TOWARDS INTEGRATION OF IRRIGATION AND DRAINAGE MANAGEMENT IN THE ARAL SEA BASIN

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Introduction

Integration of irrigation and drainage management in this presentation will be linked to and based on the different management levels in a water control system of the Aral Sea Basin.

This topic is based on on-going studies in the Aral Sea Basin in Central-Asia. In the context of Central Asia, the theme of this symposium is mostly identical with integrating water quantity with water quality management. Water quality includes the non-point source pollution, mainly caused by irrigated agriculture, and the point source pollution mainly caused by industries, cities and municipalities. The non-point source pollution consists of salt and residues from agro-chemicals.

Figure 1. Regional map
The regional map (Figure 1) shows the principal river basins feeding the Aral Sea. The two main rivers, Amu Darya and Syr Darya, are now mainly being used for irrigating some 8 million ha in five nations: Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan. A major off-take is the Karakum canal conveying flow from the Amu Darya to irrigate areas in Turkmenistan.

The following management levels are distinguished:
1. River Level
2. Regional Level, Major Irrigation Schemes (Oblast)
3. District Level (Rayon)
4. Tertiary Unit/Farm
5. Effluent management (Drainage Disposal Schemes)

The options for integration of irrigation and drainage management are discussed for each of these levels.

1. River level

The options for the management of river flows as controlled by the Basin Valley Authority, are determined by the following factors or conditions:

- **regional (transboundary) limitations: or the individual republic's water rights**: every republic has a certain right to delivery of water for mostly historical reasons, related to the capacity of off-take structures and irrigated area; as the now independent states were formerly one nation, the water rights were not based on individual state's interests but on goals set by the Central Government in Moscow for irrigated agricultural production with a correction for local political realities. The choices made were to promote the production of cotton and some other crops largely at the expense of the economic value (fisheries) of the Aral Sea. This inner lake rapidly shrunk as a result of the two major rivers being tapped almost entirely for irrigation.

- **per republic: the individual scheme's water rights**: the agreed schedule of water delivery is related to a predetermined area to be irrigated, and this is related to a targeted crop yield output in the concerning major irrigation scheme. (This major irrigation scheme is the so-called Oblast-level, see par. 2.)

- **forcible return of effluent**: the drainage effluent is partially evacuated to disposal schemes, as evaporation ponds, etc. However, part of this effluent is returned to the rivers and must then be accepted by river water management and included in its operation of irrigation water delivery schedules. This factor is of extreme importance for users downstream of the point where the return flows occur.

- **adequate information system**: the monitoring of river water levels, of river water quality and the scheme's inlet and outlet quantities needs an accurate measuring and communications system to allow the river water management to adjust delivery schedules for optimum water use.

- **scenario's for river discharges deviating from average flows**: as river flows fluctuate daily, mostly depending on rainfall in the upper reaches and on scheme's intake volumes deviating from previously agreed amounts, an alternative water delivery schedule prepared for differing conditions is to be set in operation again aiming for optimum use of available river water.
2. Major irrigation schemes (Oblast)

Figure 2 gives the typical layout of a major irrigation scheme. The management options for the scheme management to integrate irrigation and drainage management include the following:

- **at head water intake:** assess water quality (salinity and point-source pollution): decisions on intake moments and volume depend on agreed schedules, but may be adapted for different circumstances, e.g. when a slug of dirt passes, then the water intake may be suspended temporarily, or whenever the salinity content is judged as too high the same decision may be taken.

- **at the level of the main and secondary canals:** an accurate information system on water intakes by the different main and secondary canal command areas, or districts (Rayons), together with water level and water quality data, provide the necessary tools for the scheme’s water management to optimize the water use given their water rights. The collected data are transmitted to the Oblast’s Water Control Operation Center and are fed into a decision support system that allows the management to operate the scheme’s water delivery system at the highest efficiencies possible and truly integrate irrigation and drainage management. For the integration of irrigation and drainage management this is a very relevant management level as much reuse occurs, with effluent from districts and the large collective farms partially being returned to the irrigation system. This requires careful water quality management to be integrated with the agreed flow delivery schedules.

Figure 2. Typical lay-out of irrigation scheme
• **attunement of demand and supply**: the regular and peak water requirements (leaching doses) and the evacuation of effluent will not exactly coincide with water supply offered and drainage disposal available. This requires temporary storage facilities and emphasizes even more the need to integrate irrigation and drainage management.

### 3. District level (Rayon)

The options for integrating irrigation and drainage management at this level must focus especially on the following issue:

- **reuse and equity**: as the value of water for irrigated agriculture depends on its quality, especially the salinity content, the distribution of flow in the districts over the farms (collective farms or colchozes) requires an in-seasonal and multi-annual assessment and adjustment so that the farms are delivered water of equal average quality to avoid unequal treatment and injustice and to promote equity. There are consequences for the design of the water conveyance system, as flow directions may be seasonally reversed, and for the water pricing in case water charges are levied. Figure 3 shows a typical reuse case, where effluent is blended with water of better quality for subsequent use on more downstream located land.

**Figure 3. Typical reuse case**
• **Effluent disposal:** the remaining drain effluent may be disposed of into wetland water purification schemes, evacuated to evaporation ponds, used in saline agro-forestry systems, or returned back into the river. The options for the management of the major irrigation schemes is dependent on the alternatives possible and allowed for by the river flow management, i.e. the Basin Valley Authority.

4. **Tertiary unit/farm level (Colchoze)**

The management option for integrating irrigation and drainage at the prevailing farms in Central Asia, predominantly the collective farms (colchozes) of a size of 1000-2000 ha, is limited to:

• **Internal reuse of internally produced effluent:** as crops cultivated may allow this, to a small degree reuse may be practiced, after blending effluent with water of a better quality.

Further it is at this level that efficient irrigation, efficient leaching schedules, and minimization of the local salt mobilization, through the optimum design of the water conveyance systems and the sub-surface drainage systems, should contribute to the efficient operation of the scheme’s water control system.

5. **Effluent management**

The water control over the drain effluent must decide over when and where to evacuate this effluent to. The various options are:

• **Evaporation ponds:** in the vicinity of the schemes in low lying areas or desert depressions, the effluent is disposed of by evaporation; also by deep percolation to deep aquifers some disposal is done. They could also be used as temporary storage facilities and be included in the overall effluent management at the national and transboundary level.

• **Wetland water purification systems (WWPS):** effluent of the schemes may pass through WWPS to effectuate a certain purification. Several systems are possible: polder system, flooding system, bank and floating system, see Figure 4. This purification is effective for most of the non-point and some point source pollution, except for the salt content, which may be reduced only slightly or could even increase. More investigation is required to assess the relevance for drainage disposal. After purification reuse of the water may be considered, e.g. after blending with water of better quality.

• **Saline agro-forestry systems (SAFS):** this system is aiming at using the effluent directly for mainly irrigated agricultural production with a sequence of crops that are increasingly salt tolerant. Experience is available from other countries, but not yet in Central Asia. Especially the tree component in the SAFS needs more research on location as it is very climate dependent. The principals of the SAFS are outlined in Figure 5.

• **Return to rivers:** direct return to the main rivers is possible, but significant downstream effects may be present in case downstream users experience too high salinity levels. This also could become gradually worse over the next decennia. It must be integrated with the salt and water management for the whole of the Aral Sea basin.

• **Main outfall drains:** the most expensive but probably most effective alternative is to evacuate the effluent through especially for this purpose constructed large outfall drains that take this effluent to the final destination: the only natural sink with sufficient capacity
Figure 4. Wetland water purification systems

Figure 5. Salt/selenium removal by means of a saline agro-forestry system
in the region viz. the Aral Sea. (Under consideration is the construction of the so-called RBCD, or Right Bank Collector Drain, located along the right bank of the Amu Darya).

**Conclusion**

The integration of irrigation and drainage management should be linked to the various levels of management in a water control system. The responsibility of integration is then clearly linked to the levels where the decisions are taken on water delivery to the water users. Moreover the linkage to investment is then also made very clear as this responsibility should be connected to the same institutions or persons in charge at the respective levels.

Integration of irrigation and drainage management is at the same time integrating water quality with water quantity management. Adequate information on water levels (flow) and water quality monitoring is required for the needed integration of the water management.

Drains are not only used by irrigated agriculture to dispose of the polluted effluent from irrigated agriculture, causing mainly the non-point source pollution, but also by industries, cities and municipalities who add the so-called point source pollution. The non-point source pollution consists mainly of residues from used agro-chemicals and of leached salts as evacuated by the sub-surface drainage systems. This justifies the conclusion that the effluent management, especially in case of reuse requires an integrated water management that is alert on the water quality situation.

Design and the sustainable long-term operation of water control systems must take into account long-term trends of water quality development. The planning of irrigated agriculture and of industrial development cannot be done separately but requires an integrated approach.

Only when the above conclusions are given due consideration in actual management and in future planning, the maximum benefits may be derived from the available water supplies.

**Discussion**

In response to a question from the audience about evaporation ponds, Ir. Denecke replied that these are only a temporary solution on a local scale. It was emphasized that the self-purification of rivers does not represent a solution for removal from the system of common salts. The agro-forestry option and the creation of wetlands were considered questionable, because of the severe winters in the area. It was also mentioned that the loess soils (high capillary rise) in the area and the artesian pressure in the rolling landscape are making the drainage situation more complex.
Session 2 Technical innovations towards integration of irrigation and drainage management

Ir. R.J. Oosterbaan (ILRI). SALTMOD: A tool for the interweaving of irrigation and drainage for salinity control

Dr. Safwat Abdel-Dayem (DRI). DRAINMOD-S as an integrated irrigation and drainage management tool

Dr.Ir. J. Boonstra (ILRI). Constraints and opportunities for integrated water management tools

Dr. M. Bakr Abdel Ghanya (DRI), I. Lashin (DRI), Dr.Ing. W. F. Vlotman (ILRI) and A. El Salahy (DRI). Farmers participation in the operation of modified drainage system

Ir. F.W. Croon (Euroconsult). The choice of crop rotation: An important parameter for creating an acceptable salt balance under minimum water use

Chairman: Prof.Dr.Ir. W.H. van der Molen (Wageningen Agricultural University, emiritus)

ILRI rapporteur: Dr.Ir. Th.M. Boers