Water conservation

Environmental conflicts in irrigated areas: impact assessment in the Tunuyán river basin, Mendoza, Argentina

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Tunuyán catchment

Recent agricultural development of Mendoza’s central oasis region is strongly linked to the flows available from the Tunuyán River. The river catchment is divided into a 54,500ha lower sub-basin and a 81 000 ha upper sub-basin, each with registered irrigation rights. In the early 1990’s, there was a boom in agricultural development in the Upper Tunuyán River command area. Large investment in quality grapevines for winemaking brought about a rapid growth of the cultivated area. It also brought about considerable use of groundwater due to the requirements of pressurized irrigation systems. This study has focused primarily on what happens as the groundwater withdrawal intensifies. The concern is that stream flows from the upper area will diminish and salinity will rise in the waters of the Lower Tunuyán River. This will impact adversely on crops in one of the most important agricultural areas of the province. This article describes a study, financed locally by AMPCOT and SECYT, to develop solutions to this problem.

The problem

The environmental impact of current and potential development in the upper sub-basin on the lower sub-basin of the Tunuyán River has been assessed in a recent study by INA and Cuyo University. The main scenario investigated comprised a 70% increase in the use of groundwater irrigated area cultivated with quality grapevines. This will lower the water table, deplete streams (which are tributaries of the river downstream from the Valle de Uco diversion canal), and transform it into drainage collectors. This will raise the salt content in the irrigation water, which is used to irrigate crops such as peach trees and vineyards that are “sensitive” to salinity, is expected to be degraded. Reduced irrigation water supply in the lower oasis and increased water demand will lead to soil salinization and reduced crop yields. Pollution in the irrigation water may be further worsened due to evaporation of most of municipal wastewater – if the treatment plant capacity is exceeded.

The study

A multi-disciplinary research group studied the physical and socioeconomic characteristics of the area in terms of salt-water balance, irrigation water pollution, socio-economic description of the area, administrative and management aspects, economic aspects, and characterization of production models. Water quality samples were taken from: (i) inlets to the upper area, (ii) outlets from the upper area (iii) downstream at El Cardenal dam (which is the physical division between the upper and lower Tunuyán basins), and (iv) at the Tiburcio Benegas dam (where irrigation water flows into the lower basin).

The cultivated area of the upper sub-basin was surveyed to collect socio-economic and cultural information. The study also focused on agroecological conditions and profitability, farmer profiles, social aspects, and irrigation water management. Environmental impacts were identified, linked and qualitatively valued by means of an “importance matrix” which enabled the more significant negative impacts to be identified and quantified. This lead to an economic impacts assessment from which mitigation and control measures for the area were proposed.

Results

The study found that a sustained increase in cultivated area as well as in the economic activity of the upper basin would lead to the lower basin being affected, and salt content (as is the case of the Colorado River in the Province of Mendoza); and (iii) that groundwater be integrated into water management and pollution control). The economic impact assessment identified that soil salinization and water pollution in the Lower Tunuyán River area would lead to increased water demand for leaching, and would affect the productivity of the irrigated areas. Unnecessary costs are taken; the current 4 500 ha of peach orchards would be lost and grape yields would drop. The financial impact of the losses is estimated to be $30 million per year.

Incomes lost by farmers (in terms of unemployment compensation) would be $3 200 million (US$1900 per ha). Farmers’ contribution to the maintenance and modernization of their irrigation and drainage system would be reduced, and urban migration from the area would increase.

On the basis of these assessments, mitigation measures were developed to control the impact of uncontrolled growth and development in the Upper Tunuyán River. Agreements for the protection of surface and ground water components (“improvement of the canal system, rehabilitation of the drainage system, wetlands, depressions and lagoons etc.”) and “management improvement components” (consolidated basin administration, integrated register of uses and users, training and technical assistance to managers, and strengthening of the control of surface and groundwater users and users).

Recommendations

The outcome of the study were recommendations: (i) that water management be considered at the basin level; (ii) that water be distributed in a proportional and equitable manner on the basis of quality and salt content (in the case of the Murray-Darling Basin in Australia and the Colorado River in the Province of Mendoza); and (iii) that groundwater be integrated into water management (with users’ organizations assuming responsibility for water management and pollution control).
The search for productive bio-saline crops

The search for plants that grow naturally in a saline environment and can be economically cultivated, is still in its early stages. Initially the focus is on indigenous plants from tidal land. There is a question as to what these plants can be used for. As a source of fibre, oil, cattle feed, and specialized vegetables, seems to be the most promising use. Some successes have already been achieved with commercial cultivation of bio-saline crops as vegetables. Other plants that grow naturally in saline habitat have potential uses in coastal protection, erosion control, and the production of ornamental plants and shrubs.

Limitations of salt tolerant or bio-saline crops

All plants and crops have a limit to their salt tolerance. They maintain an optimal production below the threshold salinity. If the salinity rises above the threshold value, production declines and eventually the plant dies. Determining the threshold salinity and the rate of production decline at increasing salinities above the threshold value is complicated by the variation of these values with the growing stage of the plant. For instance, the salt sensitivity of plants is higher during germination and seed-forming stages, and can vary between varieties of the same species. The figure shows the threshold value for three wheat varieties varying from a soil salinity of ECe= 2.1 dS/m for Forage Durum, 8.6 dS/m for the dwarf varieties of wheat. The lists of salt tolerance for crops and conditions will be presented in the next issue of GRID. (River Management) in Central Water Management (France), 14-19 September 2003, three new vice-presidents were elected all of whom have had significant interaction with IFPRI.

Dr. Alan Vidal, at present, Head of Cemagref’s European and International Affairs Office, was formerly IPTRID Theme Manager for Water Conservation in the Mediterranean and North Africa region. Mr. R. Jayaseelan, Chairman of the Indian Government’s Central Water Commission (CWC), was involved in discussions between IFPRI and organisations such as CMAPS in identifying research priorities.

Prof. Victor A. Dukhovny, Director of Cemagref’s European and International Affairs Office, was formerly IPTRID Theme Manager for Water Conservation in the Mediterranean and North Africa region. Mr. R. Jayaseelan, Chairman of the Indian Government’s Central Water Commission (CWC), was involved in discussions between IFPRI and organisations such as CMAPS in identifying research priorities.

The consequence of all this is that if reasonable productivity is to be achieved, then soil salinity levels have to be maintained below a certain value during the growing cycle – whether this be for traditional species, salt-tolerant varieties, or bio-saline crops. Since the values fluctuate during the cycle – whether this be for traditional varieties or bio-saline crops, this means that crops. Since the values fluctuate during the cycle – whether this be for traditional varieties or bio-saline crops, this means that crops. Since the values fluctuate during the cycle – whether this be for traditional varieties or bio-saline crops, this means that crops. Since the values fluctuate during the cycle – whether this be for traditional varieties or bio-saline crops, this means that crops. Since the values fluctuate during the cycle – whether this be for traditional varieties or bio-saline crops, this means that crops. Since the values fluctuate during the cycle – whether this be for traditional varieties or bio-saline crops, this means that crops. Since the values fluctuate during the cycle – whether this be for traditional varieties or bio-saline crops, this means that crops.
**Controlled drainage to improve water use efficiency in semi-arid areas**

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Irrigated agriculture uses about two thirds of all water abstracted from rivers and underground aquifers in developing countries, and in many areas available water resources are already fully utilised. If irrigated food production is to be increased, irrigated agriculture must use water more efficiently.

Research has been undertaken by HR Wallingford and the Drainage Research Institute, Cairo, to develop and test controlled drainage strategies that improve water use efficiency of surface irrigated agriculture in semi-arid areas. Loss of excess water through drainage is a major cause of inefficiency in some systems. Integrating irrigation and drainage management through the use of controlled drainage opens up new opportunities for water savings. This work was funded by the Governments of Egypt and UK (DFID).

Controlled drainage is a practice that allows farmers to control drainage outflows, storing water in the soil profile for use by the crop and reducing it from the drainage area. Drainage flows are managed so that drainage occurs only after the ground water level in a field has risen to the point where drainage is needed to prevent crop damage, or to provide salt leaching. Irrigation applications can thus be reduced, and the relatively good quality water that is “saved” becomes available for use by downstream irrigators.

While improved water use efficiency is the prime motive for the use of controlled drainage in semi-arid areas, there are other benefits, including:

- Improved crop yield
- An increased insurance against crop losses
- Maintenance of soil nitrate and phosphate levels, so that soil fertility is not degraded in high-yielding areas
- Reduced nitrate and phosphate losses to downstream water bodies, reducing the need for nutrient control and the ecological damage to receiving surface water bodies
- Conservation of wetlands and water-sensitive regions.

It is particularly applicable to areas that experience periodic water shortages, and suffer from limited crop production and high costs for water application. In terms of the basin water balance, the benefits are greatest where rice forms a significant part of the crop rotation, and in areas where water quality is poor or uncertain.

The following set of prerequisites apply to identifying land suitable for application of controlled drainage:

- Relatively flat agricultural areas
- Surface irrigation is the main method of water application
- Artificial drainage systems comprising a network of open drains or horizontal subsurface pipelines with suitable access points (such as manholes) in place or planned
- There is an incentive for introducing controlled drainage (such as water supply being sporadic or unreliable in the area, or the need to pump lift water from canals to the fields)
- Crop patterns can be consolidated with respect to drain lines. (This implies that landholdings need to be relatively large, or that farmers are able and willing to collaborate over crop rotations.)
- Farmer organisations are willing to take on the organisational tasks associated with controlled drainage, or can be formed.

**Egypt**

Egypt is one of the countries where controlled drainage is most useful. Significant benefits to the farmer and the wider community. The vast majority of the agricultural land is irrigated (most of it by traditional surface methods) and over 90% is served by artificial drainage systems. The extensive drainage network comprises open drains and horizontal subsurface pipelines, with many suitable access points for operation of controlled drainage. There are certain areas where the incentives for controlled drainage will be attractive to farmers – this includes areas where spills of water shortages impact crop production, and rice areas where savings in water application translate to considerable savings in energy and manpower costs. Farmers groups also appear to be sufficiently developed to facilitate management of controlled drainage across farming areas.

Agricultural production in Egypt relies almost totally on irrigation, so controlled drainage management can be driven by local irrigation applications. Simple controlled drainage devices have been tested that enable farmers to use water more efficiently. Farmers testing controlled drainage under rice in a number of Nile Delta areas have already achieved new water savings in the order of 40%. The main attraction to them was the reduction in irrigation application times. As the water requirements for rice are lower, the farmers even for those dry-foot crops, the potential savings in water application from controlled drainage are also higher. Areas with rice included in the rotation are the ones that will benefit most from controlled drainage.

The use of controlled drainage under other crops is expected to increase as water resources across Egypt become more limited. The major crops within the Nile Delta are sufficiently developed to provide the collaboration required. The necessary soil drainage management across cropped areas would be provided by a marginal drainage management service.

Other countries of potential application include India, Pakistan, Northern China, Uzbekistan, Tajikistan, Israel, Syria, Iraq, Bahrain and Algeria.

**Project outputs:**

A number of reports on the technical testing and potential use of controlled drainage are available. Further details from the authors

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**Salinity control needs for salt-tolerant and bio-saline crops**

Frank Croon

The challenge for the future development of salt-tolerant and bio-saline crops is in creating soil salinity conditions that are stable and within the threshold levels for good production.

What these levels are depends on the characteristics of the crops chosen, but the principles on which this approach can be based are already well known.

Bio-saline crops are generally selected from wild plants in tidal areas where the high, stable, soil salinity conditions are in balance with the salinity of seawater. Modifying tidal areas for agricultural production results in changes to the salinity of soil conditions, e.g. the exclusion of tidal inundation from coastal polders. Consequently soil salinity conditions will change and, if not properly controlled, can rise dramatically. The engineering challenge is to create an infrastructure that can maintain soils at an acceptable and stable salinity (such as making use of the stabilising capacity available from the adjacent seawater).

The agronomic challenge consists of:

- increasing the salt tolerance of the traditional crops while maintaining their productivity,
- selecting stable varieties of economically useful bio-saline crops and (iii) determining the condition under which they can thrive. This includes determining threshold salinity levels for new crops or new varieties as well as their environmental and climatic conditions.

**Background**

- Progressive salinisation of existing agricultural areas, especially the irrigated areas, is a major threat to agricultural production and has negative environmental consequences.
- Salinity in coastal and delta areas, whether or not combined with the scarcity of fresh water, hampers agricultural productivity and development.
- Soil salinity in areas adjacent to the sea are in balance with the salinity of seawater.
- Considerable areas in arid regions cannot be brought into production just because of water scarcity but also because of the potentially high soil salinity.
- Soil salinity in some cases increases in a dynamic process that frequently results in progressive salinisation.

Limiting the use, such as – (i) scarcity of fresh water, (ii) high upfront costs of drainage, (iii) the requirement that large areas are dealt with in one go, (iv) the adverse impact on existing infrastructure, farming communities and agricultural customs, (v) the need for a consistent, disciplined water management (and) (vi) potential pollution of “drainstream” areas by saline drainage effluent.

New approaches to dealing with these problems, and to making salinity areas more productive, are starting to replace the more standard approaches:\n
- Adjusting the crop to the existing environment (e.g. development of salt tolerant varieties)
- Producing cultivation of plants that grow naturally in saline environments i.e. bio- saline crops.

There is often an expectation that expensive and complicated engineering works (and related water and salinity management) can be avoided, and existing farming practices can be continued when salt-tolerant or bio-saline crops are grown. This is unfortunately not always the case - see below.

**The search for salt-tolerant varieties of traditional crops**

The creation of varieties of traditional crops that give moderately good yields under saline conditions in problem areas, is not simple. The threshold soil salinity values of most traditional crops vary in a narrow EC range - from 4 to 8 dS/m. (The threshold value of a crop indicates the soil salinity value at which the crop starts to suffer yield reduction).

The salinity levels occurring in coastal and salinised inland areas are often 4 to 6 times as high as these threshold values. Even barley, which is classified as one of the most salt-tolerant grain crops, has a threshold salinity of 4dS/m which is considerably lower than the soils salinities of 20 to 40 dS/m that are often encountered.

Creating a suitable crop variety that can grow under the prevailing soil salinities in problem areas requires a huge jump in salt tolerance – something that is not just around the corner, if at all possible. So the use of salt-tolerant varieties is not going to be a universal solution for the large-scale saline problems that are threatening world agriculture.

There are however important advantages to the cultivation of crops that have a higher salt tolerance than the traditional varieties. If crops can tolerate higher salinity levels, they will need less water, because leaching rates can be reduced. Furthermore, the system would perhaps be less sensitive to seasonal fluctuations – so water and salt management could be less stringent than would otherwise be required.