will contribute to income generation is the transformation of marginal land into fish ponds, making use of drainage water. Again, this requires mapping of site suitability.

The spatial distribution of health-related aspects of drinking water quality, specifically the incidence of those heart diseases related to high water salinity, will continued to be monitored and documented in the GIS-database. This data set will serve as a base-line from which to assess the impact of restructuring in the pilot scheme at a later date.

A soil-ecological monitoring program will be established to evaluate the impact of the newly introduced land-use and cropping systems. This is coupled to an intensive investigation of carbon and nitrogen budgets in these systems under different irrigation regimes.

A central task in Area N will be the development of the Land Use Change Model (LUCM) that will integrate the different aspects of land use and resource use, and feed into the overall Model (KEOM, see below).

Area P (Production Systems): Agriculture consumes about 70% of all water resources in Uzbekistan, and the agricultural water-use efficiency in Khorezm is notoriously low. Research will therefore be dedicated to establish alternative cropping and crop management systems that have been successful elsewhere. These include the introduction of a permanent bed-and-furrow system and improved irrigation techniques in combination with optimized fertilizer management via a judicious combination of organic and mineral materials. We will also test the introduction of alternative crops like potatoes, sorghum, sunflowers, or crops with a high value density such as flowers or spices, and work on crop rotation – all this as a means to both improving resource-use efficiency and assessing new market opportunities. The proper production functions of the four main crops to date (cotton, wheat, rice and fodder maize) under these modified conditions will have to be established. The same will be needed for promising alternative crops. Studies initiated in 2002 will continue to establish the production functions for different fish species using cheap locally available plants and crop residues for feed. Economic feasibility of bed-and-furrow (B&F), tree plantations (TP) and aquaculture will be studied (link to Area E), and the ecological effects of B&F and TP will be assessed through groundwater and soil studies described above for area N.

Area E (Economy): The key to the success of restructuring will be functioning markets and privatization of agriculture. It will be necessary to study up to which point privatization and land set-aside policies may diminish the employment opportunities in the farm sector, and how far market restructuring might be able to compensate for these losses. An in-depth analysis of the institutions necessary to create functioning markets, of constraints prevailing in input markets as well as in those affecting output at various stages (processing, storage, and marketing) will be undertaken in order to assess the various options for privatization of these sectors as a viable alternative to the procurement system of the government. In addition, a socio-economic evaluation of possible winners and losers of agricultural reform will provide the necessary background information to minimize or avoid social disruptions. Judgment on the economic effects of re-allocating land and water use will be mainly based on analyses of individual farms started in 2002 and carried out with Linear Programming Models (LPM) that will represent the three major farm types at each district level. These investigations not only will provide a reliable insight into the status quo, but will also provide the levers with information for economic re-organization into more market-orientated agriculture. Furthermore, the computable general equilibrium model will be extended in several respects in order to properly quantify the economy-wide effects of agricultural reforms (e.g., through an up-scaling from a static to a dynamic version).

Analyzing the costs of regulations will provide a clear assessment of the hidden expenditures in the current system and visualize the possible financial improvements through privatization. Also in Area E, the modeling studies initiated in 2002 will be continued with the emphasis on integration of the farm data into the Farm Level Change Model (FLCM) to support the overall model, KEOM.

Area S (Society and Institutions): Any implementation of modifications of resource use will involve regulatory, organizational and social issues. The analysis will determine where improvements of the institutional system are needed with regard to the restructuring of the use of land, water and ecosystems, and will assess the political feasibility of reform proposals. Furthermore, the possible legal forms of small and medium enterprises (SME's) that could seize the new chances in marketing and processing provided by privatization will be elaborated in close cooperation with Area E. The applicability of successful property concepts and models of land use reform from other countries with socialist tradition (e.g., China, Kyrgyzstan, Kazakhstan) to the Uzbek situation will be studied. Privatizing farms and liberalizing markets calls for alternative institutional arrangements in water delivery as well as in monitoring markets. Research will be intensified on appropriately anchoring the new institutional settings in the formal and traditional societal structures in Khorezm. On the supra-regional level, a study of water distribution and allocation in countries upstream (Tadjikistan, Turkmenistan and Afghanistan) will address the political dimension of water availability, help to assess arbitration options for future conflicts over water, and allow adjustment of water management in the downstream area of Khorezm according to upstream competition.

Area M (Modeling): A central goal in this project phase will be the modeling of economic and ecological processes in order to understand their dynamics and to allow, through simulations, to develop scenarios for optimization of land and water use. This will be obtained through simulations in a spatially distributed, agent-based computer model consisting of subunits for resource utilization, natural constraints, economics and human driving forces (the Ecological-Economic Optimization

Model (KEOM). The KEOM will allow assessment of the impact of possible scenarios (climatic changes, policy changes, introduction of different land management, etc.) on the long-term sustainability of ecological and economic conditions of Khorezm and Uzbekistan. The model will be based on appropriate linear as well as non-linear programming tools; the scientific challenge will be internalization of the ecological externalities such as ecosystem services. This model will be an education- and research-oriented open-source platform for integrating the various databases and identifying the relevant key processes. It will also serve as the basis for developing a comprehensive decision support system at a later stage. The KEOM will assemble the different parallel multi-disciplinary approaches into a truly integrated interdisciplinary research tool. The management and administration of the project's central GIS facilities in Urgench through the DLR will provide the platform for this task.

Figure 1 shows the sub-models that process the data sets from the different disciplines and will themselves be incorporated in the overall model. The KEOM integrates the Land-Use Change sub-model, the hydrology model, (natural resource sub-unit, left side) and three economic models acting at different scales: the Farm-Level Change Sub-Model (FLCM) which deals with farm restructuring, the Uzbekistan-wide economic model which addresses market reform, and the Economic River-Basin Sub-Model (huma driver sub-unit, right side).

Organizational Aspects: Research in ZEF projects is commonly done by Ph.D. students. Phase II of the program foresees the fieldwork to be carried out by 11 Ph.D. students from Uzbekistan and Germany participating in ZEF's International Ph.D.-Program. Additionally, several Ph.D. studies will be done under Uzbek supervision, and a M.Sc. Program started in 2002 will be continued in which young students from Khorezm can obtain their degree and undergo advanced English training in Tashkent. These represent the pool of Ph.D. candidates for the next project phase. Several smaller complementary studies will be outsourced to Uzbek and German scientists as consultants. As in Phase I, DLR will coordinate the maintenance of the GIS-Center Khorezm and of remote sensing research through a subproject arrangement; UNESCO will provide, as another sub-contractor, logistical and institutional backstopping in Uzbekistan.

Leadership in the project will be provided by a senior core staff member of ZEF (Dr. Martius) while the coordination in Uzbekistan remains in the hands of a senior project scientist (Dr. Lamers). In addition, senior staff (Drs. Wehrheim and Schoeller-Schletter) and junior scientists (Dr. Ruecker-DLR, and NN at ZEF) will complete the ZEF team in the project.

Proper control of project progress will be secured by the organization of the single work packages (tasks) into a logical framework (logframe) and the breakdown of tasks into milestones. Regular meetings will ensure the interdisciplinary integration of the single tasks, with active participation of the main local partner, the Ministry of Agriculture and Water Resources (MAWR).

We seek support for 3 non-core staff members dedicated to the project at ZEF and 6 stipends for Ph.D. students from BMBF (four Ph.D. stipends will be requested from NRW-MSWF, one from the EU Marie-Curie-Program and one post-doc scholarship from the Alexander-von-Humboldt Foundation), funds for the necessary equipment and consumables to carry out field research in Urgench, for administration costs for maintaining the project infrastructure in Uzbekistan for travel costs and the organization of workshops to strengthen the interdisciplinary integration to the total amount of Euro 2.1 million for three years. The funds will top-up those available from Phase I and extend the program for one additional year (till 31.12.2006), making the total of Phase I and II a four-year period.

Table 1: Overview of the research areas, themes and work packages in Phase II of the project

Code	Name of Area	Themes	Individual Work Packages	
			Numbers	Topics
N	Natural Resource Management Strategies	Hydrology and salinity management	N21	Upscaling of field water measurements, Khorezm-wide hydrology model
		Soil fertility	N22, N23	Soil ecology and fertility status
		Drinking water quality	N24	Salinity in drinking water and related diseases
		Alternative land uses (trees, ponds)	N25	Plantation of trees and shelterbelts: growth, irrigation needs
			N26	Establishment of ponds for fish production
Forecasting natural resource use	N27	Remote-sensing of land use and biophysical parameters; landscape planning for trees, ponds and crops; Establishment of Land Use Change Model (LUCM)		
P	Production Systems	Crop diversification and optimization	P21, P22	Introduction of alternative crops (potatoes, sunflowers), optimization of fertilizer use
		Alternative cropping systems	P23	Introduction of conservation agriculture through bed&furrow systems
		Irrigation efficiency	P24	Irrigation system performance
		Modeling production systems efficiency	P25	Establishment of production functions for crops and systems
E	Economy	Market analysis	E21	Agricultural input and output markets, role of SME's
		Economic resource management	E22	Costs and effects of restructuring land and water use
		Socioeconomic assessment	E23	Losers and winners of reform: Socio-economic effects of restructuring land and water use
		Farm analysis	E24	Development of Farm Level Change Model (FLCM)
S	Society and Institutions	Legal and political prerequisites of land reform	S21	The regulatory environment for land tenure. Environmental legislation.
		Water allocation: Institutions & networks	S22,	Institutional and informal systems for water allocation: Distribution of competences and decision-making
			S23	Competition for water in the Aral Sea Basin: Regional and supra-regional conflict potential and viable arbitration mechanisms
M	Modeling and Decision Support	GIS data basis	M21	Maintenance of GIS Center Khorezm as a service component
		Modeling (KEOM)	M22	Scenario Analysis using the Khorezm Ecological Optimization Model, and preparation of DSS for Phase III