PROCEEDINGS

Water Security – Opportunity for Development and Cooperation in the Aral Sea Area

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WATER SECURITY - OPPORTUNITY FOR DEVELOPMENT AND CO-OPERATION IN THE ARAL SEA AREA

by Ulf Ehlin

Introduction

One of the most severe manmade environmental and ecological disasters of all time was created during the last decades of the 20th century due to the lack of consciousness regarding the consequences of the integrated effects of widespread deforestation and water withdrawal for large-scale irrigation. The increased water withdrawal for irrigation reduced the inflow of water from the Amu Darya and the Sur Darya rivers to the Aral Sea by 90% compared to mid-20th century levels, and resulted in a large decrease in the water volume and surface area of the Aral Sea. Also, the water quality of both the in-flowing water and the Aral Sea itself has drastically changed. The altered land use and massive irrigation caused basin-wide soil and water salinization, desertification, poor quality drinking water and chronic health problems for the population. The aquatic ecosystem collapsed, destroying a fishery.

The increasing environmental degradation and its effects on the living conditions and health for people in the region has been known for decades. In spite of several initiatives designed to reverse the trend, however, very little improvement has been achieved and the impoverished people in the region continue to suffer adverse health effects.

Recently, there have been a number of national, regional and international efforts to reduce the effects of this environmental catastrophe. Regional cooperation among the surrounding republics has developed, and international actors like the World Bank and the Global Environment Facility (GEF) are sponsoring efforts such as the Aral Sea Basin Program. Research foundations and aid agencies from different countries are also contributing. At the same time small-scale projects supporting the effort by poor people to improve the health and social situation have been initiated by national and international organizations and donors.

A concern for the health and social situation of the people in the region inspired several such-concerned organizations to host a conference in Stockholm in April 1998, the "Conference on the Aral Sea – Women, Children, Health and Environment". The Swedish UNIFEM Committee, the Swedish Save the Children and the Swedish Academy of Sciences convened the conference and continued to be active by creating contacts between scientists and with people in the region, examining the impacts on children and facilitating the establishment of projects related to human living conditions.

The seminar reported here, "Water Security - Opportunity for Development and Co-operation in the Aral Sea Basin", is the next Swedish step. Its aim was to present ongoing framework programs and research work working to reach water security and to provide a forum for discussion of future-looking methodologies. The report contains an extensive overview of the Aral Sea's problems as well as some of the ongoing programs and activities aimed at minimizing the effects on land, ecosystems and human health and living conditions.

It was a great pleasure for the Stockholm International Water Institute (SIWI) to convene this seminar jointly with the Swedish Royal Academy of Sciences and the Swedish UNIFEM

Committee, and we hope that this seminar was the start of a long-term co-operation among the three organizations.

The basic idea for the work at Stockholm International Water Institute is to serve as a link between practice, science, policymaking and decision-making in the search for effective, long-term water resources management. The approach - across disciplines, professions and societal sectors – integrates natural sciences and engineering with social sciences, and scientific understanding with policy responses and citizen involvement. This approach makes it relevant for SIWI to be involved in the search for solutions to the Aral Sea's problems.

SIWI thanks the speakers and the participants in the seminar, especially those from the Aral Sea region, and the co-operating organizations.

Dr. Gunilla Björklund was actively involved in the planning of the Seminar and has also carried out the editing of the report in co-operation with SIWI staff. SIWI thanks Dr. Björklund for her great contributions to both the Seminar and the report.

Ulf Ehlin

WATER SECURITY - OPPORTUNITY FOR DEVELOPMENT AND CO-OPERATION IN THE ARAL SEA AREA – INTRODUCTORY SUMMARY

by Gunilla Björklund

The Aral Sea at the beginning of this century was the forth greatest inland water body on land with an area of 68 320 km^2, including 2 230 km^2 of islands, a volume of about 1 066 km^3, and a depth in most parts less than 30 m. Between 1960 and 1990 the sea area decreased to 37 000 km^2, the volume decreased to 340 km^3 and the sea level dropped from 53.3 m a s l to 39 m a s l. The total drainage basin of the Sea is 1.9 million km^2, and situated in South Kazakstan, Turkmenistan, Uzbekistan, North Afghanistan, Tajikistan, to a small extent in Iran, and in the Kyrgyz Republic. Due to the arid climate, very little of the water reaching the Sea, only 20% is originating from the countries downstream of Tajikistan and the Kyrgyz republic.

By 1989 the Aral Sea has receded into two parts, the northern Small Aral, where the Syr Darya is terminating, and the southern Large Aral, where the Amu Darya is terminating.

After the Russian revolution Central Asia was regarded as the ideal part of the country for cotton production (*Klötzli 1994*), and the cotton growth expanded after World War II. This resulted in that the production demand for water grew beyond any sustainable limits. In 1989 4.3 million hectares in the Amu Darya Basin and 3.3 million hectares in the Syr Darya basin were irrigated (*Raskin et. al 1992*). Almost 30% of irrigated land is severely salinised and the crop yields are reduced by 20 to 50%. And the salt-concentration of the lake almost tripled between 1960 and 1990 (*Kotlyakov 1991*). The increasingly less productive condition of the soils resulted in an overuse of fertilisers, herbicides and pesticides. All this has made the water in the rivers as well as in the shrinking Aral Sea unfit for any type of human consumption and the soils have become polluted and unproductive. The consequences are detrimentious to human as well as environmental health. Several frequently occurring serious diseases are presumably linked to the bad water - and soil - quality.

In April 1998 the Swedish UNIFEM (United Nations Development Fund for Women), the Royal Swedish Academy of Sciences, and the Swedish Save the Children arranged a conference on the Aral Sea, focussing on contributions to alleviate the consequences of this environmental catastrophe. It concentrated on the relation between health and the environment and, in particular, the health of women and children, as well as equal participation of men and women in the societal development (*Lindahl-Kiessling 1999*).

At the SIWI seminar "Water Security - Opportunities for Development and Cooperation in the Aral Sea Area", co-convened by the Royal Swedish Academy of Sciences and the Swedish UNIFEM presentations were made by representatives for UNESCO, SOAS-UK and SIWI and, thanks to generous contributions from the Swedish Council for Planning and Coordination of Research, FRN, The Bank of Sweden Tercentenary Foundation, Royal Swedish Academy of Sciences and the Swedish UNIFEM, by several representatives from the region. These presentations are published in this volume.

1. Ongoing activities

The Aral Sea Basin Program, ASBP, was a result of interstate agreements of 1992 and 1993 and was designed to be administrated by the new regional institutions. The main actors that have an influence on the co-ordination of international assistance towards this programme are UNDP and the World Bank together with UNEP. An other important actor has been UNESCO, who in co-operation with the Scientific Advisory Board for the Aral Sea Basin prepared the regional Water Related Vision for the Aral Sea Basin, which was presented at the Second World Water Forum in The Hague, the Netherlands, March 2000 (*Se the paper by Verhoog, in this volume*). This Vision presented goals to be reached by 2025 within the area of health, nutrition, environment, wealth, agriculture and drinking water supply. The Vision concluded:

- that the Aral Sea Basin has everything necessary for a bright future, including sufficient water but that regional co-operation is needed to reach the socio-economic development objectives established. However, the present knowledge on water and land and related socio-economic factors in the region is not sufficient, not reliable, not consistent and availability not sufficiently well organised for planning and decision making.
- that the largest environmental problem in the basin is soil salinity,
- that a higher agriculture productivity/ m^3 of water is needed to avoid water shortage.
- that non-agricultural water use activities, such as industry and tourism, are potential water saving activities as they allow for food imports,
- that the restoration of the Aral Sea to its before 1960 state is not feasible any more,
- that water saving measures are initially expensive but long term economical.

The ASBP objectives as formulated in 1998 are: to stabilise the environment; to rehabilitate the disaster zone around the Aral Sea; to improve the management of international waters; and to build the capacity of the regional institutions. Several international projects and programmes are ongoing within the Basin, the most important being the one by the World Bank/Global Environment Facility, GEF, closely linked to the ASBP. The main components of the GEF Programme are Water and salt management; Public awareness; Dam and reservoir management; Transboundary Monitoring; and Wetland restoration. There are also large projects within the area of Water supply and sanitation, Hydro-meteorological monitoring, Water and energy agreements, Ecological research in the delta areas etc. Several small-scale projects, mostly within the area related to assist the human population, and mainly run by different NGOs do also exist.

The vision both of the ongoing activities and of the future is somewhat different for different actors, the international actors, the national high-level actors, part of the national science community and the people living in the country. This could partly be seen from the other presentations.

Historically the Aral Sea has varied a lot in size, depending on the climate, since its "birth" approximately ten thousands years ago, when it was very small and only the Syr Darya was discharging into it. Amu Darya at that time discharged into the Caspian Sea (*See the paper by Aladin and Plotnikov in this volume*). Amu Darya, four to five thousand years ago changed its course into the Aral Sea, which at that time was four to five times larger than in the middle of the 20th century. Thus, the Aral Sea historically has gone through several ecological crises, the last one, though, inevitably a man-made crisis. *Aladin*, however, did not recognise the desiccation, resulting from the decreasing lake as the main problem. This would from the environmental perspective be possible to adjust to by introducing salt adaptive species such as *Artemisia salina* as key organisms. *Aladin* also saw the subdivision into a small Northern Lake and a larger Southern Lake as inevitable in order to save as much as possible of flora and fauna in the Northern Lake. In keeping a dam between the two lakes to prevent any leakages between the two water bodies it would be possible to reduce the salt content in the Northern Sea from 2.9 to 1.8 %. He saw the Southern Lake as being increasingly salinised reaching up towards 6.5%. Thus the environmental health, according to *Aladin*, could be reclaimed for the Northern Lake but not for the Southern Lake. The main problem, however, is according to *Aladin* the chemical pollution of the area.

The health of the population in the Amu Darya River Basin is very much depending on the water quality, and the decreasing surface water quality is mainly resulting from agriculture water use according to *Khasankhanova-Abdullaev (in this volume).* There is a clear linkage between domestic water quality and infant mortality. There is also a linkage to infectious diseases. The study undertaken by *Khasankhanova and Abdullaev* did show the need to apply adequate technical, political and economic actions to improve human health, particularly for the Karakalpakstan area. Cooperative projects at the local level, possibly between national organisations or/and NGOs in the Aral Sea area should according to the study be encouraged.

The need to apply water use efficiency methods within irrigated agriculture has inspired the Centre "Ecology of Water Management" to develop applied research programmes (*See the paper by Razakov in this volume).* The Centre is developing different types of water saving irrigation technologies, improving irrigation and drinking water quality, treatment of huge volumes of drainage water and reusing water for irrigation of salt tolerant fodder crops in the desert zone. The Centre is developing methods for processing irrigation water by application of electro-activitation, magnetic and laser beam methods in irrigation of cotton etc. Experiments have also been undertaken to use hydrophonic irrigation for getting two consecutive harvests of vegetables in non-fertile soils, drip irrigation by using less saline water for growing in orchards and vineyards, etc. The different methods investigated within the Centre would, when applied, be very useful tools in decreasing the water use within irrigated agriculture production.

2. Methods for Ensuring Water Security

Application of methods developed within what is described above could increase environmental water security as well as human water security and might also contribute towards increased food security. To reach water security from a more encompassing development perspective, cooperation in a much broader framework is necessary.

Along these lines a Regional strategy on land and water resources management in the Aral Sea basin is presented and analysed by *Dukhovny and Sokolov (in this volume).* Beside a legal framework, a vision and strategy at the regional level are crucial to identify and resolve conflicts over water resources. Elements of agreements for cooperation as drafted by the International Fund for the Aral Sea Saving, IFAS and the Interstate Commission for Water Co-ordination in the Aral Sea Basin, ICWC, should include agreements on the status of the organisations within the IFAS (such as the two technical river basin authorities, BWOs) and on institutional strengthening of the ICWC organisations; on the formulation of regional, national and basin-based information systems and the exchange of information; on "Water use from transboundary waters"; on "Planning of joint interventions on the transboundary rivers"; and on "Water quality and the ecological sustainability of the rivers". In developing the strategy some tools were developed such as the Water Resources Management Information System, WARMIS, including historic and recent data within databases covering Administration, land, water, water quality, climate, industry, economy and hydropower. Different kinds of models are developed based on those databases, among those are a model on water and salt balance and a system for agriculture water use, Water Use and Farm Management System, WUFMAS.

Analysis of different models including national and regional planning modelling and application of scenarios of water resources development is made within the framework of the strategic work. It is concluded that future water development related improvements might be the fact in the region if a possible action programme be based on the following:

- Ancient water use was based on the valid use of water for the benefit of the whole society.
- Historically water use was based on water savings and the prevention of pollution
- Water use in the region could be improved with orientation to the best methods of and best water use and management under similar conditions abroad (Israel, Jordan, Western USA, Spain etc.) (*Dukhovny and Sokolov).*

The impact the human induced changes of the hydrological cycle had on the ecological system of the Aral Sea within the Soviet era, is by *Allan (in his paper in this volume)* defined as yesterdays political ecology. In the new political ecology of the Aral Sea Basin visions are discussed, in a situation where yesterday's hydraulic mission has been modified and yesterday's politics have been lost. The work undertaken within the exercise of the Regional Water Vision for the Aral Sea area and the accompanying Framework for Action include different analysis aiming at providing advice on five policy priorities; water for health, water for food, water for the environment, water for the creation of wealth, water for energy production to produce heat in the winter and water for peace in Central Asia. The study demonstrates the need to bring about improvement in irrigation management and that agriculture policy reform is a must to achieve sustainability. The current farming practices are associated with large resource costs, and at some time the cost of irrigation will outweigh the benefits of the current production. Farmers should be encouraged to grow crops suited to the prevailing agro-climate and resources conditions. According to *Allan* the main issue for the future of the Aral Sea area may not be the facing of increasing water deficits, which is an increasing water in-security, but a low social adaptive capacity. To coop with the situation it would be even more important for the countries of the region to increase their social adaptive capacity.

A successful model to ensure Water Security, presented by *Ehlin (in his paper in this volume)*, is the "Baltic Sea model" for cooperation. In this a Baltic Sea Joint Comprehensive Environmental Action Programme, JPC, was approved at ministerial level. The Programme consists of six major components: Policies; Law and regulations; Institutional strengthening and human resources development; Investment activities; Management programmes for coastal lagoons and wetlands; Applied research; and Public awareness and environmental education. Implementation of the various components is co-operative work where NGOs etc. are involved as equal partners, including as leaders for one of the components. Within the management co-operation, model networks for cooperation have been developed, where different kinds of experts are involved, both business community and NGOs, as active partners. This network cooperation, with participants on both sides of the Baltic Sea has resulted in knowledge and experience exchange and thus increased implementation capabilities. The issue was raised whether the Aral Sea region could benefit from experience exchange with the Baltic region.

3. Concluding discussion

A concluding panel discussion, with representatives for the Academy of Sciences in Karakalpakstan, the Swedish Save the Children, SOAS-UK, SIC-ICWC and Sida, was moderated by Ambassador Bo Kjellén. The main recommendations from that discussion, in which also representatives from the floor participated, were:

1. that the Aral Sea issues should remain on the Stockholm Water Symposium agenda;
2. that to reach efficient and successful cooperation between the partners, governments as well as NGOs, information exchange on existing programmes and projects should be stimulated;
3. that a participatory approach needs to be applied in the process to revert the negative trend in the Aral Sea area, such an approach would also encourage democratisation; and
4. that development of cooperative efforts in line with the "Baltic Sea model" would be very useful and should be encouraged.

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WATER RELATED INTERNATIONAL COOPERATION IN THE ARAL SEA BASIN UP TO TODAY

by Frits Verhoog

Introduction

The shrinking of the Aral Sea has been presented to the outside world as a disaster of global significance caused by irresponsible Soviet politicians and planners in the nineteen fifties and sixties, thus warranting massive international assistance.

The Aral Sea Basin extends over the territories of 7 countries, namely the five Central Asian Countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan) and Afghanistan and Iran. Iran's part of the basin is very small. However Afghanistan's portion is substantial and its contribution to the average annual flow of the Amu Darya is about 15%.

The problem with the Aral Sea can be described simply as:
Due to the increase in irrigation within the basins of the contributing rivers since the nineteen fifties, the Aral Sea begun to shrink. The two main consequences of this increase in upstream irrigation were, an increase in agricultural production and a disastrous lack of fresh water downstream in the deltas and the Aral Sea itself. The latter leading to deplorable social and ecological conditions for the people that were forced or chose to remain in the area near the Aral Sea.

The countries in the Central Asian region, which are Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, became independent in the early nineties. Except for Kazakhstan, about 90% of the territories of the four other countries are within the basins of the two main rivers, the Amu Darya and the Syr Darya. In Soviet times there was one system of distribution of water to the different regions and other distribution systems for energy, food etc. After independence, the Heads of State decided that the water distribution and allocation system between their countries would remain in force. They did not make such agreements regarding other resources such as oil and gas. Not surprisingly, some friction is coming to the surface quite frequently due to different interests and possibilities. People in such cases tend to try to prove that there is not enough water in their country.

Directly after independence in 1991, the governments of the different new republics asked the different bodies and organizations of the UN system for assistance to safe the Aral Sea environment, to help the stricken population in the Aral Sea area, and to help with the water management of the basin.

The UNDP and the World Bank coordinated the preparation of the Aral Sea Basin Program that was presented to the world in January 1994 during the meeting of Heads of State in Nukus. The objectives are: stabilizing the environment, rehabilitate the disaster zone, improve management of international waters and build the capacity of the (new) regional institutions.

In 1994 at the launching of the Aral Sea Basin Plan, there was a great willingness of the rich countries to assist the Central Asian States in solving the Aral Sea "problems".

International cooperation overview

The present and past co-operation activities

The international cooperation activities are organized under the following headings: improvement of the knowledge base, stabilizing the environment of the Aral Sea zone, improvement of the socio-economic conditions the Aral Sea zone, improvement of water management and agriculture in the Basin, and strengthening of the regional institutions and capacity building. A list of projects and donor countries and institutions can be found in the appendix.

World Bank and EU programmes for improvement of water management

The World Bank focuses on: operational water resources management and control in the Amu Darya and Syr Darya River basins; formulation of a strategy leading to new legislation on water resources use and protection; introduction of unified systems of water measurement and environmental monitoring; and installation of automated river regulation systems. World Bank intends to revive in Uzbekistan the building of the Right Bank Collector Drain that is meant to allow drainage water to be brought to the Aral Sea. An environmental assessment of this project was made. Several other World Bank financed projects are linked to this (See appendix).

The European Community implemented a project called WARMAP (Water Resources Management and Agricultural Production.) that covers many of the aspects of water management and irrigation, including enterprise development, food production and marketing and energy. This project fits well in the frame of the overall plan.

The first phase of the project was accomplished from 1995 to 1998.

The second phase started in 1998 and is executed by Netherlands DHV Consultants in cooperation with Landel mills (UK) and the Office de l'Eau (France). The aims are:
- to strengthen national and regional planning in the area of land and water use
- to promote an economic approach to land and water management

Specific objectives are:
- to develop planning and management capacities of recipient staff
- to prepare water use, water planning and other legal interstate agreements
- to establish management information systems

The following outputs are agreed upon:

- normative and legal documents on water resources management at regional level
- a regional information system on water resources management (WARMIS)
- analyses of data from a water use and farm management survey (WUFMAS)
- technical assistance to IFAS for the execution of the GEF project

WUFMAS was executed, from 1996 to 1998 and it is intended to continue. Although not specifically stated in the above objectives and outputs, the project description speaks also about using the results from WUFMAS for the WARMIS decision support models and for helping the interpretation of satellite imagery produced by the EU funded ISEAM (Information System for Environment and Agricultural Monitoring) project.

WARMIS is a system for the collection, storage, processing and analysis of data about the past and present situation of land and water resources. WARMIS comprises:

- a Data Base Management System containing tabular data
- a GIS containing spatial data and spatial analysis tools
- three strategic analysis and/or decision support models
    (1)Planning Zone Module, containing a water and salt balance model and an economic optimization model
    (2)River Reach Module, water and salt balance model for each river reach, a river basin model to simulate water availability and demand and an annual flow model for the Amu Darya river (A similar model will be developed for the Syr Darya with the assistance of USAID EPIC)
    (3)Hydropower Module, including regional exchanges with other kinds of energy

The GEF project

<u>GEF Assistance to Regional Initiatives</u>

GEF assistance to the Aral Sea Basin Programme started in 1994 with two preparatory studies toward the design of a water resources management strategy, addressing both quantity and quality. These assembled data delineating the basin's water use and environmental problems, and identified the issues in regional water management, which would need to be addressed by a basin-wide water resources management strategy.

National programs carry out the remainder of the ASBP agenda: promoting water conservation, exploring salt management options, addressing human health needs, providing clean water to the disaster zone, rebuilding infrastructure, and attempting to remedy land degradation.

Referring to projects to restore the wetlands and the Northern Aral Sea, a related Netherlands- funded study concluded that outputs from those projects will be essential to answer two questions at the heart of strategic planning: (i) whether the detrimental ecological impacts of the shrunken Aral Sea can be mitigated with ecological countermeasures and if so how much water for these is required; (ii) whether the ecological functions of the Aral Sea can be restored in selected parts of the Aral Sea zone.

For regional water management, the study identified eight major issues or themes:

- transition to a new political, economic and social setting;
- information needs;
- transboundary water management;
- water conservation;
- water quality control;
- salinity management;
- environmental impacts; and
- implementation capability.

Of these eight, six have been carried out. As a result of the ASBP Review, water conservation (improving water efficiency) is now considered a national issue rather than a regional one. On transboundary water management, a less comprehensive approach than that suggested in the preparation study is considered feasible for the near term.

For water quality assessment and management, the study dealt primarily with pollution issues other than salinity and found that those are not generally of great significance at the regional scale.

Studies on legal issues, agricultural economics and water pricing were carried out under the EU-TACIS Project WARMAP, work on water pricing under USAID funding, and work on salt management carried under funding by the Netherlands, have substantially increased understanding of regional water management issues.

Project Objectives

In accordance with the resolution of the Heads of State analytical work by the Bank on the requirements of sustainable development in the basin, and the findings of preparation work, the objective of the Project is:

> to address the root causes of the overuse and pollution of international waters in the Aral Sea basin by
>
> > assisting the basin states in formalizing, then
> > implementing the first stage of a regional Strategic Action Program.

The Project's specific objectives are:

> (i) to develop agreements and strategies acceptable to the five basin states for managing transboundary waters; and
> (ii) to protect biodiversity in the wetlands near the Aral Sea, using drainage water for ecosystem restoration.

The project objectives are relatively modest in their scope, compared to the overall ASBP objectives, recognizing that many years of effort will be needed to address fully the issues identified. The present project is expected to lay the basis for this future work by setting priorities, comparing alternatives and differentiating between transboundary and national issues.

Outputs

Outputs of the Project will include:

(i) a preliminary Transboundary Diagnostic Analysis and SAP documents agreed by all participants;

(ii) an agreement on water sharing acceptable to the five states supporting both environmental services and productive uses of water;

(iii) a strategy for salt management in the basin;

(iv) an agreement on joint management and operation of reservoirs, an action plan for restoration of any hazardous structures, and a strategy on reservoir management;

(v) a working network of water monitoring sites covering strategically critical sites and a regional information system incorporating the monitoring data and accessible to all regional users;

(vi) an ongoing set of reports, articles, or other publications designed to inform the general public of project objectives, and also a set of completed actions ensuring stakeholder input to the Project;

(vii) restoration of a potential Ramsar site, and answers to the questions of whether the detrimental ecological impacts of the Aral Sea's desiccation can be addressed by wetland restoration measures, and if so, the quantity, quality and timing of release that would be required.

Project Description

The Project is planned to take place over a 3.5 year period. It is executed by IFAS.
Other donors are being asked to fund other elements of the overall work plan needed to complete the comprehensive approach, especially those at the national level. Of great importance in this connection are pilot projects in water and salt management, upper watershed management, and wetlands restoration. A program of about 20 sites for water and salt management has been identified, and detailed planning is proceeding for ten of these with EU-TACIS funding. Four sites for upper watershed management have been identified and preliminary planning has been done. When available, data from pilot projects will be of considerable benefit in injecting realism into regional water management, as well as providing the basis for larger investment projects at the national level.

The total cost of Components 1 to 6 would be US$42.25 million, of which the GEF contribution would be US$9 million. Most of the remaining cost is for pilot projects to find the most cost- effective means to reach strategic objectives. The total cost of the Wetlands component would be US$29.25 million, of which the GEF contribution would be US$3 million. The balance would support adjacent wetlands, such as Lake Mezdureche, balancing biodiversity and human needs goals.

Formalizing the Strategic Action Plan

This activity would make use of the work, which has been done to date to produce a preliminary Transboundary Diagnostic Analysis (TDA) describing what is now known about the requirements of environmentally sustainable water use in the basin, in particular, the quantity, quality and timing of water needed for the environment. It is currently believed that the principal threats to human health and the environment posed by the degradation of transboundary waters arise directly or indirectly from salt pollution and not significantly from other transboundary contaminants

Actions under the Strategic action Plan (SAP) would include policy development, institutional strengthening and investment planning. The SAP would distinguish between baseline activities in water resources management and activities under the alternative scenario which included further GEF-funded activities and activities undertaken with funds leveraged by GEF assistance. The SAP would reaffirm the Republics' view of the importance of water charges and the respective action plans to institute such charges, first to meet operating costs and then investment costs. The rationale should also discuss public participation outcomes, which are needed to establish, among other things, the expectations of the people of the region with respect to the future of the Aral Sea itself. Following agreement by the SDC to the SAP, commitment of other key actors to the SAP would be sought. This would serve as a basis for the implementation of the Main Phase. The Initial Phase is expected to take six months or less.

Interstate Water Sharing Agreements

This component is designed to underpin national conservation efforts and needed national investments in the water sector. The principal aim of this component would be to codify existing water shares between states, including shares for the deltas, develop mechanisms for selling water between the states and to consumers, and assess water requirements needed to sustain certain identified environmental values. The output of this component would be a five- state water sharing agreement with the force of international law, covering dry, normal and wet years, specifying allocations for the five states and the deltas supporting both environmental services and productive useses of water. This would be linked to a proposed Sustainable Development Convention, including a mechanism for settlement of disputes between states, being drafted with support from UNDP's Capacity 21 program.

Consideration was given to a more ambitious objective of revising water sharing agreements. However, it is not clear that sufficient political consensus exists to make this feasible. In addition, it has become clear that decisions on water quantity management will strongly guide the basin strategy for control the increasing salinization of rivers and irrigated lands. Therefore, priority has to be given to the development of a salt management strategy for the Amu Darya and Syr Darya river basins before a revision of the current water agreements can be considered.

Salt Management Strategy including Associated Water Management Issues

Environmental values to be addressed via emphasis on salt management include water quality, soil quality, and reversal of deteriorating trends linked to the salinization problem. This component would aim to develop a cost-effective salt management strategy for the Amu Darya and Syr Darya river basins, in a form that could later provide the basis for provisions for interstate limits on salinity in the interstate water sharing agreement.

Associated issues of water management such as irrigation methods and efficiency, groundwater management, and reservoir operations, would also be addressed. The salt management strategy would set in place a framework which will enable a collaborative effort to directly tackle the urgent and increasing problems of salinization of river water and basin soils, and would provide each state with a clear picture of its opportunities and constraints in developing national plans toward their sustainable management objectives. Within this framework, states would be able to develop integrated catchments or land and water management policies and projects which may include on-farm irrigation and drainage, drainage disposal, land retirement, use of saline water in agro/forestry systems, water pricing, and other measures to ensure sustainable use of the basin's resources.

The strategy would address institutional arrangements for international trades in water quantity and salinity allotments, addressing the issue of legislative and policy changes, which would be required for the operation of such a regional market.

Major activities include:

- (i) assessment of movements of brackish and saline groundwater in each basin;
- (ii) development of a river basin model for each basin;
- (iii) establishment of operational salinity standards;
- (iv) development of a conceptual framework for salinity management on a river basin level comprising the potential use of market instruments, so that it is clear where each option to control salinity fits in terms of the overall water and salt management in the river basin;
- (v) development of a cost-effective strategic action program in a form that could form the basis for an interstate agreement for each basin;
- (vi) a feasibility study for the potential use of international markets in water and salinity allotments, considering also saleable credits in return for removal of land from production.

Reservoir Management

The objectives of this component are to correct safety deficiencies in regional water management infrastructure and to design and implement reservoir management programs to support regional water resource management. The outputs of this component would be agreements on operating rules and cost sharing of regional reservoirs, focusing on dams and especially on power/irrigation tradeoffs . Additional work includes dam safety reviews at all sites and exploration of cost-effective means of reducing sedimentation .

Decision Support System

The objective of this component is to expand and upgrade regional databases to support decision-making under the agreements supported by Subcomponents 2, 3, and.4. To this end, monitoring of transboundary water quantity and quality would be improved by rehabilitation or reconstruction of about 30 monitoring sites, in particular locations where rivers cross national boundaries, outlets of major drains, and other strategically critical sites. The regional information system initiated under the EU-TACIS program would be further developed, and access ensured to all users. Mathematical models would be developed on an ad hoc basis under sub-components 2, 3 and 4 at the direction of the relevant decision-makers.

A program of training, study tours and workshops would allow professionals from the regional and national organizations to benefit from world-wide experience in water, salt and reservoir management and facilitate the harmonization of national efforts, for example in improving water use efficiency, establishing water charges or setting national water quality standards.

Public Awareness and Participation

The objectives of this component would be (i) to expand public education on the nature and extent of problems, and (ii) to engage participation by principal stakeholder groups in the development of the water resources framework and in decision-making

Wetlands Restoration

It is believed that some former functions of the Aral Sea and its wetlands, including biodiversity, provision of environmental goods and services to the riparians, and buffering against desertification, could be restored on a smaller scale by creating or expanding wetlands. The Government of Uzbekistan has created several lakes already, which are replacing part of the fish catch of the former Aral Sea. A further wetlands restoration program has been prepared with the assistance of the Government of the Netherlands, principally directed to the restoration of the environmental functions of the wetlands most needed by people living near the Sea. This activity, a pilot project, would take on the restoration of one particular wetland, Lake Sudoche, which is important to biodiversity, and restore it through the reuse of drainage water.

Lake Sudoche is a wetland of international importance for biodiversity, one of the last wetlands remaining from the Amu Darya delta's former system (see Attachments to Annex 6). It is especially important to birds, lying as it does in a vast desert in one of the most important palæarctic flyways in Western Asia. The delta is also important to mammals. And finally, the wetlands are believed to harbor remnant populations of almost-extinct fish species.

The aim is to stabilize Lake Sudoche by rehabilitating existing canals and constructing a pumping station, water regulators, and a small barrage, to facilitate a controlled supply of drainage water to the Lake. Activities under this component would also establish an institutional structure to manage the lake and adjacent floodplain. It is hoped that by these means the project will improve Lake Sudoche's ecological condition to the extent that it can become the first Ramsar site in Central Asia.

An important aspect of this project is its demonstration value. One limitation of the works to restore freshwater wetlands, which have been undertaken so far, is that they have depended on freshwater sources. But these have wide annual fluctuations. To overcome that limitation, the works at Lake Sudoche would test wetland restoration by reuse of drainage water. The annual volume of drainage water does not vary much, and it is a by-product of agriculture for which there are few other uses. Thus these activities will demonstrate a means of wetlands restoration that will be applicable to further projects in the Aral Sea Basin and also around the world.

Activities under this component are closely linked to improvements in regional cooperation that will take place under the other components. Improvements in regional cooperation will ensure rights to the water needed for restoration to the deltas, assuring the sustainability of investments. Activities under Component 7 will in turn provide experience on reuse of drainage water, a critical planning issue, thus providing important practical support to Component.3. Finally, Component 7 will address directly the desiccation of the Aral Sea and its deltas, the original focus of international concern.

UNESCO activities

The UNESCO/BMBF project « "Ecological Research and Monitoring in the Syr-Dar’ya and Amu-Dar’ya Deltas at the Aral Sea as a Basis for Restoration "

In 1992, a joint project run by the German Federal Ministry for Education, Science, Research and Technology (BMBF) and UNESCO was launched entitled: « "*Ecological Research and Monitoring in the Syr-Dar’ya and Amu-Dar’ya Deltas at the Aral Sea as a Basis for Restoration* ». The project mobilized over 130 scientists from Russia, Uzbekistan, Kazakhstan and Turkmenistan. UNESCO published the results of the first phase 1992-96 in 1998 a compilation of research result papers in book form. It can be ordered under the title « UNESCO Aral Sea Project. 1992-1996 Final Scientific Reports ».

In 1991, the USSR disintegrated and the Central Asian States became independent. The economic situation became very difficult for everybody, but in particular for scientists in areas not related directly to economic production, thus in areas as ecology. Within a German programme for assistance to scientists in the former Soviet Union a project was launched for the mitigation of the situation in the river delta areas of the Syr Darya and Amu Darya. About 800 000 US $ were set aside to help scientists to continue their research in the region and to maintain links between them.

The project programme covered the assessment of terrestrial and aquatic ecosystems in a region badly affected by anthropogenic activities. Twenty-two sub-projects from Kazakhstan, Russia, Turkmenistan and Uzbekistan were accepted. Extensive study programmes ranging from soil and phyto-sociological questions to sedimentological, hydrobiological, ecotoxilogical and hydrochemical investigations, including agrochemical and environmental aspects, covered a variety of subjects.

With the support of the respective Governments two research stations were established, one in Kazalinsk in the Syr Darya delta and another in Muinak in the Amu Darya Delta in the autonomous republic of Karakalpakstan in Uzbekistan.

The project continued substantially to the continuity of the Aral Sea research policy; the scientists from the region could take up contact again between them and continue to work together with their Russian colleagues. In addition new working relations were established with German scientists.

The work of the scientists continued through a second phase of the project, which ended in 1999. It may be that the cooperation will continue in a different form.

The Scientific Advisory Board for the Aral Sea basin (SABAS)

After consulting the Governments and on advice of a meeting of scientists of Central Asia held in January 1998 in Almaty, UNESCO established a scientific advisory body to provide advice on scientific matters concerning the water related environment of the Aral Sea Basin to the UNESCO Director General and through him to the governments of the Basin and the international community.

SABAS met several times in 1999 and 2000 and prepared the Aral Sea Basin Vision with the secretariat of UNESCO.

Evaluating the present situation as regards cooperation for development

All kinds of preparatory activities have been carried out. Foreign consultancy bureaus have made pre-investment studies. Famous universities and research institutions have made reports. The people in the disaster stricken areas near the Aral Sea are assisted, although not enough yet. Still one has the feeling that something is missing and that not sufficient is really done to change the situation.

One of the reasons why there is a certain malaise is the general (wrong) idea that the Aral Sea Basin is a disaster area. This idea may attract humanitarian assistance, but it may very well be detrimental to investments for long-term improvements. This is even more strengthened by the people in charge of humanitarian assistance projects.

There is also uncertainty of knowing how the societies in Central Asia function at present and how they will develop in the future. This leads inevitably, as well with the people of the region as those from abroad, to a withdrawal into looking only at technical interests and the interests of the unit (or village, town, community) for which one is working, if not private interests. This is strengthened by the general, historical grown in these countries, resistance to think in terms of public interest or even to wonder why something is done at all, and to the widespread practice of withholding and controlling information.

These difficulties mentioned above can be somewhat overcome by describing always clearly why one is planning or doing something, and that down to the basic needs requirements. Thus a project, which has as objective to "improve water management" is improperly formulated.

When one formulates objectives in a proper way, the purpose of a project becomes clear for everyone and one can discuss what is the best way to reach it. The Aral Sea Basin Program for example has objectives like: to prepare a general strategy of water distribution, improve monitoring, to improve management, to build the capacity, to rehabilitate, etc. All rather vague objectives nobody can disagree with, but in fact without an object you can discuss.

One works and does things in order to relief present needs and to build a desirable future. The objective of a project or strategy should thus be clearly related to that desirable future and the objectives need to be as basic (for humans) as possible to avoid any deviation of them.

The Aral Sea Basin Vision tries to bring the above message home, and this may be its most important contribution.

The Water Related Vision for the Aral Sea Basin, for the year 2025

During the 29th General Conference of UNESCO in October 1997 the Governments of the Central Asian States asked the UNESCO Secretariat to give advice on how to deal with the Aral Sea crisis. This advice was to be independent from the normal decision making structures in the different countries yet participatory.

The essential approach of UNESCO had to consist in encouraging an optimistic, but also realistic vision of the future of the Aral Sea and its basin, which would counter the pessimistic attitudes, and lack of hope which are prevalent at this time.

In discussions with the government representatives it was decided that a Water Related Vision for the Aral Sea Basin, for the year 2025 would be developed. The regional vision, which has been prepared in 1999with the Scientific Advisory Board for the Aral Sea Basin (having scientists from all the five Central Asian States) was presented to the Second World Water Forum in The Hague, Netherlands. March 17th to 22nd, 2000

Water Related Long Term Vision for the Aral Sea Basin :

Goals in the Water Related Vision for the Aral Sea Basin	Targeted thresholds for 2025

Health	
Child Mortality Rate (Children below 5 years of age per 1000 births)	<30
Life expectancy at birth in years	>70
Nutrition	
Average availability of food calories per inhabitant per day	>3000
Environment	
Water available for the environment in cubic km per year	>20
Wealth	
Increase of income per person in purchasing power in urban areas as a factor since the year 2000	>2.5
Increase of income per person in purchasing power in rural areas as a factor since the year 2000	>3.5
Agriculture	
Average water use in cubic meters per ton of wheat	<1000
Average water use in cubic meters per ton of rice	<3400
Average water use in cubic meters per ton of cotton	<1900
% of irrigated area salinized (middle and highly salinized)	<10
Drinking Water supply	
Coverage of piped water supply in urban areas, in % of people	>99
Coverage of piped water supply in rural areas, in % of people	>60
People served good quality water by biological standards, urban, in %	>80
People served good quality water by biological standards, rural, in %	>60

The conclusions of the vision exercise are:

- The Aral Sea Basin has everything necessary for a bright future, including sufficient water.
- Water is very important in the Aral Sea Basin, but water availability in the basin as a whole is not a limiting factor for reaching the socio-economic development objectives: health, nutrition, security, environment, shelter and wealth of the individuals in the region. This is best done in the frame of regional co-operation.
- A higher productivity of agriculture measured in product per m^3 of water is essential to avoid water shortage.
- The largest environmental problem in the basin is soil salinity.
- Non-agricultural activities using water, such as industry and tourism, are potential water saving activities as they allow food imports.
- The present knowledge and information on water and land and related socio-economic factors is not sufficient, not reliable, and not consistent

and availability not sufficiently well organized for planning and decision-making.

- The restoration of the Aral Sea to its before 1960 state is not a suitable objective anymore.
- Water saving measures are economically in the long term but initially cost money. The financing problem exists, but could be solved.

The basic message is that there is enough water in the basin as a whole for guaranteeing a good socio-economic development and a healthy environment in the next 25 years. Or in other words, it would be nice if there would be more water, but water scarcity is not a proper term for describing the situation and the available water quantities and their seasonal and annual distribution are not a valid excuse for not providing for the basic needs of the population or for serious conflicts between states.

Medecins Sans Frontieres criticised the Vision for not giving enough emphasis to the difficult situation the people around the Aral Sea are in at the moment and highlights the contradictions in the Vision report. IUCN objects that the vision of the environment is practically non-existing and does not take into account the value of ecosystem services. Both say that the vision lacks a detailed plan of action. We in UNESCO agree with the points both organizations make and would welcome them coming with a specific detailed vision on health, respectively nature.

APPENDIX

Improvement of the knowledge base is among others provided by the following research institutes:

Federal Institute of Technology in Zurich	The Centre for Security Studies and Conflict Research published in 1994 a report no 11 in the series ENCOP Occasional Papers: Stephan Kloetzli: The Water and Soil Crisis in Central Asia. - A Source for Future Conflicts?
San Diego State University	The Central Asian Research and Remediation Exchange uses digital imagery and GIS to begin to identify and assess numerous problems within the region, such as desertification change. They intend(ed?) to convey this information to private and governments groups trying and educating and helping CAR specialists.
The German Aerospace Research Centre	The German Aerospace Research Centre has a project since 1993 concerning the monitoring of the present state and dynamics of vegetation in the Aral Sea region and in particular in the Amu Darya and Syr Darya deltas. Satellite remote sensing was applied. They prepared a GIS of the Aral Sea basin covering socio-economy, water management, ecology, agriculture and desertification. NATO supported the establishment in 1996 of the Center of Geoinformation Studies in Nukus State University. The Center is equipped with computers and GIS peripheral devices.
UNEP	UNEP supported the International Seminar “State of the Environment of the Aral Sea Basin”, organized by IFAS and the Kyrgyz-Russian Slavic University in Bishkek in November 1997.
The University of Texas	The University of Texas made a study on Aral Sea Water Rights and has a multi-national water allocation project.
University of Bern in Switzerland	The remote sensing Research Group of the University of Bern in Switzerland did (is doing) snow cover monitoring in the Aral Sea Basin

The following programmes are working on stabilizing the environment of the Aral Sea Basin:

UNESCO/BMFT	The UNESCO/BMFT project « Ecological Research and Environmental Monitoring in the Delta Regions of the Aral Sea », was executed from 1992 to 1995. A second phase was implemented from 1996 until 1999.
World Bank and European Union	The World Bank program foresees projects related to the restoration of the ecosystems in the deltas and seabed; and assessment and enhancement of the upper watersheds. The European Community through TACIS implements the sub-project on integrated land and water management in the upper watersheds.
Finland	Finland has also financed studies related to Integrated Land and Water Management in Upper Watersheds (1995-1997).
Global Infrastructure Fund of Japan	The Global Infrastructure Fund of Japan has organized several technical group meetings to discuss measures for the rehabilitation of the Aral Sea. GIF established the Japan-USA-USSR "Central Asia Aral Sea Project "
World Bank and IWACO	IWACO conducted the first full scale Environmental Assessment in Uzbekistan, namely of the Uzbekistan Drainage Project. The Uzbekistan Drainage programme focuses on the middle and downstream parts of the Amu Darya river basin including the regions of Kashka Darya, Bukhara, Khorezm and Karakalpakstan.
World Bank and NEDECO	The study was undertaken to assess the functions of wetlands in the Amu Darya Delta and of the requirements and impacts of the creation of wetlands. The project objectives were: provide an overall strategy and preliminary design and implementation schedule and other necessary information for a pilot fresh and brackish water wetland. A study of the Lake Mezdureche is part of the Aral Sea Wetland Restoration Project (ASWRP). The Wetland will be implemented within the GEF project that started in 1998.

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The following are devoted towards improvement of the socio-economic conditions in the disaster Zone:

WHO	WHO and the national authorities study the reasons for the sharp decline in health of the local population since several years. At the Nukus conference a paper was presented entitled: « Background paper on the Health Dimension of the Aral Sea Crisis ». WHO works also the development of national environmental health action plans.
UNICEF	UNICEF made available 3 million $ in 1994 to improve the health of children in the area
UNDP	UNDP implemented a 12 months project KAZ/94/003 « The Aral Shore Rehabilitation and Capacity Building Program ». It educates and involves the local community in resolving sanitary, water and nutrition problems as well as to encourage various types of self-employment. There was also a project in Kazakhstan, called: Aral Sea region development and Humanitarian Assistance Program". Similar UNDP projects were executed in Uzbekistan. UNDP also had a project in Uzbekistan, called: Rural Water Supply and Health Education in the Aral Sea Region. UNDP/UNV executed the project: Rapid Assessment of food security, incomes and livelihood strategies in Karakalpakstan.
USA Peace Corps	The Peace Corps has, since 1993, programmes related to community development and English teaching at schools in many areas in Kazakhstan, including in the Aral Sea region.
US Aid	US Aid works on improving water supplies and health and sanitation practices.
The World Bank	The World Bank approved in 1997 a US$ 75 million loan to Uzbekistan in support of a Water Supply, Sanitation and Health Project to help to improve the health of the rural population of Karakalpakstan and Khorezm. The project includes also financing by the Kuwait Fund and Germany.
The German Red Cross	The German Red Cross has build in Takhtakupyr on the Amu Darya delta a reverse osmosis plant for a population of 12 000.
Medecins Sans Frontieres	"Doctors without Borders" works in particular in Karakalpakstan, Uzbekistan. They work on tuberculosis, health care workers training, epidemiological tools and water and sanitation.
Denmark	Denmark has a Fishery project in the Kazakh part of the Aral Sea.

Improvement of water management and agriculture in the Aral Sea Basin:

World Bank	The World Bank focuses on: operational water resources management and control in the Amu Darya and Syr Darya River basins; formulation of a strategy leading to new legislation on water resources use and protection; introduction of unified systems of water measurement and environmental monitoring; and installation of automated river regulation systems. World Bank intends to revive in Uzbekistan the building of the Right Bank Collector Drain that is meant to allow drainage water to be brought to the Aral Sea. An environmental assessment of this project was made.
European Union	The European Community implemented a project called WARMAP (Water Resources Management and Agricultural Production.) that covers many of the aspects of water management and irrigation, including enterprise development, food production and marketing and energy. This project fits well in the frame of the overall plan.
FAO	Although not all countries in the region are a Member of FAO, FAO has collected a large amount of information on agriculture in the basin and executed several studies related to water, irrigation and salinization.
US AID	US Aid works on regional water management, and in particular the policy issues. They assist in the preparation of agreements on water issues, including the management of the Toktugul reservoir in the Syr Darya.

Strengthening regional institutions and capacity building:

World Bank and UNDP	The World Bank and UNDP undertake activities related to the strengthening of the capacity of regional institutions for managing basin systems, especially IFAS (International Fund for the Aral Sea). In the field of education and training, the emphasis is on management and economy for the World Bank as well as for the European Community.
UNOPS	UNOPS executes the project "Aral Sea Basin Capacity Development Project" from 1995 onwards. The project organizes conferences, trains nationals in IFAS and in the ministries, trains with FAO on integrated pest and pesticide management, on environmental Impact Assessment, provides advanced English language training, collaborates with the International Training Network for Water Supply and Sanitation and helps strengthening local NGO communities.
Switzerland	Switzerland is taking the responsibility for the execution of the programme: Improvement of Hydrometeorological Services in the Aral Sea basin. The project relates to network planning, the construction of pilot stations, knowledge transfer on river discharge measurement methodologies, and the establishment of a discharge forecasting system for the Syr Darya.

Basic Statistics of the Amu Darya River Basin

Administrative divisions	Republic of Karakalpakstan and 6 provinces	
Population	11.4 million	
Rural	8.002 million (70%)	
Area	384.574 square kilometers	
Irrigated area	2 380 300 ha	
Ethnic groups (percent)	Uzbek (77); Russian (6); Tadjik (5); Kazak (4) Others (8)	
Religions	Islam (Sunny Muslims)	
Language	Uzbek (State language)	
Natural resources	Natural gas, oil, coal gold, copper, lead, tungsten, uranium	
Water resources	Total : 78.46 km^3/yr 95 % probability of occurrence: 46.9 km^3/yr 5 % probability of occurrence: 108.4 km^3/yr	
Water Use (1997)		
Total :	28986 Mln.m3	
Including: Irrigation (94.36%); *Domestic & Rural (4.34%); Industry (0.7%); Fishery(0.6%)*		
From:		
Surface	*(87.6%)*	
Ground water	*(6.5%)*	
Drainage re-use	*(5.9%)*	
GNP structure (percent) Services (42)	Agriculture (31); Industry (27); Manufacturing (9)	
Trade partners (percent)	**Exporting:** I	**Importing**:
	Russia (15)	Russia (16)
	United Kingdom (10)	South Korea (11)
	Switzerland (10)	Germany (8)
	South Korea (7)	United States (7)
	Belgium (4)	Turkey (6)
	Kazakhstan (4)	France (5)
	Tadjikistan (4)	Kazakhstan (5)

WATER AND ENVIRONMENT HEALTH - HISTORIC EVOLUTION OF THE ARAL SEA SYSTEM

by Nick Aladin

Introduction

As the Central Asian countries since historic times have experienced a serious water deficiency, water use was and is seen an important issue in all Central Asian cultures. Careful water treatment and a sustainable use of water is a prerequisite for the existence of human society and of wild animals and plants, e.g. for the total ecosystem health.
The main sources of freshwater in the countries of Central Asia are rivers, underground water and precipitation. The rivers Amu Darya and Syr Darya, and also their former tributaries Sarysu, Chu, Zeravshan, Tedjen and Murgab, are the main contributors. Today these tributaries are lost in sand and do not run into the Amu Darya and the Syr Darya, as they previously did. The water balance in Central Asia is strongly influenced by existing storage capacity such as natural lakes, existing in the region, and artificial reservoirs. The Aral Sea plays an especially important role. From the surface of this large lake, a huge amount of water evaporates and it is possible to talk with confidence about its important role as a climate-generator for the basin area. The modern Aral Sea is approximately 10 thousand years old and since then it, alongside with the Amu Darya and the Syr Darya, has had a determining influence on life of the people and nature in the region.

The Pre-Historic Aral Sea and its Recharging Rivers

Evolution of a terminal reservoir in arid and semiarid conditions depends on the development of the catchment basin and its feeding rivers. As a whole in arid zones the general supply of water by rain, ground and underground water is essentially less than the contribution by river drain (for example, Lake Chad with its two rivers and the Dead Sea with the one river running into them).

In the case of the Aral Sea the development of the river basins of the Amu Darya and the Syr Darya was determined by two main factors: on the one hand, local tectonic activities, and on the other, the fluctuation between pluvial and arid climatic phases, growth and melting of mountain glaciers. Rubanov (1991) specifies three regressions during the history of the Aral Sea: first in late Akchagyl (less than 2 million years ago), second — in early quaternary time (less than 1 million years ago), third — in late Holocene (about 1600 years ago). All salts dissolved in water of the modern Aral Sea have river origin. It appeared as a result of evaporation of river water, which the chemical structure of salt deposits (Blinov, 1956) testifies.

The Aral Sea Basin started to be developed 3 million years ago in the late Neocene period at the beginning Akchagyl. The development of the modern catchment area in Central Asia and Kazakhstan (Fig. 1) started after regression of the Paleocene Sea, which earlier covered this region. The development of the Aral Sea can be seen as resulting from the evolution of the rivers of the Amu Darya and the Syr Darya; however, we should not forget other (now non-existing) rivers which have played a role in evolution of the Aral Sea.

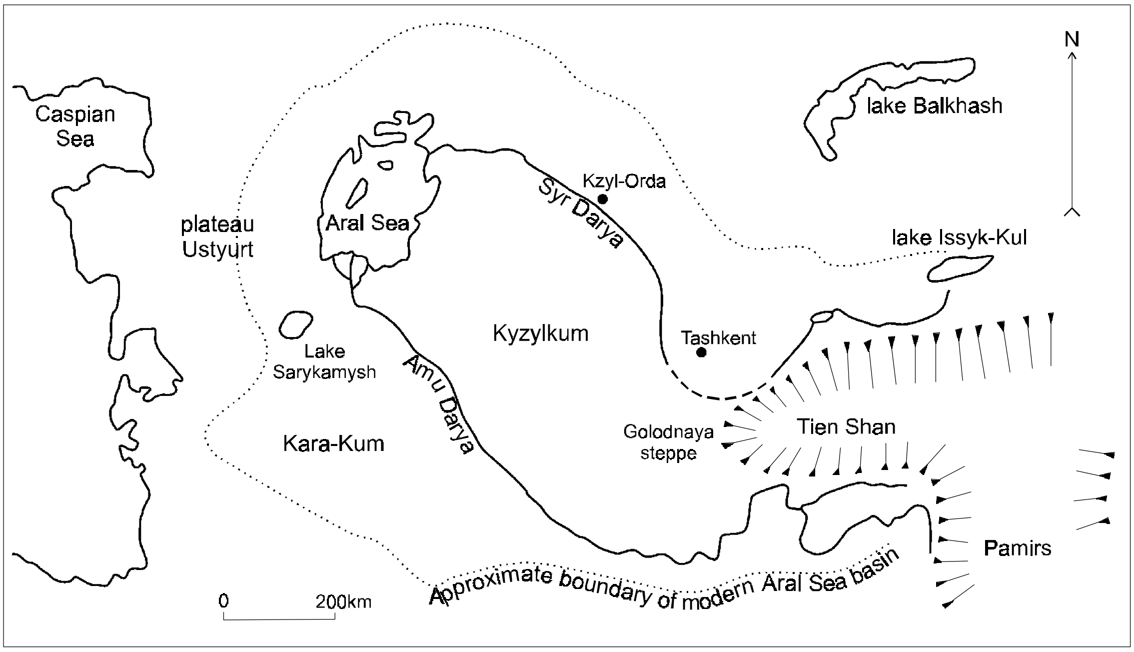

Fig. 1. Approximate outline of modern hydrographical system in Central Asia and Kazakhstan

The Amu Darya river development

The Ancient Amu Darya (together with the ancient right inflow Zeravshan) flowed into the Caspian Sea and deposited thick layers of sand and clay (Fig. 2). Up to the middle of the early Pleistocene period, the Amu Darya changed the direction of its current from the Zaunguz Kara-Kum to the side of the Lower Kara-Kum and further through the Balakhan and Donatin corridors to eventually reach the Caspian Sea. This change of direction by the Amu Darya is demonstrated by an accumulation of a powerful series of alluvial deposits with a thickness of more than 340 m. They have received the name "Kara-Kum strata" and consist of sand, clays and aleurites (siltstone).

Originally the main channel of the Amu Darya was running near the northern foothills of the Kopetdag. The Amu Darya began to migrate to the North, according to Gorelov (1985), keeping thus a western direction of the current. The northern, youngest channel of the ancient Amu Darya was located along the southwest slope of the Zaunguz Kara-Kum, reaching the valley of the Uzboy and, further, the Inter-Balkhan corridor. Up to the end of the middle Pleistocene period, the Amu Darya flowed through Lower Kara-Kum. At this time it had many inflows, the largest of them were left.

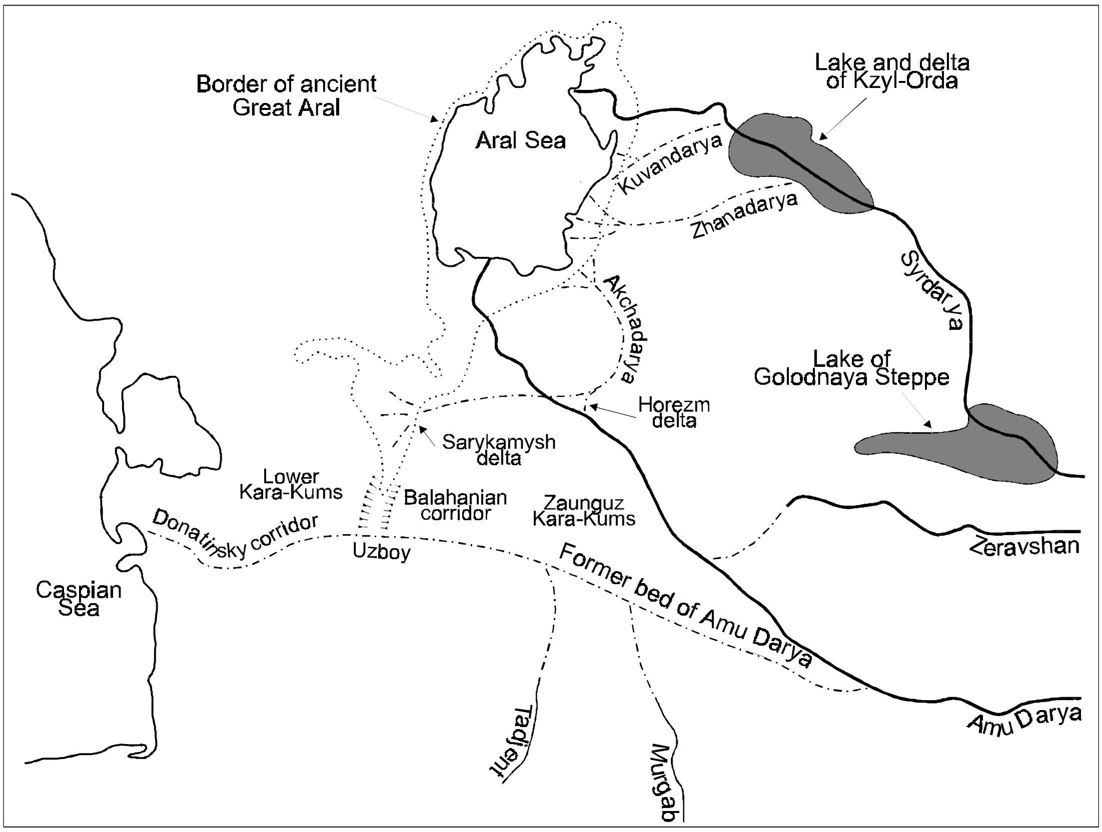

Fig. 2. Pleistocene-Holocene palaeohydrographical system of Central Asia and Kazakhstan [according to Kvasov, 1978, with changes and additions]

the Murgab and the Tadjent. Large number of smaller inflows ran as well from the right side. All these channels testify that a large volume of superficial drain was significant and supplied the region with water during this period.

During the late Pleistocene era the hydrological inclination in the basin of the Amu Darya decreased, and accordingly the process of accumulation of deposits was amplified. The drainage from glaciers also increased the erosive force of the rivers in their upper current. In the late Pleistocene or in the beginning of the Holocoene period, the Amu Darya started to flow through Kara-Kum into the Aral-Sarykamysh depression. This change of direction from the Caspian Sea on Aral probably took place in the Lavlakan pluvial period, when the increase of the water discharge resulted in flooding of the valley of Amu Darya, with subsequent overflow of waters into the valley of its tributary Zeravshan. Eventually, this has resulted in the turn of the Amu Darya to the north (Rubanov, 1991). Kes' (1960) assumed that the incorporated flow of the Zeravshan and the Amu Darya had broken through the second barrier at Tujamuyun and, probably, filled the Khorezm Lake with water. This lake existed during the early Khvalyn period or even later. In the further the Khorezm Lake expanded in a northern direction and, at the end, was connected with the Aral by the Akchadarya corridor, forming a delta with the same name.

Though the Amu Darya reached the Aral Sea in the zone of the Akchadarya delta, the gradual accumulation of deposits in Khorezm Lake again resulted in the turn of Amu

Darya. In this case the river turned to the west, into the Sarykamysh depression. The level of water in the Sarykamysh gradually rose up to 58 m a.s.l. After that the water has begun to flow by the Uzboy into the Caspian Sea. According to Kes' (1960) the Sarykamysh delta reached eastward from the Sarykamysh depression.

Shnitnikov (1969) criticized the ideas of Kes' on the different times and locations of deltas of the Amu Darya. He proposed that these deltas existed simultaneously. He argued that during early dry climatic phases the river flowed into the Aral depression and formed the most ancient Aral delta. In the cool, damp climatic phases the Aral was filled, therefore, only part of the water from the Akchadarya reached the Aral: the other part flowed down to the Sarykamysh depression and further, via Uzboy, to the Caspian Sea. Pinhasov (1984) has confirmed an idea of Shnitnikov, that after Tuyamuyun the Amu Darya flowed to the shallow part of the Aral Sea that is called "Lavaksky gulf". It was limited on the east by the cliffs of the Ustyurt plateau, and on the west by the Tuyamuyun-Sultanuzdag-Muynak line.

The Syr Darya development

Pre-Holocene evolution of the Syr Darya is less known. According to Fedorovich (1970) tectonic raising of the Central Tien Shan caused rapid development of the glaciers, which subsequent melting resulted in association of the valleys of Naryn and Syr Darya. The water flow from one intermountain depression to the other, and, at last, left the Fergana depression and began to flow towards the northwest, leaving up to 500 m thick deposits of sand and clay in the area southeast from Kyzyl-Kum, extending directly westward from the modern direction of the river (Gramm, 1962). Fedorovich (1952), and also Andrianov & Kes' (1967), have noted that during the early and middle Pleistocene era the Syr Darya migrated through northern Kyzyl-Kum, and modern location was reached only in the late Holocoene period.

In the lower flow of the Syr Darya, to the east from the Aral Sea, in the late Pleistocene era a large delta was developed. This delta is to the north from Kyzyl-Kum, between the Aral Sea and the modern Syr Darya. In the West this delta is incorporated with the Akchadarya delta of Amu Darya.

Approximately 9-10,000 years ago the Aral Sea was very small, and only the Syr Darya discharged into it. The Amu Darya at that time flew into the Caspian Sea. The surface level of the Aral Sea was 31 meters above sea level (m.a.s.l.).

During the Khvalynian and Mangyshlak periods in Central Asia the cold and dry climate continued. This caused a very strong regression of the Aral Sea. During the Paskevich period it resulted in complete desiccation of the Sarykamysh depression and termination of the drain on Uzboy.

Fluctuation of the Aral Sea during Middle and Late Holocene

Between the early and middle Holocoene period (about 8000-9000 years ago) the climate changed from dry and cold into warm and damp. The glaciers were situated at

5000-7000 m above sea level. The surplus of waters from the Amu Darya drained to Akchadarya in the direction of the Aral Sea, and also into the Sarykamysh depression and the Uzboy to the Caspian Sea (Shnitnikov, 1969). Probably, there were three deltas simultaneously: the delta at Sarykamysh Lake, Akchadarya delta and the delta directly at Aral (i.e. the modern). (However from the beginning of 1970 the "modern" delta has changed radically because of a withdrawal of Amu Darya water for irrigation.)

Between 4000 and 5000 years ago the Amu Darya changed its course into the Aral, and the lake level rose by more than 40 meters, reaching 73 m.a.s.l. At this time the Aral Sea surface area was 4-5 times larger than the area of Aral in the middle of the 20th century. Not only Large and Small Aral depressions, but also the depressions of Sarykamysh, Sudochie, Kamyshlybas, Khorezm etc., were covered with water. This stage can be called the Great Aral Sea.

Between 3,000 and 3,500 years ago water began to overflow from the Great Aral southwesterly into the Caspian Sea through Uzboy. This made the level fall by 15 meters and it was stabilized at 58 m.a.s.l. The drain to the Uzboy decreased, and later stopped completely. Kvasov and Mamedov (1991) assume that the complete desiccation

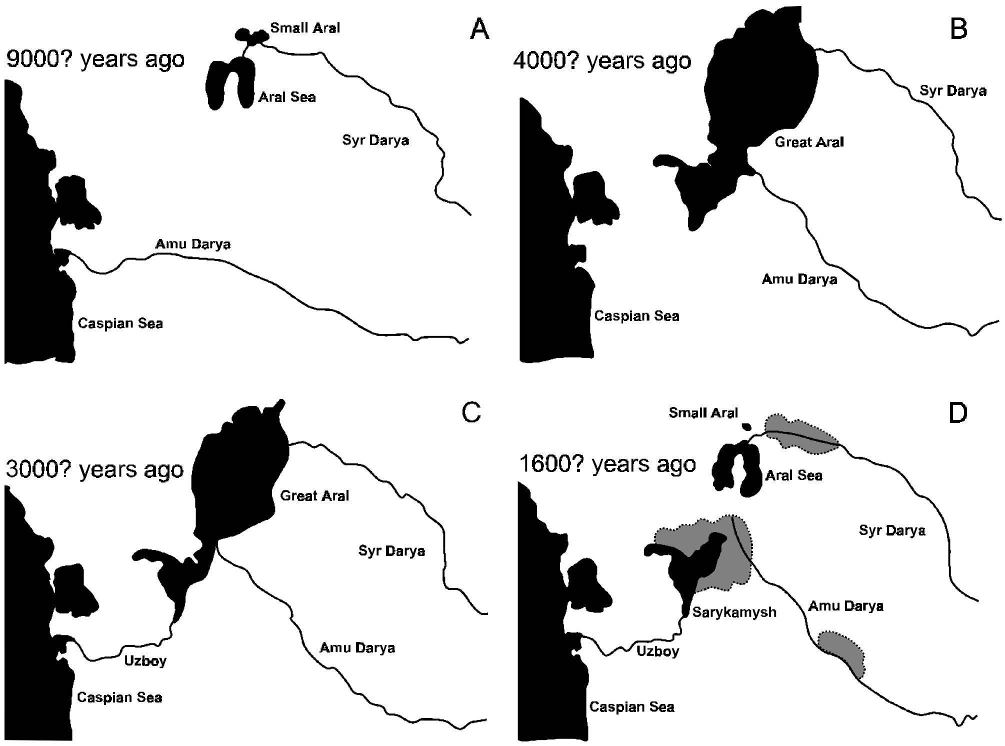

Fig. 3. Early Holocene and late Holocene palaeohydrographical systems of Central Asia and Kazakhstan:
A — Paskevich stage; *B* —the Great Aral stage; *C* — stage of the first natural discharge throw Uzboy to the Caspian Sea; *D* — stage of the first anthropogenic dessiccation.
Areas of irrigation are *shaded*.

of the Uzboy was caused not only by a change of climate, but also by the activities of the people. These authors also considered that the influence of people (through irrigation development) on the process of dividing of the Aral basin into the Aral Sea, Khorezm and Sarykamysh lakes was larger than usually it is assumed.

The inhabitants in the ancient Khorezm during antique times influenced the drainage of the Amu Darya into the Aral and the Sarykamysh. The people could force the river to flow either into the Aral or into the Sarykamysh or into both reservoirs simultaneously. In the latter case the volume of drainage water into each of the lakes could, too, be adjusted. The control of the Amu Darya could be supported only during relative social stability.

Already by 400 A.D., irrigation made the Aral Sea dry up even stronger than today at the end of 20th century! At that time, due to the efforts of man, the Sarykamysh depression was filled with water even to a larger extent than was the Aral one, and from there water was drained through the Uzboy into the Caspian Sea. Important irrigation development resulted in the exhaustion of water resources in the region and in salinization of irrigated grounds. It has resulted in a severe deterioration of the environment's health and, together with economic and military-political factors, caused the first ecological crisis of the Aral Sea. The causes and consequences of this first crisis showed the negative effects that irrigation can have in terms of salinization. Deterioration of environmental health has resulted in the decline of ancient civilizations.

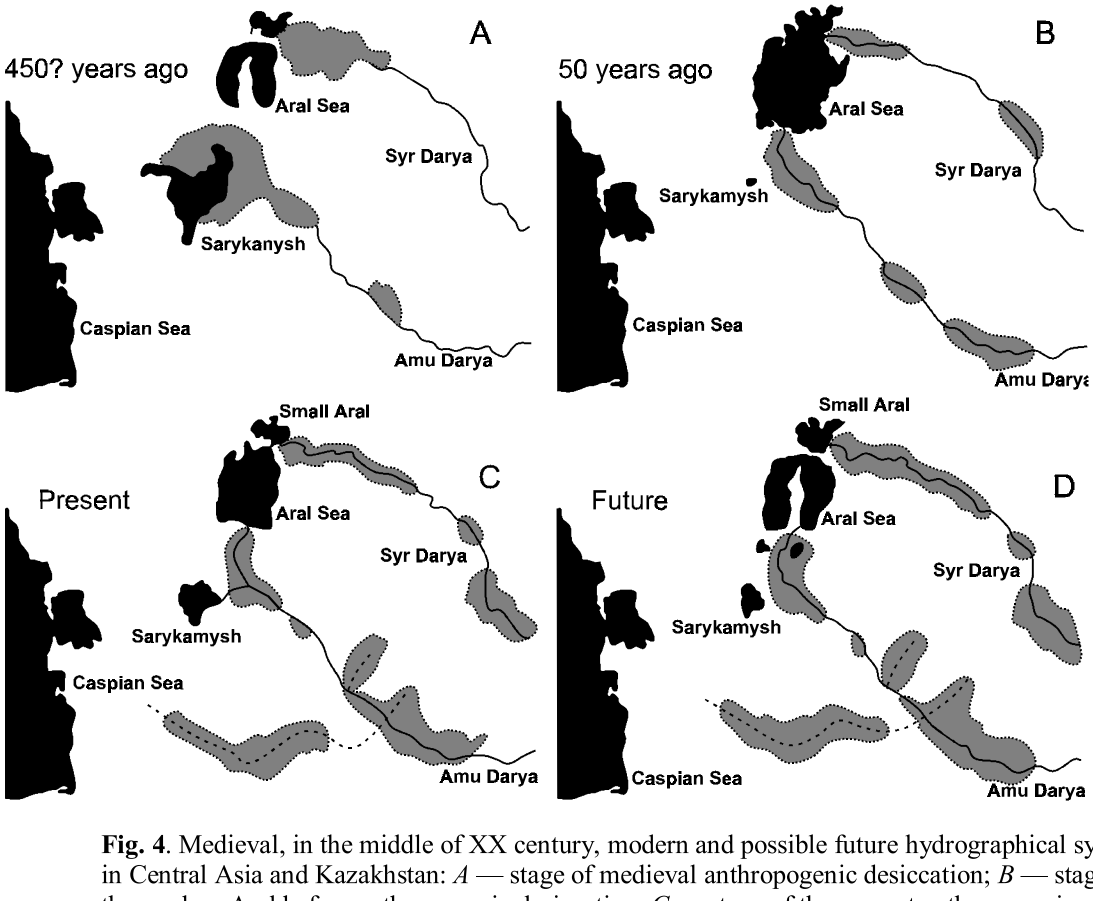

Fig. 4. Medieval, in the middle of XX century, modern and possible future hydrographical systems in Central Asia and Kazakhstan: *A* — stage of medieval anthropogenic desiccation; *B* — stage of the modern Aral before anthropogenic desiccation; *C* — stage of the present anthropogenic desiccation; *D* — stage of the Aral stabilisation in future. areas of irrigation are *shadowed*

Approximately 450 years ago, again owing to the important development of irrigated agriculture, the Aral's level was lowered again. This anthropogenic desiccation was less strong than in the fourth century and can be compared with the modern. At this time the Sarykamysh depression again was filled with large amounts of water (less, however, than in the fourth century) and there was no run-off through Uzboy. The medieval drying up of the Aral can be seen as the second "ecological crisis" of the Aral Sea. The first and second ecological crises showed the importance that water resources have for maintenance of environmental health.

It is clearly proven that the third "ecological crisis" was - and is - the most devastating one, in comparison with the crises in 4th and 15th centuries. In the 20th century the ecological crisis was -and is - also due to strong chemical pollution, mainly by mineral fertilizers, insecticides, pesticides, defoliants and many other agricultural, industrial, households and even military chemical pollution substances. It is obvious that in the 20th century the environment's health has become even more dependent on the quality of water, and that in the 21st century, access to clean water in Central Asia can become the most important problem.

The Amu Darya and the Syr Darya During the Last Millennium

Since the 13th century or, most likely, since the 14th century, and before the 19th century, there was a small glacial period that shows study of glaciers of Northern Europe, Asia and America. The accumulation of ice resulted in increasing amounts of thawed water during summer and, hence, increases of the drain of the Amu Darya and the Syr Darya.

Probably, during the 13th and 14th centuries, and, undoubtedly, from the 14th to 16th centuries, the lower Amu Darya Sarykamysh Lake received plenty of water, sufficient for, at least, partly an overflow into Uzboy. The historical records show that in 1537 the Amu Darya turned from the Sarykamysh Lake to the Aral Sea. It could take place then, when the local population lost control of the current of Amu Darya, which before that artificially was turned to the Sarykamysh. In the further the entire drainage of the Amu Darya went to the Aral Sea. The first Englishman who visited Central Asia, merchant Anthony Jenkins, wrote in 1588, that probably the local population soon will lose the control of the river. "*... the water that serveth all the country is drawn by ditches out of the river Oxus* (old name for the Amu Darya), *unto the great destruction of the said river, for which it falleth not into the Caspian Sea as it hath done in times past, and in short time all that land is like to be destroyed, and to become a wilderness for want of water, when the river Oxus shall fail*" (Berg, 1908, p. 28).

The scientific proof of a change in the flow direction of the Amu Darya into the Aral Sea can be found in various sources, and the event is dated to between the middle of the 16th century and the first half of the 17th century. It is quite probable that within the limits of this 70-year interval the drain of water from the Amu Darya into the Sarykamysh depression completely stopped.

Because of the termination of drainage to the Sarykamysh depression and further to Uzboy, the latter soon dried up, and the level of the Aral Sea rose quickly. The former turn of the Amu Darya away from the Aral, which has been carried out by the local population in the Middle Ages, resulted in a desiccation of the Aral Sea down to a level comparable with the modern. The subsequent fast rise of level of the Aral (about four centuries ago) destroyed saxaul brushwood, here and there bordered the sea. The radiocarbon analysis of flooded saxaul stumps (now revealed because of the modern fall of level, Fig. 5), dates them to 1663±5 (i.e. 287±5 years ago; S. Stine, personal communication).

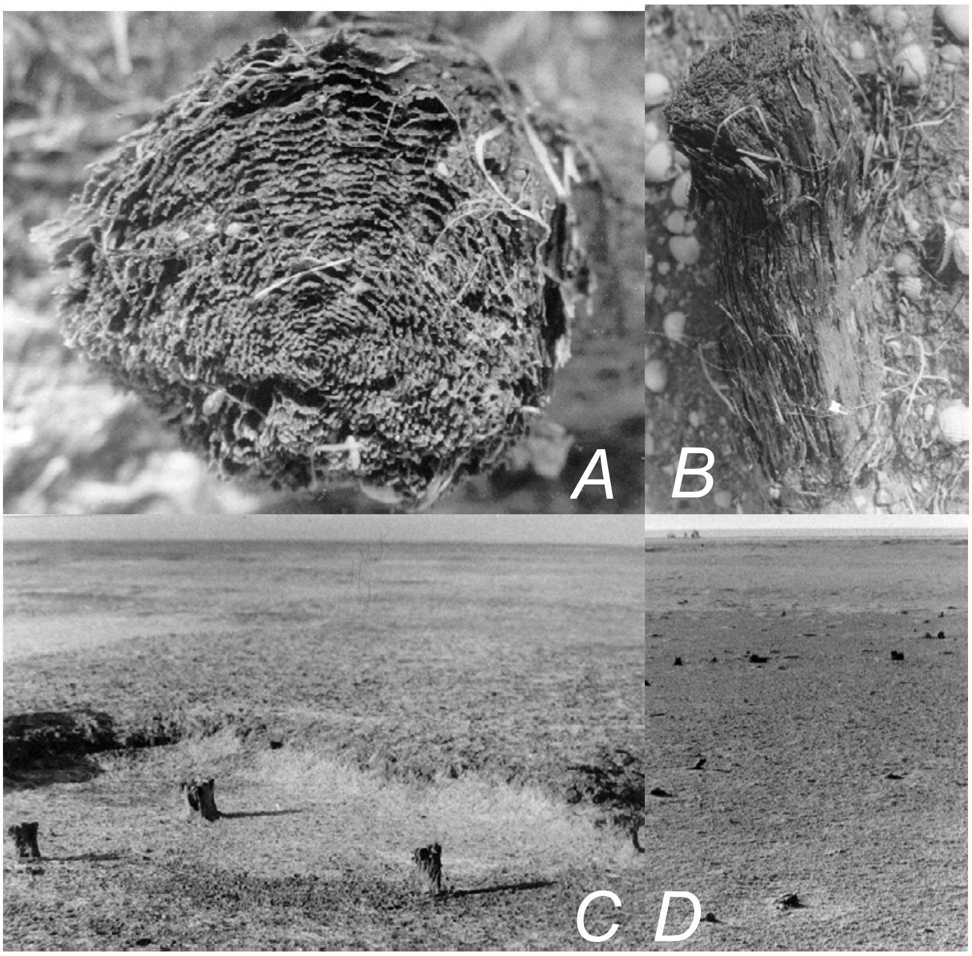

Fig. 5. Stumps of saxaul – markers of black saxaul forests formed on former Aral Sea bottom during its regression in XVII century. Photo by D. D. Piriulin.
A, B — former of black saxaul forest on postaqual dry land (*A* — former sea bottom near Bugun village; *B* — northern coast of Barsakelmes island) *C, D* — lower part of saxaul trunk remained during the last transgression in solid ground at anaerobic conditions and appeared again on the surface during modern regression due to erosion and deflation, there are well visible circles of growth.

The last deep regression took place (according to Rubanov, 1991) approximately 1000 years ago. The medieval regressive phase was not as appreciable as 1000 years ago but appeared as forceful as the modern. Regression in the 4th century was, probably, one of the most remarkable: the lowest level down to which the sea receded, 30-32 m.a.s.l., 20 m lower than the "normal" level of the Aral in the 20th century.

Eight Different Terraces are Representing Different Stages

Berg (1908), Lymarev (1967) and Shnitnikov (1983) convincingly have proved that the history of the Aral Sea is a history of transgressions and regressions. Most obvious attributes today indicating the last changes of the Aral Sea water level are eight different terraces (Fig. 6), distinguishable in the Aral basin.

I. — 72-73 m.a.s.l. — Terrace of Great Aral (maximum during Lyavlyakn pluvial period);
II. — 57-58 m.a.s.l. — Ancient Aral terrace;

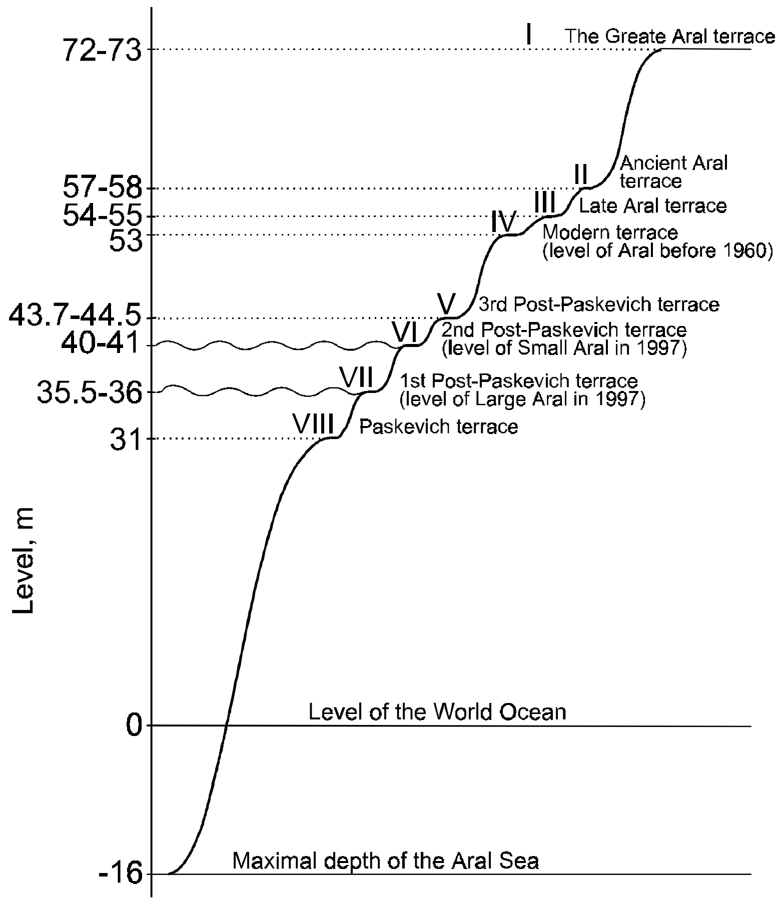

Fig. 6. Holocene terraces of the Aral Sea

III. — 54-55 m.a.s.l. — Late Aral terrace;
IV. — 53 m.a.s.l. — The modern Aral terrace (it is considered, that it represents "normal" level for first half of XX century);
V. — 43.7-44.5 m.a.s.l. — 3rd Post-Paskevich terrace;

VI. — 40-41 m.a.s.l. — 2nd Post-Paskevich terrace;
VII. — 35.5-36 m.a.s.l. — 1st Post-Paskevich terrace;
VIII. — 31 m.a.s.l. —Paskevich terrace;

Vainbergs and Stelle (1980) have described terrace VIII, the Paskevich terrace developed during the late Pleistocene and early Holocene periods. They considered that terraces V, VI and VII simply reflect periods of stability following the increase of the sea level after (the lowest) level of the Aral in the Paskevich time (terrace VIII).

According to Vainbergs and Stelle, the Aral Sea during the Paskevich period was divided at least into two basic reservoirs – Small Aral and Large Aral – and that their levels varied between 31 and 36 m.a.s.l. Mamedov (1991), on the contrary, considered that the lowest level of the Aral during the Paskevich time was 35.5-36.0 m a.s.l., assuming that changes of water level by 5 m during one climatic period as being improbable. Mamedov attributes terrace VII to Paskevich time and did not recognize the existence of terrace VIII, described earlier by Vainbergs and Stelle.

Epifanov (1961) was the first one who described the top most terrace (72-73 m) on the northern and western coasts of the Aral Sea. Hondkarian (1977) and Fedorov (1980) described the dividing structures at the southeastern parts of the Aral basin, which could allow sea level to rise up to hypothetical maximum (72-73 m). These authors also noted that the structure was destroyed early, which resulted in a lowered water level at 57-58 m.a.s.l. (Ancient Aral terrace). They have rejected any assumption that the fall of level was attributed directly to climatic factors, instead they consider it being a consequence of the destruction of a natural barrier.

As terrace I (72-73 m) and terrace II (57-58 m) contain *Cerastoderma edule* or *Cerastoderma lamarcki* and, hence, cannot be older than from the time of the first occurrence of these taxons in the Caspian region, i.e. they are older than New Caspian deposits and therefore should be referred to as Holocene.

A number of authors have presented data received from various sources. So, for example, for terrace of level II (Ancient Aral) with widely varying suggestions of age Yanshin (1953), Vainbergs and Stelle (1980) - 5000 years ago, Kes' (1983) — 3000 years ago, Maev et al. (1983) — 3000-2000 years ago, Serebryanny et al. (1980) and Shnitnikov (1983) — 12000 years ago. Though the exact age of terrace II remains to be determined, we know that the small duration of existence of a barrier means that the terrace I cannot be significantly older than terrace II. Most often exact dating of terrace II is attributed a higher age than the Neolithic deposits connected to this level, which give the age at 5000 years ago. As *Cerastoderma edule* first entered the Caspian Sea about 5000-7000 years ago (Fedorov, 1983), and the species reached the Aral Sea not earlier than 5000 years ago (Maev et al., 1983), its presence both on terrace I and on terrace II means that these terraces cannot be older than 5000 years.

Table 1.

Changes in Palaeoaral Aral Sea palaeohalinity during last 9000 years

Period	Phase	Region	Time of the beginning, thousands years ago	Salinity by ostracods, g/l
Aral	Paskevich	Small Aral	9	From 1 to 4
		Western Large Aral		From 22 to 25
		Eastern Large Aral		From 25 to 41
	Great Aral	Small Aral	4	From 1 to 2
		Western Large Aral		From 0.5 to 1
		Eastern Large Aral		From 2 to 3
	1st natural discharge throw Uzboy to the Caspian	Small Aral	3	From 1 to 2
		Western Large Aral		From 0.5 to 1
		Eastern Large Aral		From 0.5 to 2
	1st anthropogenic desiccation	Small Aral	1.6	From 100 to 104
		Western Large Aral		From 36 to 48
		Eastern Large Aral		From 1 to 2
	Medieval anthropogenic desiccation	Small Aral	0.45	From 2 to 3
		Western Large Aral		From 22 to 30
		Eastern Large Aral		From 22 to 40

Nikolaev (1991) has calculated that during the IV century the deepest parts of the Aral Sea were about 3 m depth, thus supporting the assumption by Maev (1983) about regression in IV century. He also considered that at this time the basic channel of Syrdarya, or, at least, one of its basic branches, meandered close to the northern coast of Barsakelmes Island in the northern part of the main Aral basin, eventually running into freshwater/brackish water parts of the Aral Sea remaining during this time. Nikolaev (1991) doubted that the Amu Darya could reach this shallow reservoir, but if it reached it, it could bring only a small volume of water through Zhanadarya delta.

During this (IV century), maximal regression of the eastern-central and western depression of the Aral Sea were included in the northern parts. With some more high levels of water, the connection between these two depressions existed in the south as well. The levels of salinity in the eastern-central depression during adjacent times varied with the maximal regression from freshwater to slightly saline. This variation was caused by a stronger influence of a fresh river discharge into some areas. The given situation has resulted in coexistence of freshwater invertebrates and brackish water *Cerastoderma*. In the western basin the salinity was rather high compared to in the eastern-central depression, though its absolute values were not determined.

Nikolaev (1991) considers that the last "middle scale" regression has taken place about 600 years ago and that, besides the maximal transgression of the Aral Sea was, probably, 3600-4800 years ago.

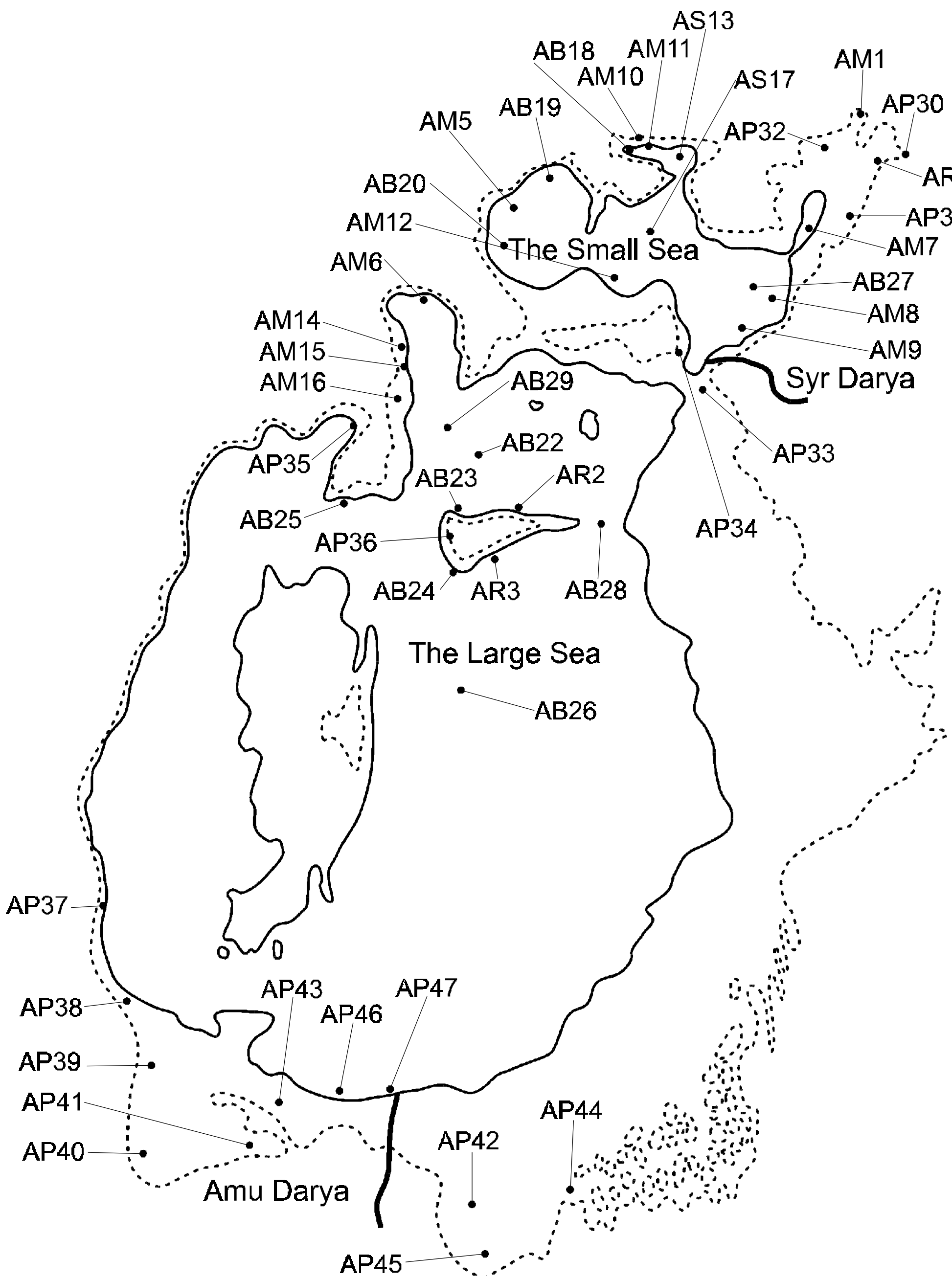

Fig. 7. Places of bottom sediments sampling

Dotted line shows shore line in 1960

The detailed analysis of the data about palaeohalinity of the Aral in the Holocoene era summarized in Tab. 1 can be found in the appendix. As it is visible from the given data, the salinity conditions in the ancient Aral were, as a rule, extremely non-uniform. Only during the phase of the Great Aral, and the phase of the first natural discharge in the

Caspian Sea in it the relative stability of mineralization in oligohaline level was observed.

Kvasov (1976) postulated that if the basin of the Aral Sea was not so strongly irrigated during its history, the Aral Sea would be significantly larger than today, would be united with the Sarykamysh basin, and would through the Uzboy be discharged into the Caspian Sea.

Conclusions

During Pleistocene era and at the beginning of Holocoene period, both the salinity and the surface level of the Aral Sea were controlled by local climatic factors, causing changes in the river discharge. In later development human activity has become a primary factor. Effects of irrigation, wars, economic and political decisions have been influencing the sea level and the salinity of the Aral Sea to a larger extent than nature has been. Modern ecological problems of the Aral basin are not new for the region: similar variations have repeatedly happened before. What is new is that in modern time chemical pollution of water resources and land has occurred as a disastrous consequence of the use of chemical fertilizers, pesticides and defoliants.

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Appendix: Background Analysis to Table 1:

From deposits appropriate to the Paskevich phase (Fig. 1, A) and collected by us in three areas of the Aral Sea (Small Aral, western depression of Large Aral, and eastern depression of Large Aral) were extracted about 150 valves of *Cyprideis torosa* shells. When analyzing a microsculpture of shells it is important to take into account from which areas they were collected. From columns of ground deposits AM-5, AM-7, AM-11, AM-12, AB-27, AP-31 taken by us in the first area (Fig. 7), 26 valves (11 left and 15 right) were analyzed prevailing rounded channels. The highest percent of rounded sieve pore channels made 81 %, and the lowest — 59 % — which corresponds to palaeohalinity 1 g/l and 4 g/l. From columns AB-25, AP-35, AP-37, AP-38 from the western depression of Large Aral (Fig. 7), 67 valves (35 left and 32 right) were analyzed. The percent of rounded sieve pore channels changed from 26 % up to 29 % — that corresponds to palaeohalinity 25 g/l and 22 g/l. From columns AB-22, AB-23, AB-26, AB-29 selected by us in the east depression of the Large Aral (Fig. 7), 73 valves (39 left and 34 right) were analyzed. On valves from this area of the Aral Sea the percentage of rounded sieve pore channels has appeared even lower, and made from 26 % up to 17 % — that corresponds to palaeohalinity 25 g/l and 41 g/l. From deposits appropriate to a phase of the Great Aral Sea (Fig. 1, B) and its water areas, taken on all, from columns AM-1, AM-6, AM-10, AB-24, AB-28, AP-30, AP-36, AP-39, AP-40 (Fig. 7), were allocated valves (10 left and 9 right) of *C. torosa*. On all investigated valves prevail rounded sieve pore channels. Their maximal share was made 90 %, and minimal — 65 %, that corresponds palaeohalinity 0.5 g/l and 3 g/l.

Only 21 valves (14 left and 7 right) from a deposit appropriate to a phase of the first natural drain on the Uzboy from the Great Aral into the Caspian Sea (Fig. 1, C) and taken from columns AM-14, AM-15, AB-18, AB-19, AB-28, AP-33, AP-41, AP-45 (Fig. 7) were taken. As well as in the previous case, on all investigated valves prevail only as rounded sieve pore channels. They are from 90% up to 72%, which corresponds to palaeohalinity 0.5 g/l and 2 g/l.
From deposits appropriate to the phase of the first anthropogenic desiccation of the Aral Sea (Fig. 1, D) and collected in three areas of the Aral (Small, western Large, eastern Large) were found many (about 1000) valves of shells *C. torosa*. The analysis was made on samples from different areas. From columns of bottom deposits AM-12, AS-17, AB-27 taken by us in the Small Aral Sea (Fig. 7), 76 valves (32 left and 44 right) were analyzed. rounded sieve pore channels were very few for all investigated valves. The highest percent of rounded sieve pore channels did not exceed 7 %, and the lowest was 6 %, which corresponds to palaeohalinity 100 g/l and 104 g/l. On four shells rounded sieve pore channels were absent completely, that specifies palaeohalinity above 104 g/l. From columns AB-25, AP-35, AP-37, AP-38 taken in the western depression of the Large Aral (Fig. 7), 68 valves (35 left and 33 right) were analyzed. The percentage of rounded sieve pore channels changed from 20 % up to 15 %, that corresponds to palaeohalinity 36 g/l and 48 g/l. From columns AM-16, AB-24, AB-26, AB-28, AB-29 selected in the east depression of the Large Aral (Fig. 7), 22 valves (9 left and 13 right) were analyzed. It is necessary to note that in the given area of the Aral (as opposed to two by other) valves of *C. torosa* were met very sparsely, and only 22 valves were found. On valves from the east depression of the Large Aral prevail rounded sieve pore channels. Their maximal share made 81 %, and minimal 72 %, that corresponds to palaeohalinity 1 g/l and 2 g/l.

From deposit appropriate to the phase of medieval anthropogenic desiccation of the Aral Sea (Fig. 4, A), also collected in three areas (Small Aral, western depression of Large Aral, eastern depression of Large Aral), was obtained more than 300 valves of shells of *C. torosa*. With the analysis of a microsculpture of shells was taken into account, from what areas they were selected. From columns of ground deposits AM-1, AM-5, AM-7, AM-12, AS-17, AB-27 taken in the Small Sea (Fig. 7), 20 valves (8 left and 12 right) were analyzed. In this area of the Aral (as opposed to the Large sea) shells *C. torosa* were met very sparsely, and from all columns only 20 valves were obtained. On all investigated valves prevail rounded sieve pore channels. The highest percent rounded of sieve pore channels made 72 %, and lowest — 56 %, that corresponds to palaeohalinity 2 g/l and 3 g/l. From columns AB-25, AP-35, AP-37, AP-38, AP-43 taken in the western depression of Large Seas (Fig. 7), 89 valves (43 left and 46 right) were analyzed. The percentage of rounded sieve pore channels was low and changed from 29 % up to 22 %, which corresponds to palaeohalinity 22 g/l and 30 g/l. From columns AB-22, AB-23, AB-26, AB-29, AP-46, AP-47 selected in east depression of the Large Aral, 86 valves (39 left and 47 right) were analyzed. On valves from this area of the Aral, the percentage of rounded sieve pore channels has appeared also low and changed from 29 % to 18 %, which corresponds to palaeohalinity 22 g/l and 40 g/l.

WATER QUALITY AND HEALTH OF THE POPULATION IN THE AMU DARYA

by *Gulchekhra Khasankhanova and Umid Abdullaev*

"Water is life" was stated long time ago in Central Asia. Now it is high time to recognize the need of increased water quality to sustain life, health and the environment.

Introduction

The Amu Darya river and its river basin is an important part in the socio-economic, health and environmental Aral Sea catastrophe. The socio-economic sector dominating in the basin is agriculture, particularly irrigated agriculture. Some 30-60% of the population is employed in this sector. Surface water pollution is an important result of this sectoral use. The health of the population in the Amu Darya river basin reflects the critical environmental situation combined with socio-economic conditions.

Main Causes and Sources of water pollution

Natural causes

Climatic aridity, relief, hydro-morphology and geological formations of the Pamir and Gissaro – Alay Mountains and the development history of the Turan province are natural factors behind salinization and water pollution of the Amu Darya River. Mountain ranges comprise granite, schist, and limestone. Since these are mainly insoluble formations, mineral content of the water is relatively low and the quality in the headwaters is suitable for most uses. In the valleys, where more soluble deposits are found, sulfates and chlorides enrich waters.

Anthropogenic causes and sources

The intensive development of irrigated agriculture in the Amu-Darya River Basin for the last 30-40 years resulted in establishment of an extensive network of canals and structures designed for collector-drainage water (CDW) collection and disposal. CDW discharge to river network has caused deterioration of river water quality, reduction of crop yields and deterioration of the ecological situation in upper reaches.

The irrigation and drainage infrastructure has been operating more than 30 years without modernization and rehabilitation. Overall water use efficiency is 32-39. In 1997, surface irrigation, mainly furrow, was practiced on 97% of total area. Other methods of irrigation (sprinkler, drip, etc) were not accepted for wider use. Methods used for leaching of saline soils in the basin are characterized by extensive water requirement as well as labor. Leaching of saline soils during periods of mid and lower stream flow of the Amu-Darya basin are resulting in poor water quality flows.

The Amu Darya has already been polluted when it reaches Uzbekistan, but considerable water quality changes occur downstream, where the river is a main source of drinking water supply (Figure 1 and Table 1).

Figure 1. Variation of Mineralization Along the Amu-Darya River (1985-1995)

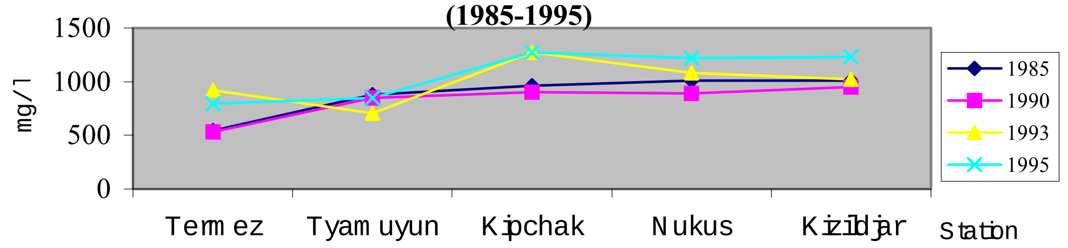


Table 1.
Mean Annual Pollutant Concentrations in the Amu Darya River (1991-1995)

Pollutant	Mean annual pollutant concentration (mg/l)									
	Termez					Nukus				
	1991	1992	1993	1994	1995	1991	1992	1993	1994	1995
Dissolved oxygen	10.5	9.94	11.9	10.8	10.7	8.09	8.61	9.33	10.3	10.1
BOD	1.81	0.84	1.13	2.06	1.16	0.68	1.26	0.62	1.1	1.49
COD	13.2	8.5	8.8	6.1	6	16.3	12.8	19	9.6	8.5
Ammonium nitrogen	0	0	0	0.03	0.04	0.06	0.07	0.06	0.02	0.04
Nitrates	1.26	0.69	1	1	0.94	0	0.88	0.8	0.52	0.56
Nitrites	0.02	0.02	0	0.01	0.01	0.01	0.034	0.021	0.019	0.011
Fe (III)	0.04	0	0.04	0	0	0	0.03	0.02	0.03	0.02
Oil products	0.03	0.03	0.02	0.07	0.03	0.04	0.06	0.04	0.06	0.03
Cr	1.9	2.2	2.2	0.6	1.3	1	2.7	1.6	0.7	0.5
Surface active substances	0.01	0.01	0.01	0.01	0	0.04	0.01	0.01	0.01	0.02
Suspended solids	753	546	410	123	12	101	435	277	260	136
Alpha-HCH	0.02	0.05	0.02	0.02	0.01	0.02	0.13	0.05	0.02	0
Gamma-HCH	0.01	0.04	0.02	0.01	0	0.01	0.07	0.03	0.02	0
Fluorine	0.4	0.21	0.21	0.15	0.19	0.36	0.31	0.2	0.21	0.26
Arsenic	1.7	0.9	0.1	1	0.2	0.6	2.5	0.1	1.2	1.7
Salinity	546	619	920	652	772	814	995	1090	1025	1244

Source: State Committee for Nature Protection

Domestic waste from urban areas can be an important main source of pollution. Urban wastewater amounts to some 1,322 Mm^3/yr; wastewater treatment plants have insufficient capacity. Less than 40 % of towns are provided with sewerage systems.

Agriculture water use is a major polluting source in the Amu-Darya River Basin. Analysis along Amu-Darya river showed that water quality in the river depends considerably on the inflow of CDW and their mineral content. Nearly 35% of all drainage water is discharged via main collectors - Yuzhny, Parsankul and Beruny. Main polluting substances are pesticides, nitrates, fertilizers, phenols, oil products, etc. (MMTU, 1998).

A decreasing quantity of allocated water, and badly functioning irrigation and drainage network have resulted in increased salinization and water logging, caused by raising groundwater levels. In 1998, only 46 % of the irrigated lands were non-saline areas by Central Asian standards. Dissolved salts from upstream irrigated areas are accumulated downstream. About 90 – 98 % of the lands in Khorezm and Karakalpakstan are salinized. It is adversely influencing the population's income, rate of employment and access to safe drinking water supply. According to The World Bank (1999) data for economic losses resulting from soil salinisation amounts to 2 billion US$ (about 5 % GNP of Central Asia).

Water Quality and Health

The health of the population in the Amu Darya river basin reflects the critical environmental situation and socio-economic conditions. The interrelations between drinking water quality and human health are important to assess. These relationships are complex with many influencing factors. This study is concentrating on determination of effects of domestic water quality on infant mortality and on mortality from infectious diseases; the impacts of other parameters have been excluded as far as possible. Figure 2 and 3 shows this dependencies.

Figure 2. Influence of Drinking Water Quality to Infant Mortality (by bacteriological index)

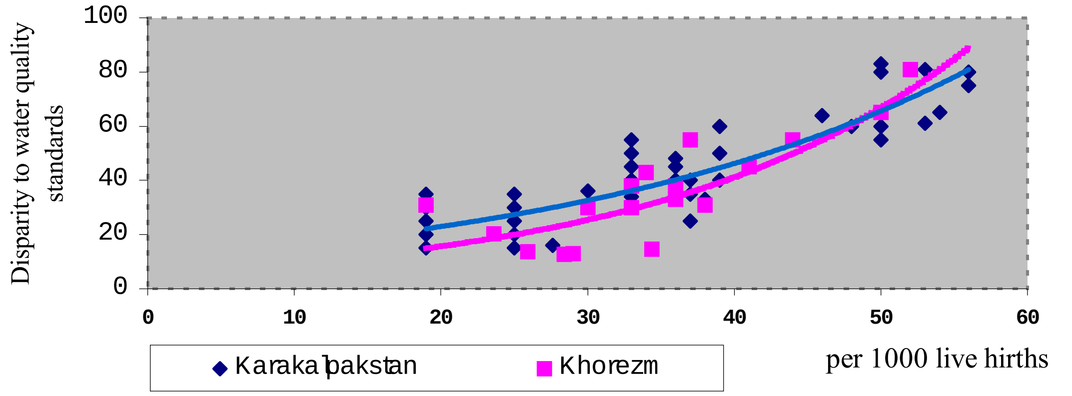
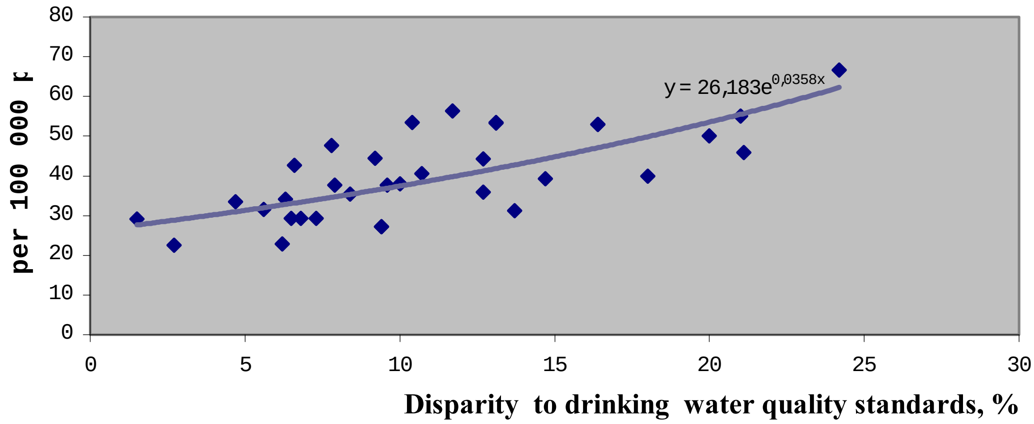


Figure 3. Influence of drinking water quality to mortality from the infectious diseases in downstream



Source: *Data from Public Health Ministry of Uzbekistan*.

The study identified three health risk zones as those to be given primary attention.

Very high risk zone. The study identified three health risk zones as those to be given primary attention. Karakalpakstan and the Pre-Aral zone show serious health effects, but the Muynak, Shumanai, and the Karauzak districts of North Karakalpakstan and four districts in the Khorezm are the worst affected areas. The drinking water situation in these areas is poor, especially from a bacteriological point of view, and infant mortality exceeds from 40/1000 to 56/1000 (for Nukus). Dramatic increase of tuberculosis, nerve system diseases, and anemia has occurred.

High risk zone. The health situation in Khorezm and Bukhara is comparable with South Karakalpakstan. The incidence of sickness is less than average, but high for the majority of the districts. Infant mortality exceeds 34/1000 in five districts in Khorezm with maximum of 39/1000 (in Yangiarik and Gurlen) and remains relatively high in Bukhara. The incidence for intestinal, respiratory and hepatitis diseases in Khorezm and Bukhara is considerably higher than average for Uzbekistan, with extremes of hepatitis more than 40/1000 for Karaulbazar and Peshkun. The drinking water situation in these provinces is poor (above 50 to 100% of permissable limit or below the standard), especially from a bacteriological point of view.

Upstream risk zone. In three districts of Surkhandarya region the sickness index exceeds 1100/1000(Denau, Kumkurgan and Muzrabad). Hepatitis has a higher average incidence level than Kashkadarya, but with a low maximum of 5.6/1000 for Sariasay district. The average levels for intestinal and respiratory diseases are higher [IWACO,1998].

Water and Food

Sufficient and good food is essential for good health. Soil and water salinization is resulting in considerably decline in agricultural productivity. Crop yield is decreasing sharply when the level of water mineralization is increasing. Thus with a mineralization of 4 to 6 g/l water for irrigation, the yield may be reduced by about 18 to 20%, with a 50% probability of occurrence (MMTU, 1997).
In the former SU Uzbekistan focused primarily on agricultural production and particularly on cotton production. After independence, it was necessary to reform the overall policy for food production. The decision to revise cropping patterns, privatising livestock farms and establishing private farm dekhkan enterprises was an important step toward food self sufficiency. The Government of Uzbekistan adopted a special program on crop self sufficiency which allowed the republic to stop importing crops and to use locally produced crops. These increases resulted in some improvement in food provision to the population. But only for wheat are the norms for food per capita completely satisfying; meat, milk, vegetable does only cover 55-60%, and on fish and fruits only 27-28% of the food norm.

Basically there are two major threats to productivity and sustainability of irrigated agriculture: i) Constrained farmers' incentives to improve production and productivity; ii) The deterioration of the production base. The lack of incentives and funds for proper operation and maintenance (0&M) and rehabilitation of irrigation and drainage infrastructure has led to a serious deterioration of the irrigation and drainage systems, huge water losses, widespread and severe water and soil salinization and declining crop yields. It is estimated that the deterioration/losses of the resource base for agricultural production costs the country US$ 1,000 million annually at economic prices (World Bank, 1999).

Uzbekistan Drainage Project

The World Bank Drainage Project in Uzbekistan is addressing one of the transboundary water problems. To solve the improvement of water quality, the alternative and priority technical solutions on management of drainage flow and improvement of Amu Darya water quality are being assessed and some provisions in these projects are already considered. The alternative decisions have been carried out for three scenarios of water-related sectors at varying intensity of political and agricultural reforms and investments. Project identified the high problem area as those to be considered for primary attention. One of the alternative technical solutions to improve downstream water quality is developed within the Beruni Collector Project [MMTU,1998]. There are two possible courses of action: Gravity and Pumped Drainage variants. The Gravity drainage variant will mean that saline water no longer flows from the Beruni collectors into the Amu-Darya with consequent benefits for river water quality and potential downstream benefits. The average mineralization of the CDW is 4.8 g/l and, as a result of this being diverted away from the river, average mineralization at Kipchak, downstream from the Beruni, would fall from 1.01 g/l to 0.96 g/l.

Concluding Remarks

For the achievement of good health and sufficient food supply, the adequacy of technical, political, economic actions and socio-cultural policy are of major importance and necessity. In Uzbekistan these issues require in-depth research and concrete actions. Without the large-scale and small-scale improvement decisions and projects, the tendency to decreasing water quality and increasing salt accumulation in the irrigated areas will continue, and the quality of life and environment will continue to worsen. We would like to suggest that cooperative projects at the local level, possibly between national organizations or NGOs in the Aral Sea and Sweden should be initiated.

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RESEARCH IN ENVIRONMENT AND IRRIGATION AT CENTER ECOLOGY OF WATER MANAGEMENT (EWM) IN UZBEKISTAN

by R. Razakov

Abstract

The balance between optimal use of limited natural resources and environmental conservation is of key importance for the sustainable social and economic development of Central Asia. Central planning of economic sectors in the former USSR without considering the environmental consequences has taken part during the last 30-40 years and has resulted in the ecological crisis in the Aral Sea Basin. The Aral Sea large-scale desiccation and desertification is a result of the instability of the economies of the countries.

Inadequate management and control of land and water resources is causing distortion in scientific crop rotation, water logging and land salinization, increasing wind and water erosion, and declining soil fertility and crop yields. 30-60 % of total water withdrawal is returning as drainage water and is including salt mobilized through evaporation from deep geological strata. This water runs off to rivers and lakes and some depressions and has polluted irrigated areas and drinking water, resulting in an adverse impact on the health of the population.

In this situation there is a need to study the development trends and to investigate the real environmental situation through programs including monitoring of natural resources and long-term measures to help stabilize the economy by improving the environmental situation. The activity of Center "EWM", founded 10 years ago, is directed towards solutions to these problems.

Introduction

Environmental problems concern all economic sectors, ministries and the whole society. To work out solutions to such problems there is a need for ministerial integration and cooperation, and for enhanced competence and diversified knowledge of complicated ecological processes. Some large-scale projects have been undertaken without any environmental impact assessment, or assessment of damages or suggestion of alternative options. For example, application of erroneous management strategies for saline lands have resulted in mobilization of salt from deep geological strata, increasing land salinization and mineralization of river water, its hardness enhanced by 2-5 times in the lower parts of the Syr Darya and Amu Darya rivers. The right bank collector along the Amu Darya river was directed to transfer large amounts of drainage waste water, but not of drainage water, and alternative options had to be worked out. An expensive drinking water pipeline with a cascade of pumping stations at Tuia-Muin-Nukus-Tahtakupir and Tuia-Muin-Urgench has not solved the problem of drinking water in Priaralie, and because of poor water treatment and management the rate of population morbidity is high. The environmental damage cost is estimated to be 20-30 % of GNP. Center "EWM" aims at undertaking integrated research of land and water resources and their optimal management, increased crop productivity, practical realization of water saving technologies, and innovations in agriculture applied in different soil-climatic condition etc, bearing in mind that 85-90 % of all water is used for meliorated irrigation in Central Asia.

Monitoring of the Environmental Situation in Uzbekistan

Existing, inadequate monitoring of the environment (water, air, land, plants, etc.) has not presented the real situation of environmental pollution and why the efficiency of nature's own protective measures is rather low. The situation is deteriorating because of the absence of proper co-ordination between organizations responsible for monitoring, which are using different methodologies and devices for analyzing samples. As soil surveys were undertaken 15 - 20 years ago without using remote sensing images, GIS methodology is less valuable for that material. Limited compounds (3-6 indicators) are monitored for groundwater, sewage water and drinking water quality. That is why Center "EWM" is using its own precise equipment for fulfilling complicated analysis of water, soil, plants, and hydro-systems when testing for pesticides, biogenic and organic pollutants, trace and heavy metals, etc. The studies include:

1. Monitoring of landscapes of the Aral Sea zone, including by analysis of remote sensing images by a combined team of specialists – botanist, soil scientist, hydrogeologist, ecologist, etc., for preparing thematic maps for the years 1985-1995. (Razakov, 1999).
2. Monitoring of erosion, transport and deposition of the dust-salt aerosols by wind processes. They were measured at 40 spots in South Priaralie for quantitative and qualitative analysis of deposition, calculated salt balance at different distances from the Aral Sea, impact of these aerosols on natural and artificial plants, and assessment of damage to agriculture (Razakov, Kosnazarov, 1994).
3. Monitoring of surface and groundwater quality in rivers, canals, lakes, groundwater, and water reservoirs, including processes of eutrophication, migration and accumulation of contaminants in hydro-systems, etc. (Borodin et al., 1998).
4. Assessment of 20-25 compounds, including parasitic organisms, in the main sources for drinking water in Priaralie (Razakov, 2000).
5. Monitoring of salt accumulation at one meter's depth of the soil strata in soils of Karakalpakistan (10 years of sampling) (Razakov, Kosnazarov, 1994).
6. Preparation of thematic maps of pollution of soils and crops by residue of organochlorine pesticides for almost all oblasts (13) of Uzbekistan (the term “oblast” refers to a political subdivision of a republic in the former U.S.S.R.).. The correspondence between accumulation of salt in root zones of plants and bio-accumulation in different types of agricultural crops was also investigated (Razakov, 2000).

Methodology and Ecological Regionalization (Zoning) in the Terriroty of Uzbekistan

The living conditions for the population settled in ecological disaster zones have been aggravated by the transition to market economy. It also decreased the opportunity for the government to make additional investments for environmental measures. Center "EWM" has worked out a methodology for assessment of ecological regionalization on the basis of integrated indicators and criteria to estimate the rate of the ecological disaster (Razakov, 1999; Razakov, 2000).

This methodology proposes using integral ecological load for nature complexes and human health, through a number of synergistic factors, reflecting the complexity of this phenomenon. The methodology includes ecological, social-economic and medical-hygienic blocks, each of them consist of 16-18 criteria.

Ecological bloc – covers index of atmospheric pollution, climatic potential promoting air pollution, index of soil contamination, its salinization, soil fertility, degradation of pastures, accordance to norm of drinking water quality and food, water logging of territories, number of ecological dangerous objects in each raions, etc.

Medical-hygienic bloc – includes the rate of general and child morbidity, child mortality, also some diseases connected with worsening of environmental quality – viral hepatitis, intestinal, respiratory, endocrinological, cancer, tuberculosis diseases, etc (Razakov, 1999).

Social-economic bloc – includes population density in different raions, death rate, life expectancy, income of population, educational level, piped water supply, supply of population by gas and sanitation, social assistance, service for children, etc.

This work builds on 20 priority criteria for each raion. Fourteen different thematic maps were prepared for each oblast on pollutant distribution in the raion. They include maps of pollution of surface and groundwater, water logging and pollution area distribution. Preliminary raions of ecological impact were defined; further, all data from maps of the raions were calculated and scours (points) were ascertained according to their ecological importance. To this work leading specialists from different Ministries – Health, Statistics, Nature Protection, Meteorology, Agriculture and Water Management, Institutes of Botany and Biology, National Center – Gosgeocadastre etc., were attracted.

Fifty raions out of the analyzed 178 raions of Uzbekistan were identified as being in a critical or a tense ecological situation, from the application of proposed methodology and statistical data. Correction needed to be undertaken for 5-10 years. Most of these raions were earlier assessed as non-problematic. We have found from this investigation that ecologically tense raions are situated in all territories of Uzbekistan as well as in the Aral Sea disaster zone, and in the upstream area also in the Fergana Valley.

Impact of Agriculture, Irrigation and Drainage on the Environment

During the last 30-35 years vast, uncontrolled amounts of mineral fertilizer (500-700 kg|ha) and biocides (20-30 kg|ha) were used, which resulted in soil degradation and declining soil fertility. During the same time both environment and population health was irretrievably damaged. These processes were accentuated by a number of risk factors linked to soil improvement and irrigation (Razakov, 2000; Razakov, 1987):

1. In areas earlier dominated by mono-cultures of cotton and rice cereal, crops are increasing at the expense of alfalfa and fodder crops. These processes are impact to soil fertility, resistance of crops to different diseases.

2. Humus content in soil decreased two times (till 0.5-1.0 %) because of restricting the application of organic fertilizer. Some agronomists are trying to compensate for the deficit of humus in soil by overusing mineral fertilizers.

Spreading of agrochemicals in the environment and their bio-accumulation in different crops, and the balance of nutrient elements was investigated. Approximately 35-40 % of applied nitrogen and phosphorus are used by plants, other parts mineralize to form without becoming accessible to plant roots. Part of them is transported by water, percolates to ground water, is used for irrigation and results in drainage systems and run-off to rivers. About 30-40 % of nitrogen fertilizer transforms by soil microorganisms into gaseous form (N_2O). Phosphorus fertilizer imported from Kazakhstan contains up to 2.8 % of fluorine, as well as mixed microelements – Cd, Cu Pb, Fe, etc. Long-term use of phosphorus fertilizer has resulted in accumulation in soil of uranium and thorium, of which the amount increased by 1.5-2.0 times above the natural geochemical level.

Special experiments were undertaken in Khoresm viloyat on the accumulation of organochlorine pesticides in different crops, depending on pollution of soil in root zone by pesticides. Practically all kinds of plants do accumulate pesticides, but they show various degrees of selectivity for different pesticides. For example, pumpkin does not at all accumulate pesticides, in spite of the potentially high content in the soil. There is also a moderate accumulation of pesticides in tobacco and root-crops, but a high rate of accumulation (DDT, a-HCH, lindan) in cereals, rice and cotton is observed. Regular use of pesticides has decreased the occurrence of beneficial entomophagos and soil micro-organisms. At the same time insects have increased resistance and their population has grown from 2-3 to 15 species. Weed species also increased under the impact of herbicides.

Center "EWM" is also investigating the transport of nitrogen in different soils down to the groundwater (to a depth of 50-100 m) and the accumulation of agricultural and industrial contaminants in bottom deposits of water reservoirs. Accumulation of organochlorine pesticides in lakes was investigated in hydro-systems, mainly in different organs of fish species (Razakov, 1990; Borodin, 1998).
Soil salinization in Central Asia two-fold during the last 15-20 years. The situation in Turkmenistan and lower reaches of the Amu Darya and Syr Darya rivers is even more dramatic; there, moderate and heavy saline land increased 50-60 %. The subsurface groundwater table was elevated to 1-2 m below land surface. At the same time in the upstream areas of the Syr Darya and Amu Darya rivers, the area of saline land does not exceed 10-11 % (Razakov and Nasonov, 2000). Salt accumulation in the root zone demands an annual application of water for the leaching of salt during the non-vegetation period. Water logging and land salinization resulted in that the yield of cotton decreased in Karakalpakistan from 3-3.4 t|ha to 1.0-1.5 t|ha, and in Horezm from 3.9-4.1 t|ha to 2.8-3.0 t|ha. The World Bank estimates that the losses of agricultural production as a result of land salinization in Central Asia is 0.5-1.0 billion USD.

The amount of drainage water leakage is very high compared with other rivers of the world (Nile, Indus, Murray-Darling, etc). It reaches 30-60 % of general freshwater withdrawal from rivers. The volume of drainage water contains 130-140 million tons of salt, mainly mobilized by evaporation from deep geological strata. The volume of salt which was released by rivers (20-25 mln. t.) to the Aral Sea till 1960 – period of balanced development of economy – was thereby exceeded by 5-6 times. About 38-50 % of total volume of drainage water polluted by agrochemicals run-off to the rivers, thus decreasing the quality of irrigation and drinking water in down stream parts of the rivers, causing diseases among the population (Razakov, 1999).

Water Saving Technologies in Irrigated Agriculture

The increasing deficit of water resources in Central Asia is resulting in a need for the application of alternative water saving technologies in irrigation, recycling of wastewater, and (mainly) drainage water for irrigation of salt tolerant fodder crops and greening of desert territories. In this there will be a need for using different methods of improving quality of irrigation water, including using surface and groundwater, etc.
Some of these proposals have been tested in Center "EWM"

1. Combined hydroponic irrigation in open air was tested on one hectare of saline sandy soil with shallow subsurface mineralized groundwater not far from city Nukus. The system consists of a head installation with pump, filter, mixing tank, supply and distribution polymer wavy tubes which are 63-mm diameter. Irrigation tubes at a spacing of 0.5-1.0 m perforated by holes (diameter 0.3-0.8 mm) irrigate two furrows (flumes) with plants. Furrows were lined by polymer film coats and filled by a mixture of humus, sandy soil and sawdust. In the pilot station 14 crops of vegetables were tested. Total irrigation demand was 5600 m^3 per hectare, which is 1.3-1.5 times less than traditional irrigation. The tomato yield in hydroponic irrigation was 3.75 $kg|m^2$ as compared to 1.75 $kg|m^2$ in soil (furrow) irrigation. An optimal irrigation and nutrient supply of plants increased the efficiency of using solar energy (PRA – photo synthetic radiation activity) 3-4 times. This ecological clean technology doesn't demand soil cultivation, and labor use is reduced 5 to 10 times. It is possible to grow two yields in a vegetation season. The return time of capital investment is 1.3-3.0 years (Habibullaev, Razakov and Kosnazarov, 1998).

2. It was proposed to use drip irrigation of orchards and vineyards, wind-breaking forest crops using mild mineralized water for irrigation (0,8-1,7 gram|litre) with biological drainage of sorghum, glycyrrhiza glabra L. and others in Muinak region. The system consists of a silting basin with filters, pump, and measuring devices. An irrigation net consist of polymer tubes with dripers "Agrodrip" types (German made) with a common length of 2300 m for one hectare area and a diameter 20 mm with trickleis spacing at 90 cm. The system works with an operational pressure of 1.0-1.5 atm for irrigation of 665 bushes of vineyard and 120 apricot trees. The duration of irrigation for sandy loam and light loam soils was 2-3 hours. The time lag between irrigation varies from 1-2 days to 3-10 days. The discharge for each tree and vineyard is 5-7 liters per hour. The growth of plants was intensified by 30% in the leaf area compared to the use of traditional furrow irrigation. Water savings amounted to 40-42.2 % for vineyards and 32.7-40.7 % for apricot orchards. The light dry fertile soils in the Amu Darya delta show a good natural condition to implement this technology

3. Successful results are presented for the pilot stations situated along the Ozerny collector in Horezm viloyat, and the Akbulak collector in Djizak viloyat on sandy desert soils, where drainage water with mineralization of 3-6 grams|litre is used for irrigation. A yield of three varieties of sorghum was reached by additional application of mineral

fertilizer to 140-160 cwt|ha, corn to 180 cwt|ha, melon – 167 cwt|ha, water melon – 190 cwt|ha and sunflower (for grain) – 5 cwt|ha. The optimal irrigation rate was 8-10 times with the total volume of water demand 8000-12000 m^3|ha shown when using groundwater from a depth of 6-8 m (Rahmatov and Razakov, 1991).

4. During three years on the farm "Karakalpak", situated in the Amu Darya delta, experiments of irrigation of sorghum and corn by mild saline water without any drainage systems have been undertaken for 2-3 years. The field was irrigated twice – before seeding with 1500 m^3|ha for the leaching of salt and accumulation of water stock, and a second time with 1000 m^3|ha. After 2-3 years a neighboring territory for plant cultivation was developed. A former saline field was ploughed without seeding of crops and not used for the next 4-5 years. During this time the salt was to leach through natural precipitation. This extensive irrigation may be recommended for developing small farms in a huge territory of the dried delta region using dry drainage. Such methods also are used for growing macrophytes for fodder crops using two times of irrigation, the first one for flooding of macrophytes.

During 1989-1991, Center "EWM" as a coordinator of the practical nature protection measures for the Aral Sea problems, financed by Science Committee of former USSR, organized three pilot stations on the dried bottom of the Aral Sea and attracted botanists, chemists, and forest scientists from the Academy of Science and other organizations on a contract basis.

Positive results were achieved when developing heavy saline clay soils using a technology of salt leaching, ploughing, seeding plants and additional irrigation. Natural desert crop productivity of the plants has been reached after leaching to 0.2-0.4 t|ha. Additional irrigation (one-two times) increased the yield of cultural crops to 1.5-2.5 t|ha when using mild saline water from Muinak water reservoirs (2-4 gram|litre). After two-three years 60-70 % of the heavy saline area was covered by green plants (Kamalov, 1995). After 8 years of interruption Centre "EWM" resumed this promising experiment this year (2000).

Another interesting experiment was done on the marshy solonchaks on the dried bottom of the Aral Sea with seedling halophytes near the sea shore which tolerate to high mineralization of shallow ground water with mineralization (20-40 gram|litre) (Sheviakiva, 1991).

Chemists from Moscow University, local military chemical unit, near Nukus, from Institute of Chemistry and Water Problem of Academy of Science Uzbekistan jointly with specialists of forestry and Center "EWM" have tested new chemical substances for stabilization of moving sand dunes and fixated them in Akpetki archipelago of the Aral Sea floor.

Unfortunately all of these interesting experiments applied for preventing desertification was stopped in 1992, because of break-up of the USSR and lack of financial means in the NIS countries.

5. Laser, magnetic and electric activated methods are used for improvement and treatment of irrigation and drainage water quality (Razakov, 1991, Rahmatov and Razakov, 1991).
6. Six different options of bioplateau using biocenoces of various macrophytes were developed for treatment of huge amounts of collector and drainage water (1,0-50,0 m^3|s), waste water from organic, biogenic pollutants, and trace metals, etc. Cleaned water can be used depending of its quality and mineralization for different purpose – irrigation, fish breeding, industry, etc. (Razakov, Rahmanov and Hamidov, 2000).

Bioplateau combined with bioengineering infiltration units and local sorbents can be used for treatment of surface water for supplying rural population by drinking water. Such systems have been built in the settlements of Porlatau and Hodjeili and are now under operation.

Perspectives of the UNESCO Vision Program for Uzbekistan (2025)

The initiative of UNESCO (1999) directed to mobilize action of scientific potentials of Central Asia countries to overcome the deep social-economic crisis in the Aral Sea Basin has initiated the work on developing long-range prognosis. A national group of scientists of Uzbekistan in the framework of UNESCO VISION program, has worked out a possible future of the country in 2025 (Razakov, Kajimov, Nasonov, Hasanhanova, 2000). The group elaborated measures for a sustainable use of water resources, development of economy, and a stabilization and improvement of the environmental situation by 2025. In optimistic scenarios, by efficiently using the scientific potential, progressive agro-technics, technical innovation, and application of water saving technologies, increasing crop yields are demonstrated. This would increase GNP by 3.0-4.0 times, which would transform Uzbekistan into an industrial-agrarian country, with a self-supply of the population of balanced food products. This would require a water use of 55-61 km^3 for a population of 38 million (2025).

Conclusion

1. The complicated social-economic situation in the countries of Central Asia and Uzbekistan is taking place because of transition to market economy and ignoring the ecological consequences of the realization of large projects, a cost that is assessed to be 20-30 % of GNP.
2. Desiccation and shrinking of the Aral Sea, increasing desertification in surrounding areas, high level of population morbidity, low levels of living standards, poor quality of drinking water and sanitation are some results of the unsustainable development of economy in the last 30-40 years in Central Asia.
3. Inadequate monitoring of natural resources is not reflecting the real environmental situation. Application of the method of environmental zoning for the territory of Uzbekistan shows that more than 50 % of the population of Uzbekistan lives in a tense ecological situation.

4. Modern technologies and innovation developed by local scientists and international organizations are being implemented very slowly, including water saving technologies in the field of optimal using water and land resources, which is disturbing the economic growth.
5. The UNESCO Vision program for Uzbekistan (2025) demonstrated in optimistic scenario of possible sustainable growth of the economy of Uzbekistan by optimal use of natural and labor resources, with a changing demographic situation, and by increasing crop productivity: 3.8 t|ha for cotton, 5-6 t|ha for cereals. It is possible for an optimal use of the same volume of water as today to fully supply the population with food and provide water for the requiring economic sectors, and yet to save 3-4 km^3 water for environmental measures.

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FORMULATION AND ANALYSIS OF REGIONAL STRATEGY ON LAND AND WATER RESOURCES MANAGEMENT IN THE ARAL SEA BASIN

by Vadim Sokolov

Introduction

The Aral Sea Basin includes territory within the five countries: Kazakhstan, Kyrgyz Republic, Tadjikistan, Turkmenistan and Uzbekistan. This is a region of ancient irrigation, where fresh water has been vital to life since the earliest human occupation. The large-scale irrigation development in the second half of the XX centure has changed the hydrological cycle in the region and this has created serious environmental problems here. The actual irrigated area now covers 7,948,100 ha (or 5.1% of total territory). The unexpected collapse of the Soviet Union in 1991 added socio-economic problems. The countries are now in a phase of deep socio-economic transition, absorbing the effects of the collapse of the Soviet Union and the shift from a centrally planned to a market-oriented economy.

The Current Situation

The common aspiration of the Central Asian states to adopt new forms of economic development has been accompanied by changes in government priorities. In the past, most attention was paid to irrigated agriculture, but now each country has selected its own course for survival.

Kazakhstan has used a “shock therapy” to transition by removing subsidies to agriculture, and by creating the possibility for all new farmers to openly compete in the world market. The majority of industrial enterprises were privatized, many of them with the participation of foreign investors. The oil sector became the principal sphere of governmental interest.

The Kyrgyz Republic, with almost a total absence of sources of fossil fuel, identified hydropower production as a first priority for ensuring self-sufficiency. In agriculture, the approach has also been to privatize farming and minimize the support from the government. Political instability has delayed government regulation in agriculture and industry, but even under the current conditions agriculture did not decline significantly.

Turkmenistan and Uzbekistan followed a path of a much more gradual transfer to privatization in agriculture and industry, but economic weakness reduced attention for the water sector.

Tadjikistan has been threatened until recently by political instability. The transition process began only one year ago but suffers from a very difficult economic situation.

Towards the New Water Resources Strategy

The water management requires a new legal basis because the rivers in the region have become transboundary. The new inter-state agreements and procedures are to be developed in accordance with international law as well as taking into account local traditions and experience. The five Central Asian nations have taken the first steps to respond to this need and overcome the inter-regional water problems and minimize ethnic tensions. On September 12, 1991, the Water Resources Ministers of these countries declared that henceforth joint water resources management would be established on the basis of equity and mutual benefit, which is consistent with modern legal approaches in international water affairs as enunciated, for example, in the Dublin Principles (1992 International Conference on Water and the Environment) and the 1997 UN Convention on Non-navigational Uses of International Watercourses.

On February 18, 1992, the countries signed a second inter-state agreement stipulating that water allocation should respect the historical uses and that the two technical river basin authorities (BWOs) should continue to operate but now under the control of the newly established Interstate Commission for Water Coordination (ICWC). All the water resources of the region (surface, underground, drainage) are divided into either transboundary courses which are located on the territory of two or more countries, or national ones, located on the territory of one country and not interacting with the transboundary waters.

Each country has the right to manage its own national resources as well as part of the transboundary water within limits agreed with the other countries, and based on the principle that no damage should be caused. In addition, the Aral Sea and its deltas were defined as an independent sixth riparian with their own water rights. All transboundary water was declared the object of common ownership by all riparians, and its development, protection and use should be carried out on the basis of inter-state agreements by the inter-regional bodies, according to the national requests and regional interests.

A legal framework emerging

Nonetheless, the existing documents do not yet ensure proper water use and control. This is due to the fact that the existing framework agreements do not comprehensively cover all the important technical and financial issues and eventualities that emerge from this transboundary water management. For instance, water flows to the Aral Sea are not yet ensured, emergency conditions are often allowed to occur, and, overall, water use is still inefficient. Therefore, the legal documents must be further expanded upon. They should elaborate the mechanisms for their fulfillment with due regard for regional traditions as well as international standards. Legal support should include a system of normative technical documents that specify all technical aspects of water use and consumption, and what are deemed permissible impacts of human activity on the environment. They should develop rules for the preparation, adoption and implementation of decisions. In 1996, a first start was made for the establishment of this codex.

Besides the legal framework, a vision and strategy at the regional level are crucial to identify and resolve conflicts over water issues. Major conflicts can develop between (i) the zones of flow formation and deltas; (ii) the water users and the environment; and (iii) irrigation and hydropower. The following basic matters in particular require further study and clear definition in the international documents:

- The principle of *equity* in the use of water, and how to operationalize this principle.
- The criterion of *efficiency* in the use of the common water resources.
- The principle that the *regional interests have priority over national ones*, and how to ensure this principle is effectuated.

Policy provisions to prevent conflict over water resources management

Among the key solutions to the basin problems the legal documents to regulate the water resources management and their use have priority. Such legal documents should specify the countries' obligations that can be enforced through a court of law. The legal framework that should support the water management strategy should comprise policy provisions that clearly and unambiguously regulate both phases of the development and the implementation of the water strategy, thus serving as guidelines to prevent or minimize conflict in all eventualities that may arise in the water resources management. These documents should preferably cover the following issues:

- Inclusion of all waters of transboundary nature (surface, groundwater and return flow) under the authority of the ICWC.
- Specification of the BWOs' functions and structure with due regard for the concept, currently being developed, that aims at embracing the entire channel of each river by its BWO.
- Rules for joint use of common water resources.
- Legislation and standards on water quality, and qualitative and quantitative standards restricting discharges.
- Procedures for the decision-making by inter-state bodies.
- Procedures for settling disputes and arbitration.
- Specification and accountability for violating abstraction limits, flow regimes, water pollution and for failure to feed water into the Aral Sea.
- Protection of structures and waterways which are of international importance.
- Assigning responsibility for information exchange.
- Technical and operational procedures for the collaboration on transboundary rivers, lakes and waterways.
- Procedures for the determination of damages and for their compensation, including compensation for flooding, water pollution, etc.

This is a large agenda that inevitably will require much technical work and negotiation. However, the foundation for this work was laid by the *Fundamental Provisions of the Strategy,* which has been agreed upon by ICWC, and the Governments of Kazakhstan, Tadjikistan and Uzbekistan, as well as, with some comments, by the Kyrgyz Republic and Turkmenistan.

As follow-up, the International Fund for the Aral Sea Saving (IFAS) and ICWC, assisted by legal advisers from the European Union, drafted a set of basic agreements:

- Agreement on the status of the organizations within the IFAS.
- Draft agreement on institutional strengthening of the ICWC organizations.
- Draft agreement on the formation of regional, national and basin-based information systems and the exchange of information.
- Draft agreement on “Water use from transboundary waters”.
- Draft agreement on “Planning of joint interventions on the transboundary rivers”.
- Draft agreement on “Water quality and the ecological sustainability of the rivers”.

The first text was approved by the Board of IFAS in 1997 and confirmed by the Head of States on April 9, 1999. The second and third drafts have gone through a long process of negotiation, and the final versions will be submitted for endorsement to the next meeting of ICWC mid-2000. On the water use agreement, it was decided after five unsuccessful negotiation rounds to prepare separate agreements for each basin, and these are now only in a preliminary stage.

Tools for Water Resources Management Strategy Analysis

The Water Resources Management Information System (WARMIS) was created in 1995 by Scientific-Information Center of ICWC (SIC ICWC), the BWOs and foreign specialists, sponsored by the European Union TACIS Program. This system consists of three regional (SIC ICWC and BWOs) and five national nodes within the common network and permit permanently exchange information related to water resources use in an agreed format. The system covers:

- historical data for all rivers for a period of about 90 years;
- annual and monthly water allocations and use since 1986;
- administrative sub-divisions, land use, and irrigation and drainage data since 1986;
- socio-economic data; and
- GIS covering the most parts of the irrigated area in the region.

In WARMIS version 1.0, the sub-databases contain primary as well as secondary information. Grouped according to subject, the following sub-databases are present:

- Administration; containing basic data and reference codes on administrative and political boundaries, planning zones.
- Land; containing periodical data on land capability, groundwater level, mineralisation of soil and groundwater.

- Water; containing basic data and reference codes on rivers, lakes, reservoirs, hydrological objects, irrigation and drainage networks; periodical (monthly) information on water flow/distribution and reservoir volumes.
- Water Quality; containing periodical (monthly) information on quality of water in rivers and outfalls (in future will contain water quality data for intakes, transboundary transfers, collectors, wells and escapes).
- Climate; containing basic and periodical (monthly) data on weather and climate.
- Industry; containing basic data on non-irrigation water users and periodical (monthly) data on water use.
- Economy; containing information on economic indicators, market prices for agriculture, and water management costs.
- Hydropower; containing basic information on hydropower and thermal power plants, power generation and consumption.

Other sub-databases under development are:

- System, containing information on the WARMIS database version, on clients and contracts, and on authorisation levels for users.
- Planning Zone Water and Salt Balance Model; containing input/output data.
- Planning Zone Economic Optimisation Model and River Basin Model; containing user defined input parameters and secondary input/output data for these models.
- Meta Database;
- Agriculture; containing secondary data based on analysis results and output from WUFMAS and agricultural models, to provide information on water productivity in irrigated agriculture.

All sub-databases within WARMIS are linked with each other by the common unit: planning zone.

The Water Use and Farm Management System (WUFMAS) was organized with the assistance of the same donors. It comprises a unique system of observations and analysis of the irrigated agriculture at farm level. Initially, WUFMAS covered 36 representative farms in the five countries. All observations were carried out by national groups of specialists, who collected the technical, biological, agricultural, hydrological, managerial, economic and social data related to agricultural production at the farm level. Also, the water and land use, the efficiency and finances, and the contents of the work are observed. The regional team prepares the analytical reports on the basis of this data. These reports then are disseminated annually among the five states. In 1999 the observations were changed to include indicators for the improvements in productivity of water and land covered only 9 representative farms in the five countries.

System of Models

The program for development of system model's was elaborated by SIC ICWC (V.A. Dukhovny and others). This program consists of a set of models:

- Three river basin models (Amu Darya, Syr Darya and Zeravshan);

- Model of planning zone, typically adopted for each planning zone in the Aral Sea Basin;
- Models for national water policy, which satisfy water demands of each State, depending on their socio-economic development.

This set of models can be adopted to assist in the creation of a methodology and data on an interconnected base which will support the next phase of modelling:

- for future development at the regional level as a tool in the preparation of Regional Water Strategy;
- for future development at the national level as a tool in the preparation of National Water Strategy;
- for multiyear flow regulation by ICWC and for BWO multiyear planning;
- for annual planning of water allocation and correction of this planning in interests of BWO;
- for operational tasks of water management by each BWO.

The elaboration of basin modeling system for future development at the regional level, and modeling of planning zone and operation work for BWO, was began by SIC ICWC together with the Ministry of Agriculture and Water Resources (MAWR) of all states during the WARMAP-2 Project. In addition, modeling of the basin for annual planning purposes was carried out by SIC ICWC, BWOs, national teams and Energy Dispatch Center under the USAID EPIC Program.

National and regional planning modeling for water resources development in each country was worked out by a team from SIC ICWC with use of the "Globesight" methodology (Prof. Messarovich) with incorporation of some corrections. On the basis of this tool the different options of the regional development were prepared within the framework of "21 Century World Water Vision ".

The completion of these as a tools for ICWC and BWO will permit to organize the proper water management and operations in real time and, in the future, for priorities definition of the national planning for water resources development.

Future Outlook

Under current trends and conditions the region will have not more then 1500 m^3 per capita by 2030, in comparison with 2700 m^3 at the present time. From this fact the region could be characterized as a region undergoing gradual degradation. This may give the impression that it is hopeless to expect future improvements in the region. However, it is not hopeless and a possible action program could be based on the following:

- Ancient water use was based on the valid use of water for the benefit of the whole society. Unfortunately, the traditions and customs in water allocation, use and conservation have been partially lost. Now in the irrigated agriculture a strict control should be established ensuring equal access to water for everybody and proper operation and maintenance of the infrastructure.

- Historically water use was based on water saving and the prevention of pollution.
- Water use in the region could be improved with orientation to the best methods of water use and management under similar conditions abroad (Israel, Jordan, western states of the USA, Spain), or regional experience in some advanced irrigation schemes. The analysis of water allocation and water losses on different levels of management shows that it is possible to set a strict limitation of water use for all the countries in accordance with the 'criterion level of the best water use'. This guide is very high, but it is required for the benefit of future generations in the region.

The "Globesight" Model

Using the modified "Globesight" model there were tasted three prospective scenarios of water resources development: (a) optimistic; (b) intermediate; (c) no change future.
The optimistic scenario includes the following:

- Region will develop on the base of integration processes which are being elaborated by the governments of all countries;
- Mutually beneficial use of transboundary water resources on base of water saving and common environmental approach;
- Mutually beneficial development of agricultural sector with maximum stress on beneficial crops specialization;
- Agreed processing of agricultural production;
- Economic growth will be provided by development of industry and services.

Intermediate scenario foresees the following:

- Integration processes in transboundary water resources management will be developed slowly;
- There will not be crop specialization and agreed processing of agricultural production.

No change future scenario includes the following vision**:**

- Regional development will continue under current tendencies in joint transboundary water resources management and integration of agricultural sector;
- Main efforts of the countries will be directed to local water resources conservation.

The following table presents results of those three scenarios testing.

Table. Total Water Demands in the Aral Sea Basin (Billion cub. m)

Scenario	Time Horizon					
	2000	2005	2010	2015	2020	2025
Optimistic	119.1	106.5	94.5	93.1	92.1	92.0
Intermediate	119.1	111.0	102.8	101.6	100.6	100.2
No change	119.1	120.6	121.8	123.3	125.0	126.8

Conclusions

From the above mentioned scenario analyses it is clear, that only the following main principles could ensure future progress in the water sector and irrigated agriculture**:**

- Improve co-operation of governmental and non-governmental organizations on the management of trans-boundary river basins. In this context, rules and financial conditions for common water use and conservation should be adapted.
- Develop common political approaches and measures for preventing transboundary water pollution. Water quality improvement is needed for effluent from urban, industrial and agricultural users.
- Develop and implement (inter-state) regional investment projects, attract funds from international and bilateral donors for a well balanced use of water in the Aral Sea basin.
- Gradually reduce surface water diversion and increase the water demand of the environment of trans-boundary rivers and the Aral Sea zone as natural consumers (water user).
- Develop and implement measures for creation of a sustainable ecological profile around the Aral Sea.
- Develop a plan for a common agricultural market in Central Asia. This plan should include the regulation of custom procedures, import tax, etc.

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ARAL SEA - WATER VISION AND FRAMEWORK FOR ACTION: LESSONS FROM PAST VISIONS, YESTERDAY'S HYDRAULIC MISSION AND LOST POLITICS

by J. A. Allan

Abstract

The study contrasts the period of Soviet water management inspired by the assumption that Nature could be controlled with the remedial approaches of the 1990s when the environment and notions of efficient natural resource development gained a voice and were prioritised. The search for a viable environmental and socio-economic strategy since 1990 in the very different and complex hydropolitics of the Aral Sea Basin without Moscow has proved to be very challenging. The Soviet government imposed its lethal hydraulic mission but had a certain detachment in mediating the contending interests of the five republics using the shared surface waters of the region. The Aral Sea Basin was one of the regions targetted for consultation and review for The Hague Global Water Forum in March 2000 (GWP 2000). The Vision Process of the World Water Council (WWC 2000) and the Global Water Partnership in its Framework for Action programme (GWP 2000) prepared keynote reports for Forum. This study will summarise the *Vision* and the recommendations of the *Framework for Action* with respect to the Aral Sea Basin after outlining the recent evolution of global discourses on the allocation and management of water.

The Aral Sea Basin and shifting water management paradigms

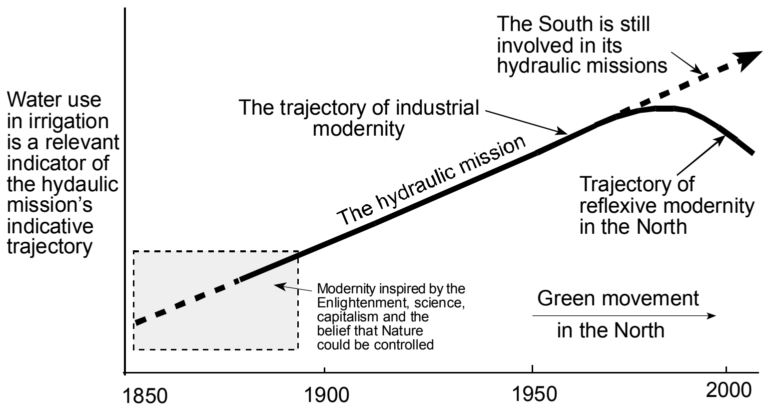
The Aral Sea Basin environmental history of the last two decades of the twentieth century climaxed in an extreme emblematic event (Hajer 1996). Nature normally takes the credit for leasing extreme droughts and floods that concentrate the minds of water users, politicians and the media. Converged awareness provides windows of political opportunity (Kingdon 1984) enabling the devotion of national resources to enable the introduction of management practices that are considerate of water and the environment and reform the use of water in the economy.

In the Aral Sea Basin responsibility for the extreme impact on the region's ecology was not Nature but the grand political vision inspired by the hydraulic mission of the planning authorities in the Former Soviet Union. The purpose was to control and redistribute the waters of the Amu Darya and the Syr Darya rivers. The Aral Sea Basin project involved five political entities subordinate to Moscow. The project could not have been envisaged without Moscow's hydraulic mission and could not have been implemented without the political structures of the Former Soviet Union. Customary arrangements to allocate and regulate the use of water developed over centuries were replaced. Until the first decades of the twentieth century village committees had laid down strict laws governing water use and controlling access acording to Muslim traditions (Dukhovny 1999 p 2)

Figure 1 illustrates the concept of the twentieth century hydraulic mission (Swyngedouw 1999) of industrial modernity (Beck 1992) in the economies of the West. In the event both the liberal political economies of the West and the socialist political economies of the FSU very thoroughly subscribed to the ideology of the hydraulic mission. The ideology was based on the notion that nature could be controlled by applying the combined power of science, engineering and investment. The investment was public, and carried out by public bodies in both the West (Reisner 1993) and in the Former Soviet Union. The wisdom of the hydraulic mission was first questioned in the United States by the green movement in the 1960s. By 1976 water in big projects had become an issue in serious contention in Washington (Carter 1982, Reisner 1993).

In the period between the mid-1970s and the mid-1980s the trajectory of water use changed in the Northern industrialised semi-arid regions of the world as policy makers and water users became more reflexive first, to the needs of the environment and secondly, to the arguments of those advocating the economically efficient use of water. (Allan 2000)

Figure 1 The hydraulic mission, industrial modernity, reflexive modernity



Source: based on Beck 1992, Giddens 1990, and Swyngedouw 1999

The period of the Soviet Aral Sea hydraulic mission achieved substantial increases in agricultural production but also caused environmental degradation (UNESCO 2000 p33). The mission of the 1960 to 1990 period was superseded by a new political ecology after 1990.

'Since 1990 the region has gone through a difficult process of political and economic transition. As the previous political and economic value system broke down it was slowly replaced by a new one. Social, philosophical and ethical values also changed.' (UNESCO, 2000, p33)

The discourse that led to the more reflexive political ecology became prominent as well as globally eveident with the fall of the Soviet Union. Yesterday's hydraulics could not, however, be totally abandoned because so much economic activity and so many livelihods depended on them. Nor could the original vision of the Aral Basin Project be totally abandoned.

The most important change in the new political ecology was not so much a new environmental vision but the change in the way the riparians related to eachother. (Chazournes 1998, Nanni 1996, Dukhovny 1999) Without the overarching authority of the Soviet Union which had subordinated the self-interests of the five Central Asian republics, riparian relations were transformed. Contention became much more salient. Compensatory mechanisms which had, for example, worked effectively to ensure that downstrean Uzbekistan received timely summer water from Kyrgyzstan which was in turn compensated with inexpensive winter thermal power generated in the downstream republics, no longer were effective. Measures to price transboundary flows previously part of reciprocal arrangements over energy to a downstream riparian have been met with non-cooperative responses in the energy sector (Vinogradov 1996 and Vinogradov et al 1999). The new political ecology of the Aral Sea Basin in the 1990s has been one where yesterday's hydraulic mission has been modified and yesterday's politics have been lost.

Vision and Framework for Action 2000: Global and Aral Sea Basin Experience

Two closely related and internationally inspired processes to develop a new vision and a supporting framework for action for water were launched in 1998. These were the *Vision* and *Framework for Action* preparatory activities for the Second World Water Forum in The Hague in March 2000. The initiatives resulted from the frustration of the international water community, especially the multi-lateral and bi-lateral donors, that the United Nations 1992 Rio environment and development conference (UNCED) had subordinated the palpable and easy to measure global water crisis to the contentious and possibly unresearchable challenges of climate change and biodiversity.

The progress made in Dublin in February 1992 in developing the Dublin water principles for the Rio event had not proved to be the foundation for an international campaign to promote water policy reforms (Biswas 1999). The pre-Hague activities were deeply rooted in the reflexive ideas adopted widely in the North during the 1970 to 1995 period. These ideas had been articulated in 1992 in the Dublin principles, namely first, water resources are finite and managing them carefully was integral to the achievment of a secure environment, secondly, water should be managed in participatory systems, thirdly, that women play a central role in managing water and fourthy, water should be viewed as an economic resource. These ideas that environment should have a voice – 'resource as source' – and that water should be valued as an economic input and priced accordingly in privatised entities were central to the *Vision* and *Framework for Action* reports. The vigour of the message of the importance of water use efficiency is captured by the comment in the *Economist* magazine on The Hague event.

> *'Even then, private-sector participation can make a difference. In setting up a contract, argues the World Bank's John Briscoe, "issues that have long been*

submerged will be brought into the glare of public scrutiny: what is the service level to be provided? How will it be monitored? What will be paid for the service by whom?" This makes the subsidies explicit, the first crucial step to ensuring that they end up with the neediest.' The Economist 31 March 2000

The tensions between the Northern environmental and economic ideals cited above and the Southern political realities were played out both in Rio and in The Hague. The normal subordination of environmental and economic principles to the political realities reflecting socio-political circumstances occurred. Immediate social priorities had more purchase for policy makers in the water sector at the unique global hydropolitical event in The Hague. The contentious political outcome came as a surprise to the convenors and the authors of the keynote papers. After all the consultative preliminaries had been wide and numerous across the regions. The intent had been to focus scarce political and media energy on regional water crises and especially on the urgent need to allocate and manage water more effectively. In practice the occasion demonstrated the political nature of such a worthy process.

The Aral Sea vision report reflected the same political realities. In the Aral Sea vision (UNESCO 2000) there is a recurring sentence 'Willingness by society as a whole to do the necessary work and to accept the financial and eventual social costs'. The willingness of communities to be inolved in and accept change was integral to the health, food and land, environment and water and the livelihoods themes in the Aral Sea review (UNESCO 2000 pp 101-107).

The *Vision* and *Action* processes aimed to raise awareness of the water services needs of the billion people world-wide enduring the absence of domestic water services and the two billion without sanitation. In this they were successful. But the opposition to the additioanl Northern management paradigms, albeit very recently adopted, of environmental concern and economic efficiency came not only from humanitarian and environmental NGOs attending the meeting but also from ministers at the ministerial conference. Representatives of international NGOs perveresly linked visionary environmental and economic priorities to the demonised Northern icons of *privatisation* and *large dams*. Water ministers needed no prompting to be precautionary about water pricing and privatisation. The conference was diverted from the high minded goals of the authors of the *Vision* and *Framework for Action* reports. Their intent was seriously and unfortunately mis-interpreted.

The Aral Sea session at The Hague Forum was embedded in these global discourses. At the level of the Central Asia region the themes of environment and development have been contended more intensely than anywhere else in the world. Numerous members of the global professional and development communities have been spectators. Via the international donor community some of them have even been significant players. The old hydraulic mission approaches implemented by the professionals in the Aral Sea Basin until the end of the 1980s were confronted by the new environmentally sensitive and water efficient approaches. Contention was painfull throughout the 1990s. Conservationist ideologies have contended with more pragamatic ideas. The latter recognise that there must be a reflexive approach to ameliorate the environmental deterioration while keeping in place as much as possible of the livelihood providing agricultural activities.

The regional technical advisory group for the the Aral Sea Basin focused on five policy priorities. These were water for health, water for food, water for the environment, water for the creation of wealth, water for energy production to produce heat in winter and water for peace in Central Asia (UNESCO 2000). These priorities were similar to the four themes identified by the World Water Council's *Vision*, which were, water for *people*, water for *food*, water for *nature* and water for *livelihoods*. Both the global document and that of the Aral Sea were in agreement on the following issues:

> *'The message [of the Vision] .. delivered loud and clear was that we will not be able to feed and quench the thirst of the world's increasing millions of people if we systematically destroy the ecosystems that provide the water to sustain life. Because of the threats of overexploitation, pollution and environmental degradation, we must manage water resources to conserve and sustain those ecosystems—and the water and other goods and services they provide to humankind. We must also take care to prevent a long-term crisis.'*
>
> *'Sustainable development of water resources should achieve more than economic growth—it should achieve equitable development that eradicates poverty. Yet for the third of the world's people who live in absolute poverty, discussing a Vision for Water in the 21st century is a luxury they can ill afford. We must begin addressing their problems of access to water and sanitation with urgency.'*
>
> *'Water must become everybody's business. Democratic participatory processes must be established so that water can be managed locally to meet the aspirations of many stakeholders. Decisions about the relative importance of water's economic, social and environmental functions must be made locally by the stakeholders directly affected.' (World Water Council 2000)*

The Aral Sea Basin governments have been effective in raising the awareness of the importance of water for health and for liveilhoods. Public campaigns have been focused at the school level and a great deal of material in accessible language and illustrations has been developed and circulated.

Conclusions

A major problem encountered in the Framework for Action process is the familiar one of defining the social factors that determine what is politically feasible. No one disputes that achieving changes in the way communities perceive and manage water is much more difficult than installing civil works, water reticulation systems and sanitation. Conventional engineering solutions to water problems are well understood in both the North and the South. Financial and investment instruments on the other hand are easily deployed in the North but not in the South. Institutional reform is relatievly easy to introduce in the North but not in the South. Social engineering is a very poorly understood activity for which there is no professional code and only very poorly developed ideas on how to bring about change.

The enhancement of social adaptive capacity is the essential prelimimary to the introduction of changes that will achieve a sustainable water resource in a sustainable environment, supporting a sustainable society and a sustainable economy. The Aral Sea Basin like all regions can be water insecure in two senses. The economies of the Aral Sea Basin are hydrologically insecure in that the freshwater per head is relatively low compared with neighbouring more humid regions. This is first order water insecurity. The Aral Sea Basin economies are also water insecure in a second sense. They are socially water insecure. They do not have the poltical and social adaptive capacity to develop the institutions, regulate water use or introduce pricing instruments to achieve allocative and management outcomes that balance the interests of society, the economy and the environment. The Vision and Framework for Action activities of the past two years reveal that the necessary analysis has been done in the Aral Sea Basin to identify the problems. The challenge is to develop the tools to strengthen institutions and economies so that a range of public and private sector initiatives can accelarate the rate at which water policy reform is implemented.

At the inter-republic level there is deep awareness of the need for cooperation over the shared surface waters of the Basin. Significant progress was made as early as 1992 in bringing representatives of all the riparians together (Vinogradov 1996). Draft agreements on the joint planning and use of transboundary waters were discussed in 1997 (Vinogradov et al 1999). Legal strategies to address regional hydropolitics have been actively considered (Chazournes et al 1998). But the conflicts of interest are stark for economies that have few degrees of economic freedom with which to make compromises. Remedies to these international problems require that the same kinds of energy and resources be mustered as at all the other levels where water needs to be managed in an integrated way. The global and the Aral Basin technical advisory groups working on their respective *Frameworks for Action* groups noted that political will, social mobilisation and financial investment (IFAS 1993) were needed in equal measure to address the major themes of water for people, water for food, water for Nature and water for livelihoods.

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WATER MANAGEMENT CO-OPERATION: BALTIC SEA – A USEFUL MODEL?

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Characteristics of the Baltic Sea

The Baltic Sea is a semi-closed brackish sea area with vulnerable ecological conditions. It has been characterised as one of the most polluted sea areas in the world. Within the drainage area, which has varying geographical and climatic conditions, there is a population of about 85 million people. These people are very unevenly distributed, with more than 50 million living on the southern side of the Baltic Sea. There are, however, even local areas in other regions with a great population, e.g. St. Petersburg and the Leningrad region, with more than 8 million.

The seven riparian states until the collapse of the Soviet Union 1991 were Finland, Soviet Union, Poland, German Democratic Republic, Federal Republic of Germany, Denmark and Sweden. The iron curtain divided strongly the Baltic Sea into two political regions. Today, the number of riparians is nine, with Russia, Estonia, Latvia and Lithuania replacing Soviet Union and Germany is one united country.

The human influence

The vulnerable Baltic Sea marine environment is strongly threatened by human activities. It started during the 1940s and continued through the 50s and 60s with population growth in areas without wastewater treatment plants or with poorly functioning facilities, industrial development without good treatment facilities and agricultural expansion with excessive use of fertilisers and pesticides. The threats to the water environment are coming from all the countries, but the most acute are the ones from the former socialist states on the eastern, southeastern and southern sides of the sea. Of the 85 million people living in the drainage area in the mid-1990s, 30 million lacked proper wastewater treatment. We found municipalities and industries discharging their untreated wastewater directly to watercourses and coastal waters. The inadequate or total lack of municipal treatment was compounded by the lack of pre-treatment of industrial wastewater, which was discharged to the municipal sewage systems. Agricultural practices, including intensive livestock husbandry, were a major contributor to the high nutrient load. This was also true for nitrogen runoff from traffic within as well as outside the drainage area. Many actions have since then been taken to improve the situation and some progress has been achieved. However, the overall situation is still about the same.

The result in the marine environment is euthrophication, oxygen depletion and the formation of hydrogen sulphide in the deep water, decreased populations of important fish species and threatened species of other animals and marine plants.

Tools for protection and remedial actions

In spite of the ongoing “cold war,” discussions across the iron curtain on intergovernmental co-operation to protect the Baltic Sea were initiated in the beginning of the 70s and resulted in the elaboration of a convention. The first Convention on the Protection of the Marine Environment of the Baltic Sea Area, in short the Helsinki Convention, was signed in 1974 by the then seven Baltic Sea

States. The objective of the convention is to protect the Baltic marine environment against all forms of pollution. In 1992, a revised convention based on the many years of experience since 1974 and reflecting developments in international environmental policy and environmental law was signed. The new convention presupposes that preventive measures must be taken in the whole drainage area of the Baltic Sea.

The decision-making body of the Helsinki Convention is the Baltic Marine Environment Protection Commission, or the Helsinki Commission (HELCOM), an intergovernmental organisation with a permanent international secretariat in Helsinki. In the work of the Commission participates not only representatives of the member states but also IGOs and international NGOs are invited to participate as active observers.

The Action Programme

During the late 1980ies it was evident that the Helsinki Convention had not been the leading star for all the governments around the Baltic Sea and that specific measures must be taken. Therefore a ministerial conference at the level of heads of governments was held in Ronneby, Sweden in 1990. The Prime Ministers decided to elaborate a programme to restore the Baltic Sea to a sound ecological balance. The resulting Baltic Sea Joint Comprehensive Environmental Action Programme (JCP) was approved in 1992. The Programme consists of six major components: Policies, Laws and Regulations; Institutional Strengthening and Human Resource Development; Investment Activities; Management Programmes for Coastal Lagoons and Wetlands; Applied Research; Public Awareness and Environmental Education.

As to the investments in point and non-point source control, the Programme focuses on 132 "hot spots", all land-based pollution sources. The Programme shall be implemented within a twenty-year period, 1993-2012; the financial resources needed have been estimated to be 18 billion ECU, around 20 billion US$.

Implementing the various components of the Programme started in 1993. Of interest is that some NGOs take active part in the implementation process, and concerning the element "Management Programmes for Coastal Lagoons and Wetlands," the World Wide Fund for Nature (WWF) has taken the responsibility as lead party.

Results achieved

Direct positive effects on the environmental conditions have been achieved by remedial actions in industrial and municipal wastewater treatment. Some of these actions have been taken within the framework for the Baltic Sea Action Programme, others can be seen as normal development of production processes within different industrial branches. Still, however, a lot remains to be done.

Of great importance has been the participation of non-governmental organisations and the networks for co-operation they have created between people on both sides of the Baltic Sea. Knowledge, experience and different kinds of hardware has through these networks been transferred to the countries in transition.

Other bodies for co-operation

A number of other bodies for water related co-operation around the Baltic Sea are established both on the governmental level and the non-governmental level.

Baltic 21 is a governmental initiative to jointly elaborate an Agenda 21 for the Baltic Sea region. In addition to the governmental delegations Baltic 21 has a number of intergovernmental organisations, international financial institutions and non-governmental organisations as members. The principle is that all international organisations dealing with issues related to sustainable development are welcome to participate and contribute to the work.

Union of the Baltic Cities, UBC, is an organisation for co-operation among the cities in the region.

Coalition Clean Baltic, is formed of national nature conservation associations to create an organisation which can act as a spokesman for the whole region.

The Baltic University,BU, is a co-operation among universities. BU is elaborating study material, organising courses, co-operating in research, etc.

Other examples of non-governmental organisations active in the region are the Baltic Sea States Subregional Co-operation, Baltic Fishermen Association, Baltic Sea Tourism Association, WWF International Baltic Programme.
Common for all these organisations is that they all have a broad network of contacts within the region and are sharing experiences and knowledge.

Transfer of experiences of Baltic Sea co-operation
The experiences gained from the more than 25 year of co-operation in the Baltic Sea region might be of interest for parties in other water basins in the world. This has e.g. been recognised by the Swedish International Development Co-operation Agency, Sida, in conjunction with its co-operation with the riparian states of Lake Victoria in East Africa. Lake Victoria is suffering from pollution from cities and industries without wastewater treatment, from bad agricultural practices in the drainage area, from over-fishing etc. and the population in the basin is suffering of poverty.

Sida is supporting the Commission of East African Co-operation, EAC, in establishing a legal and institutional framework for environmental and sustainable development co-operation in the Lake Victoria region. In this ongoing work knowledge and experiences gained in the Baltic Sea region are evaluated and the relevance for the Lake Victoria region scrutinised. Representatives of the East African countries have visited the Baltic Sea region, met representatives of Baltic Sea governments, intergovernmental organisations, cities, non-governmental organisations, etc. Seminars have been organised within the Lake Victoria region with the participation of representatives of Baltic Sea organisations and contacts have been established between similar kind of organisations in the two regions. A formal agreement on co-operation has e.g. been signed between Union of the Baltic Cities and Lake Victoria Region Local Authorities Co-operation.
The strategy is to create networks of co-operating parties in the two regions facilitating exchange of knowledge and experiences and possibly also support of various kind to the East African organisations from their northern partners.

The question is if the Aral Sea region could gain from a similar co-operation with the Baltic Sea region?

CONCLUSIONS AND FUTURE PERSPECTIVES - THE OUTCOME OF THE PANEL DISCUSSION

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Background to panel discussion

There is no disagreement that social and political decisions have had a profound adverse impact on the Aral Sea basin including on the downstream parts of its discharging rivers, the Amu Darya and Syr Darya rivers. There is neither any disagreement that this mis-management has resulted in a decreasing water quality as well as decreasing water quantity. Even though historically there has been natural fluctuations in the water content of the basin, as demonstrated in the article by Aladin-Plotnikov, these have been excesserbated by the effect of human activities. And there does not exist any disagreement that depleted quantity and quality of water in the basin area has severe effects on human as well as environmental health, which was shown by Khasankhanova-Abdullaev and by Razakov.

Even though an institutional framework for cooperation exist at political level according to Sokolov, and major donors, including the World Bank, the GEF, UNDP, bi-lateral donors and facilitating UN-expertise, according to Verhoog, are present in the region much remains to be done to turn the negative trend. The Aral Sea Water Vision and Framework for Action brought out with expertise from the region, as presented by Allan, showed elements of a strategy. The Baltic Sea model, as presented by Ehlin could be another way to foster cooperation and building partnership to achieve a more sustainable future.

A panel discussion to focus on important forward-looking issues was held with representatives for the science community: Drs Yusup Kamalov and Izzet Aimbetov, Karakalpak Branch of Academy of Sciences of the Uzbekistan, Professor Tony Allan, SOAS, University of London, UK, Dr Vadim Sokolov, SIC-ICWC, Uzbekistan, Dr Takahito Okumura, Global Infrastructure Research Foundation, Japan; for International NGO, Mrs Görel Thurdin, chairperson for Swedish Save the Children; and for the donor community Mr Staffan Herrström, head of division for Eastern Europe and Central Asia, Sida. The discussion was moderated by ambassador Bo Kjellén.

The focus of the discussion

The panel was to concentrate on what message to bring to the people in the area. How would different parts of society, scientists, national and international NGOs, governments in the area, international donors etc. be able to contribute towards increased water security for people and environment in the area? How would it be possible to establish linkages between the people in the area and large scale projects going on at intergovernmental level? What type of cooperation should be enhanced? What type of projects are the ones most needed?

Issues that were repeated over and over again, both by panel members and by the audience in their questions to the panel were

- the need for cooperation and co-ordination when implementing any activities;
- the need for information sharing with grass root level, awareness building including among decision makers, and education;
- the need for an improved governance structure to coordinate and implement projects, and to build confidence; and
- the need for a redirection of focus in the action programmes from a technical focus towards a more social and health oriented one but within an integrated perspective.

The discussion showed further that there is a need to apply an integrated perspective, both when discussing the root causes and action programmes. There is a need for an increased intergovernmental cooperation but also a much better vertical interaction between international projects and small scale on-the-ground projects.

The existing River Basin organisations, that are intergovernmental, need for instance to be strengthened, both in terms of international cooperation over the shared water resource but also in terms of governance.

The Baltic Sea model for cooperation, with its democratic approach could be stimulating for the Aral Sea region and might increase incentives for a governmental - NGO cooperation, a cooperation involving international NGOs but even more so involving and encouraging local NGOs working close to the people. It is important to recognise the social aspects and the human dimensions, to involve people concerned, to tackle realistic problems, and to regard all partners as equal.

Conclusion

The seminar expressed as its opinion that the following *Opportunities for Development and Cooperation* are important:

1. that the Aral Sea issues would remain on the Stockholm Water Symposium agenda;
2. that to reach efficient and successful cooperation between the partners, governments as well as NGOs, information exchange on existing and future programmes and projects be stimulated;
3. that a participatory approach needs to be applied, such an approach would also encourage democratisation; and
4. that development of cooperative efforts in line with the "Baltic Sea model" could be very useful.