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A STUDY OF IRRIGATION MANAGEMENT IN MENDOZA: SOCIAL, INSTITUTIONAL,
LEGAL AND ADMINISTRATIVE FACTORS */

Summary

*/ This paper was prepared by Armando Bertranou, Orlando Braceli, Armando Llop and Francisco Leiva, of the Centre on Water Economics, Legislation and Management (CELA) of the National Institute for Water Science and Technology (INCYTH), as part of the project on horizontal co-operation in the management of water resources in Latin America and the Caribbean, financed by the Government of the Federal Republic of Germany. The views expressed in this report are the authors' and may not agree with those of the Organization.

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PREFACE

This report reflects the findings of a number of research studies carried out both by INCYTH and by other institutions. It should be noted that, in view of the similarities among the studies reported, this paper is actually a summary of a larger one, bearing the same title, in which the issues are dealt with in greater depth and which contains details such as statistical series, maps and methodologies.

The purpose of the study is to analyse the overall context within which existing water resource management structures have developed, with special emphasis on economic and social, institutional, legal and administrative aspects. Within this framework, the authors discuss the characteristics of the present water management system, identifying factors which affect or increase the efficiency of management. Certain guidelines are drawn up, based on elements of the external context which affect the management agency and endogenous elements which characterize it, with a view to improving the management of water as applied to irrigation.

Chapter I describes the resource, water, from the physical standpoint, as well as its connection with economic and social activities, particularly through irrigation.

Chapter II describes the administrative apparatus for assigning the water resources of the province. A brief description is first made of the overall administration of water resources; this is followed by a review of the internal or endogenous characteristics of the agency responsible for managing water as used for irrigation, i.e., the General Irrigation Department and the Waterway Inspection Offices.

Chapter III is devoted to an analysis of the various factors of the external context which have affected the management of the resource, and still do. The first section is devoted to external factors which are beyond the control of the water management agency, while the second section deals with internal aspects of this agency.

Chapter IV evaluates the management of the system, with special emphasis being placed on the changes that have taken place in the external context and on the need for the management agency to introduce into its administrative apparatus certain elements which would enable it to adjust its work to these new conditions.

Finally, chapter V contains conclusions and recommendations that must be considered and implemented in the management of the resource if the social efficiency of the sector is to be improved.

Chapter I

DESCRIPTION OF THE WATER SYSTEM AND ITS ROLE IN ARGENTINA

In this chapter, the water system of the province of Mendoza is described, with reference being made to the characteristics of the surface water; the major water utilization works, canals and other existing infrastructure are also mentioned. The state of underground water and its interrelationship with surface water are also described. The second part provides information on the main economic activities which rely on irrigation, how they have developed and the role they play in the economy of the province.

A. The water system

Mendoza has two well-differentiated zones: to the west is a mountainous region (the Andes), which is more than 180 km wide in some sectors, and plains, spreading to the east from around the centre of the province. Between the two zones is a transitional area known as the piedmont zone.

The scanty rainfall of the province amounts to a maximum of 200 mm per year, which means that the zone is essentially arid. With these levels of precipitation, reasonably profitable production can only be attained by using irrigation.

A superficial cartographic analysis shows that the economic and social development of the province has occurred only in the basins of the few rivers existing there, leaving about 97% of the area of the province as a virtual desert.

1. The water subsystems of the province

The water resources of the province of Mendoza all belong to the endorheic basin of the Desaguadero River. There are five major rivers, i.e., the

Mendoza, the Tunuyan, the Diamante, the Atuel and the Malargüe. The Grande River, to the south of the province, is not yet used for irrigation because the transfer canal would require an investment that would be impossible to meet over the medium term. The irrigated zones in the province are divided among three watersheds: the northern zone, which is within the area of influence of the Mendoza and Tunuyan rivers; the central zone, which is fed by the upper Tunuyan River, and the southern zone, which uses the waters of the Diamante and Atuel rivers. The Malargüe River serves a small irrigated area which does not contribute much to the provincial aggregate.

As they run through highly permeable areas, these rivers feed underground water systems through a natural recharging process. The underground water, which covers the length and breadth of the watersheds, can be extracted by deep-well pumps, so that the existing aquifers actually serve as natural storage dams. In overall terms, it may be said that the province of Mendoza currently has available slightly over 162 m³/sec of surface water, including the water which seeps through the riverbeds and feeds the underground aquifers.

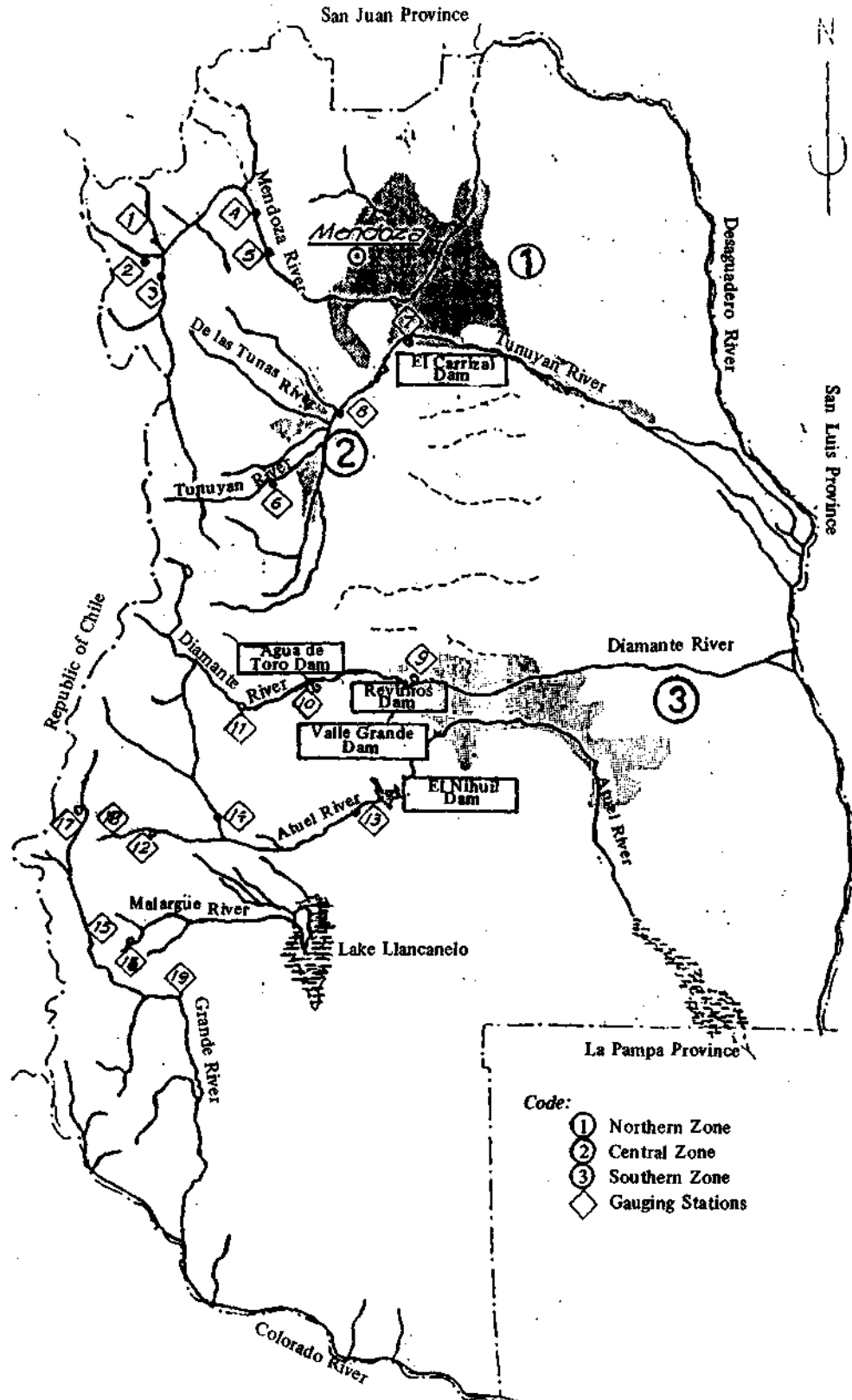
On the basis of available hydrogeological data, it appears that the known store of underground water amounts to around 60 000 cubic hectometres throughout the province. Map 1 shows the province of Mendoza and its main rivers; the three watersheds mentioned above are shown in the shaded areas. Of these, the northern watershed, known usually as the basin of the Mendoza and Tunuyan rivers, has the highest level of economic development.

2. The irrigation infrastructure

The existing water management infrastructure differs considerably from one basin to another. Although the northern Mendoza area is the most developed, it has less infrastructure in terms of large-scale works. There is only one compensation dam, the Carrizal, over the middle Tunuyan River. The Mendoza River only has one major diversion work, the Cipolletti dam, the oldest existing dam. Nevertheless, the Mendoza River offers the greatest potential for hydroelectric generation; the national water and electric power utility plans to develop a project called the Cordón del Plata, in the near future. The important feature of this hydroelectric project is that it provides for an equalizing reservoir downstream from the system, i.e., the Potrerillos dam.

Map 1

MENDOZA PROVINCE: RIVERS, RESERVOIR DAMS, IRRIGATED AREAS AND GAUGING STATIONS



Note: The names used in this map and the presentation of data do not imply any judgement, on the part of the United Nations Secretariat, concerning the legal status of countries, territories, cities or zones, or regarding their authorities, or the demarcation of their boundaries or frontiers.

This dam will make it possible to regulate the Mendoza River and will therefore play a very important role in future as regards management of water for irrigation purposes.

In the southern zone, the water system is completely regulated, and each river (the Diamante and the Atuel) has hydroelectric plants equipped with compensation dams to facilitate agricultural use of water, as well as the necessary diversion works.

In general, it may be said that the infrastructure of diversion reservoirs and dams on the rivers of the province is adequate and is working at full capacity; at present, there are no reservoirs or diversion works with idle capacity.

As regards the drainage and canal system, although it may seem paradoxical, the available data on length of canals and percentage of surfacing on them are not very reliable. Although survey maps do exist for all the irrigated areas, most of them are outdated and do not include a description of the existing condition or type of infrastructure. The areas on which the greatest amount of information is available are the lower Tunuyan and Atuel rivers.

The available information indicates that there are around 3 000 km of primary and secondary canals, including more than 550 km of waterways originating in streams and springs, in the province of Mendoza. The percentage of surfaced canals varies considerably from one basin to another; it appears that the Atuel River basin has 7% surfacing; the Mendoza River, 9%; the lower Tunuyan, 21%, and, finally, the upper Tunuyan, with the highest percentage of watertight surfacing, has 22%. The same sources of information show that there are around 2 200 return ditches in the province.

The efficiency of water use in the province is relatively low. The external efficiency is around 53% for the Mendoza River and 63% for the lower Tunuyan River and the basin of the upper Tunuyan River. With efficiency of water use at the farm level ranging between 62% and 64% on average for these basins, the total water use efficiency comes to between 35% and 40% on average for the different basins mentioned. This is quite low.

With regard to underground waters, information on the northern basin is more complete, inasmuch as greater use has been made of this resource in that area and hence more studies have been carried out. In general, natural recharging has been sufficient to meet the demand for underground water over

time, except for the years 1967 to 1971, when the aquifer levels fell dramatically because of a sequence of hydrologically poor years. At present, there are in Mendoza over 20 000 irrigation wells, mostly in the northern area, where there are more than 16 000 wells. The use of underground water was at its peak between the late 1960s and the mid-1970s, when favourable economic conditions and fiscal incentives gave rise to a considerable expansion.

It is estimated, assuming that pumping equipment is in good working condition, that the capacity for extracting underground water is about 30 m³/sec.

A problem that has arisen recently in the irrigation system is that a succession of hydrologically rich years, coupled with a fall in demand for irrigation water, has produced a surplus of water which has created problems of waterlogging due to water stored in the phreatic layers of the soil. Recent estimates indicate that in the northern zone of Mendoza approximately 60% of the surface soil is waterlogged (water at less than 2 m beneath the surface). This means that additional investments must be made in order to preserve and develop or expand the drainage infrastructure.

B. Economics of irrigated farming

Statistics on farmed areas in Mendoza are scanty and outdated. The 1974 census shows that the cultivated area in the entire province was over 367 000 hectares, of which 230 000 were planted in vineyards. Later partial censuses made by the Bureau of Agriculture show an increase of about 10 000 hectares around 1979. Nonetheless, there has been a considerable reduction of perennial crops during the last decade, and it is estimated that, at present, the cultivated area must total around 306 000 hectares. Of this area, approximately 60% is in the northern basin of Mendoza.

According to the data for 1974, 36% of the total farmed area is irrigated with surface water only, 47% is irrigated with surface water supplemented by underground water, and the remainder is irrigated with wells only.

The gross product of the province of Mendoza has varied between 1.2 and nearly 2 billion australes in 1985 currency. The austral-dollar parity in late 1985 was 1:1. The share of irrigation agriculture during this period has also varied considerably, from levels close to 18% in 1979 to only 2.4% in 1983. These fluctuations in the share of the agricultural sector in the provincial

GDP reflect the instability of viticulture, which is the single major agricultural activity of the region. An analysis of the share of the value added of grapes and wine (wine-making is the main agriculture-based industry in the region) in the gross regional product shows that, on average, it has usually ranged around 20%, with variations of between 7% and 30%. Nonetheless, in the last few years, the share of grapes and wine in the provincial GDP has been quite low, falling to 3.7% and 4.5% in 1981 and 1982. To give an idea of the magnitude involved, it should be noted that total grape production in the province of Mendoza is normally in excess of 2 million tons; of this, more than 97% is made into wine, with the coefficient of kilos of grapes to litres of wine being 0.8.

Since grape production is the main activity requiring water for irrigation, the fate of the development of water resources has been linked to the vicissitudes of winegrowing. It is no coincidence that at present, after almost a decade of profound crisis in the grape and wine industry, virtually no investment has been made in irrigation infrastructures, even to provide adequate maintenance to the existing system; this has led to a gradual deterioration of this system.

Chapter II

WATER MANAGEMENT MECHANISMS

This chapter describes the water management system of the province of Mendoza. The first part presents an analysis of the overall water management system of the province, while the second part deals specifically with the management of water for irrigation purposes. In this particular case, an analysis is made of the General Irrigation Department and the Waterway Inspection Offices, which are associated with the irrigation system.

A. The overall water management system

A brief look at the structural organization chart of the provincial government shows that there are quite a number of agencies, of different ranks and jurisdictions, which deal with matters directly or indirectly related to the water resources of the province. For example, within the Ministry of Economy, there are the Bureau of Tourism, the Bureau of Industry and Commerce and the Bureau of Provincial Forests and Parks. Within the Ministry of Social Welfare, there are the Department of Environmental Health and the Bureau of Recreation and Social Tourism. In the Ministry of Public Works and Services, there are the Water Bureau and the Department of Water Policies and Co-ordination. Finally, there are the decentralized agencies, such as Energía Mendoza S.E. (Mendoza Power Company), the General Irrigation Department and Obras Sanitarias Mendoza (Mendoza Sanitary Works). The municipalities also deal with matters pertaining to water.

These agencies, which have greater or lesser degrees of specialization, have to do with one or more of the following water uses or services: drinking water and sewerage, irrigation and drainage, hydroelectric power, recreational use, mining use, industrial use, thermal and mineral waters, flood protection,

prevention and control of pollution, groundwater and meteorological information and measurement. In addition to these agencies concerned with the management of water resources, there are many other State agents whose work requires a knowledge of and research on water resources.

The provincial Water Act assigns the following order of priority to the uses of the resource: a) water supply to the population; b) supply to railways; c) irrigation; d) mills and other factories, and e) reservoirs for fish hatcheries or fish breeding. This type of priority is in line with the main uses of water that prevailed at the time the law was passed, but that was more than 100 years ago. This explains why the relative clarity of objectives and simplicity of operation usually associated with irrigation and potable water systems has given way to this complex set of objectives, institutions, and jurisdictions which inevitably requires a tremendous effort, as regards policy-making and institutional co-ordination, in order to achieve an adequate level of efficiency in the overall management of water resources.

B. Irrigation management in Mendoza

The Mendoza Water Act was enacted in 1884; hence, it reflects the economic and social situation of that period in history. Although this Act does not set down specific definitions as to the ownership of the resource, it is understood, from the constitutional and doctrinal standpoints, that the waters belong to the province, that they are an inalienable property which cannot be sold, and that this ownership does not expire nor can it be acquired through use over time.

As time has passed, this legal structure has proven to have certain shortcomings, because of its failure to include new dimensions as they arise. Thus, in 1974, additional laws were enacted to regulate groundwater.

1. Administrative structure

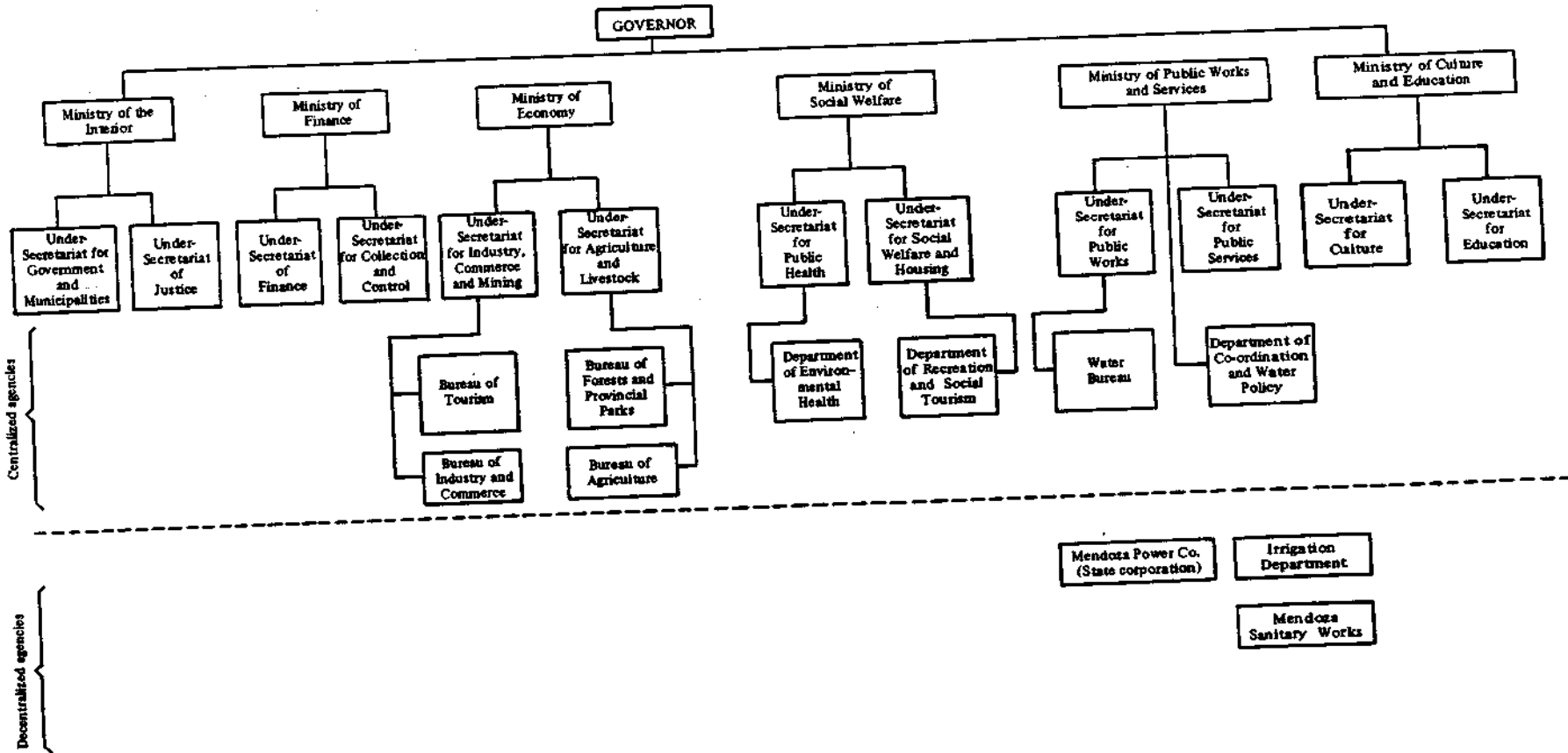
In Mendoza, two institutions are responsible for surface waters, i.e., the General Irrigation Department and the Waterway Inspection Offices. The sphere of competence of the General Irrigation Department, or central water administration agency, is, essentially, the rivers, diversion dams and master canals. The Waterway Inspection Offices, on the other hand, are responsible for administration of the irrigation system as such. There are Waterway

Inspection Offices organized at the following levels: secondary canals, known as canals; tertiary canals, or branches; quaternary canals, or subsidiary ditches (hijuelas), and so forth. Thus, they are called First Degree, Second Degree, Third Degree and Fourth Degree Inspection Offices.

As regards organizational structure, the General Irrigation Department, which is concerned especially with water management for irrigation purposes, has constitutional rank and is functionally decentralized. It has no hierarchical link with the provincial executive power, but rather has a purely functional relationship with it. It is financially self-sufficient, as it is empowered to approve its own budget of expenditures and estimates of resources, as well as to set the different rates to be charged for its services.

The General Irrigation Department is made up of three bodies with well-defined functions. In the first place, there is the Honourable Administrative Tribunal, which is the body responsible for establishing the agency's policies; thus, it approves the budget, sets rates, appoints staff, and so forth. The outstanding feature of this body is that it is made up of a representative of each irrigation zone and the superintendent, all of whom are nominated by the provincial executive power and ratified by the Senate. The second body is the Honourable Board of Appeals, which is the highest level at which an appeal can be made against the decisions of the different levels of the administration. This Board is made up of the same people who are members of the Honourable Administrative Tribunal, except the superintendent. Finally, there is the superintendent himself, who heads the body responsible for executing the water policies established by the Honourable Administrative Tribunal. This is the executive agency and its structure consists of a central and a decentralized administration. The central administration has a technical secretariat, a secretariat for administration and finance and a secretariat for institutional affairs. The decentralized administration is made up of regional offices, as follows: Mendoza Regional Office, Upper Tunuyan Regional Office, Lower Tunuyan Regional Office, and Atuel and Diamante Regional Offices.

MENDOZA PROVINCE – CENTRAL ADMINISTRATION
 AGENCIES CONCERNED WITH WATER RESOURCES



2. User participation

User participation in the aforementioned organizational structure follows different patterns; basically, there are three patterns of participation. In the first place, for policy-making, participation consists of membership of irrigation users on the highest body of the General Irrigation Department, i.e., the Honourable Administrative Tribunal. In the second place, users participate in the administration of justice, through the Honourable Board of Appeals, which is made up entirely of irrigation users representing each of the irrigation zones. Finally, users participate in the different irrigation zones at the Regional Office level, through the Honorary Boards of Irrigation Users, which assist the Head of the Regional Office and also serve as a link with the Waterway Inspection Offices.

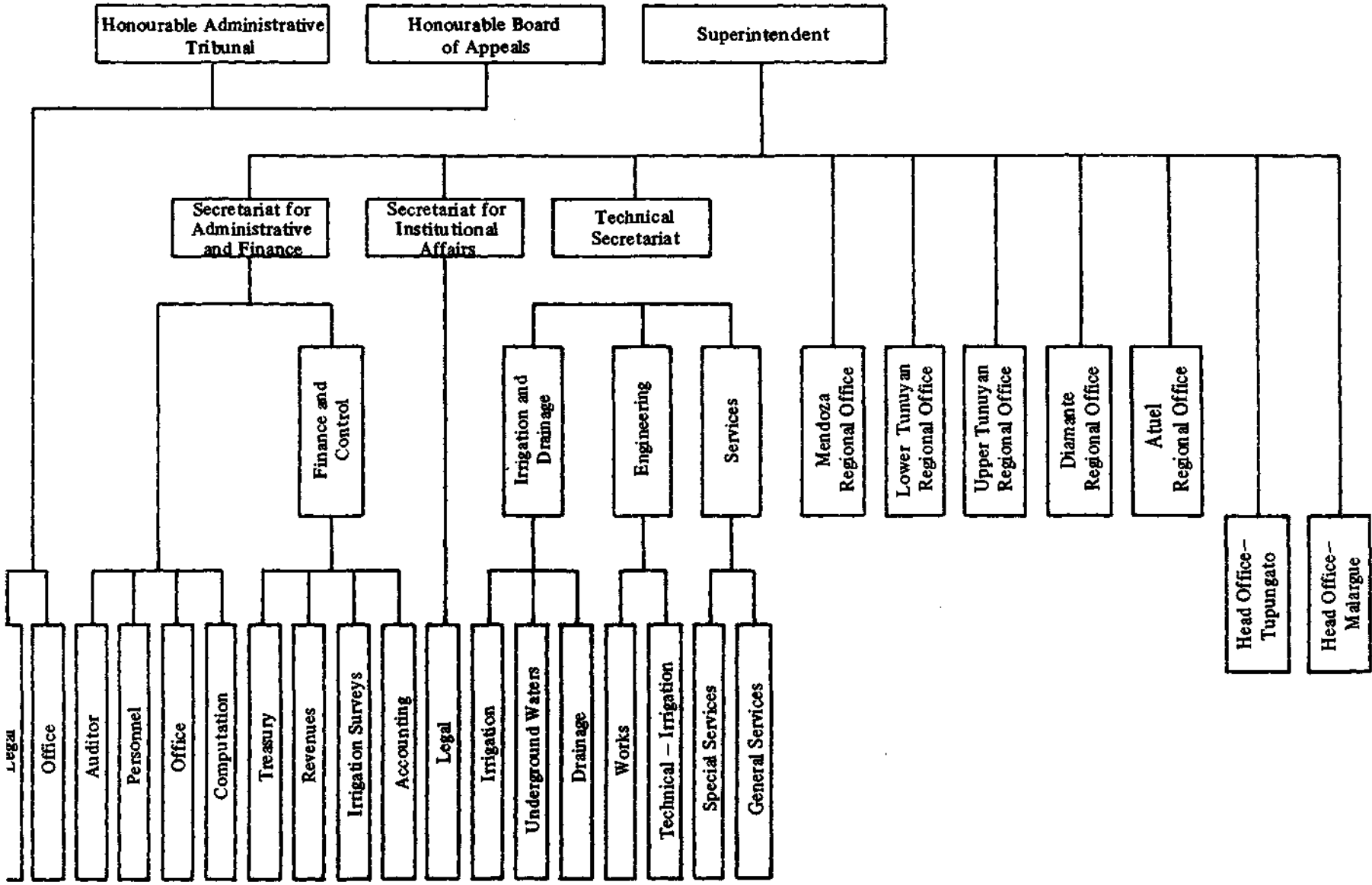
3. Waterway Inspection Offices

The Waterway Inspection Offices are public bodies representing the communities of irrigation users: they are responsible for the administration of water resources used for irrigation. In Mendoza there are approximately 1 700 waterways; of these, approximately 720 are organized as Waterway Inspection Offices. In the cases where the concessionaires are organized through Inspection Offices, the authorities are elected by means of a clearly established electoral system.

The Waterway Inspection Offices are set up according to the type of waterway over which they have jurisdiction. Thus, the First Degree Inspection Offices are responsible for managing the canals; the Second Degree Inspection Offices, for major branches; the Third Degree offices, for subsidiary ditches (hijuelas), and Fourth Degree offices, for minor branches.

Each Waterway Inspection Office is made up of the Inspector, who is elected by the registered users served by the waterway in question, and a group of delegates, who prepare the proposed budget, determine investment requirements and supervise the work of the Inspector.

**GENERAL IRRIGATION DEPARTMENT
GENERAL ORGANIZATION CHART**



4. Rate structure

The irrigation rate structure in Mendoza is determined according to the budget of the General Irrigation Department and the budgets of the Waterway Inspection Offices. The different taxes correspond perfectly with the different categories of expenditures; each budgetary unit generates its own rate component and, at the same time, determines the level or magnitude of the rate. Each budgetary unit has its own resources, which means that a specific allocation system, which necessarily determines the level of execution of the different units, is applied. Thus the percentage of the budget that is executed is directly related to the amounts received for each component of the final rate.

There are two categories of taxpayers: Firstly, the surface water concessionaires, i.e., the beneficiaries of different types of service associated with surface water; these contribute towards financing central administration, dams and master canals, mechanical equipment and minor works. Secondly, the groundwater concessionaires, who only participate in the financing of the relevant budgetary unit. These concessionaires bear the expenses involved in regulating and supervising the use of groundwater.

The rate system is conceived in terms of the method by which the benefit is received. Thus, each user's fee consists of a cumulative set of charges, which are calculated independently and added on to each other. For example, a user who is irrigating from a branch canal must pay the fee for the branch, the fee for the canal which feeds that branch, and the fees for the central administration.

Chapter III

EXTERNAL AND INTERNAL FACTORS AFFECTING IRRIGATION MANAGEMENT

This section discusses the external and internal factors which have affected the management of water resources for irrigation purposes. We first discuss external factors, especially economic and social, and hydrological factors, which have played a predominant role in the development of irrigation in Mendoza. We then discuss internal factors pertaining to the irrigation management system, including the legal structure, the information system, the organizational structure, user participation and existing mechanisms for institutional co-ordination.

A. The main external factors

In this section, we discuss the main economic, social and hydrological factors affecting water management from the external standpoint.

1. Economic factors

Economic factors have played a decisive role in the development of irrigation in the province of Mendoza. A brief look at history shows that the demand for the products of the region has been the main incentive to the development of irrigation in the region and accounts for its current production profile, in which special emphasis is placed on winegrowing. Unfortunately, the grape and wine industry has suffered crises from time to time, and this has affected the use of water for irrigation.

The present situation reflects the impact of a crisis which began in 1973. That year marked the beginning of a series of hydrologically rich years which reversed the trend towards drought which had led to overexploitation of the aquifer in the late 1960s. In addition, in 1976 an economic process began

at the national level which was characterized by a substantial decline in the purchasing power of the population. This led to a contraction of demand, which in turn brought about a sharp drop in prices and in the profitability of the sector; these phenomena apparently went hand in hand with a change in consumer tastes.

A brief analysis of State intervention in the grape and wine industry leads to a clear conclusion, i.e., that each time the State intervened in the winegrowing sector, it did so in order to solve a circumstantial crisis, but it never took action aimed at forecasting such crises in time to do something about them.

In general, State action has been geared towards protecting the winegrowing industry, and this has encouraged the establishment of single-crop agriculture in the region.

a) Irrigation-based economic activities

Because the crops grown in the region are perennial, the supply is flexible vis-à-vis growth but inflexible vis-à-vis downward adjustments. This, along with the fact that it takes a relatively long time to begin production, leads to considerable increases in future production, which in turn play a part in keeping prices low.

With regard to the marketing of grapes and wine, there are three distinct markets, namely the grape market, the market for transferring wines and the market for selling wine directly to the consumer. The grape market has practically disappeared because of the prevalence of the system of processing by third parties. On the transfer market, the system of deferred payments is followed, and on the consumer sales market, payments are usually made on a short-term basis. Commercial competition is intense in this market, which means that large sums are invested in advertising. The financial problem plays a major role in this situation, so that the people who are the farthest removed from the marketing of the final product finance those who are closest, i.e., the producer, the direct user of the water resource.

Compared with winegrowing, fruit and vegetable farming receive very little protection. Fruit growing does not receive the official support that the wine industry does; it has a much lower degree of vertical integration and is vulnerable to competition with producers from other regions of the country.

Vegetable growing suffers most among the agricultural activities of the region, as it is the most unstable and unprotected, both because of the internal structure of the region and because of the strong interregional competition.

Both the product markets and the input markets have longstanding deficiencies, such as concentration in the garlic and potato markets and concentration in the supply of tin containers.

With regard to the use of water resources, the large investment made in infrastructure for the utilization of groundwater was not accompanied by improvements in the system for distributing surface water for irrigation. This had the effect of accentuating the differences between the cost of surface water and the cost of groundwater, thus increasing restrictions on the potential reassignment of surface and groundwaters.

b) Effect of economic policies

The economic policies applied, especially from 1978 onwards, affected the region's economy, mainly through three specific actions: the establishment of very high positive interest rates, the lag in the exchange rate and the reversion to a protectionist approach. These measures acted synergistically with the already weak economy to bring about the current situation.

In brief, it is clear that the demand for the products of the region, along with the resulting demand for water, is the main factor affecting all activities pertaining to the management and utilization of water, investments in the sector, and so forth. In this regard, it is important to stress that the region is faced with a drop in demand for its products, and this will generate idle capacity in the water system.

In the context described above, the economic policy which has been applied to the agricultural sector in general and the winegrowing sector in particular has to a large extent determined the development of primary activities and the use of surface and groundwater. It is important, therefore, not to think in terms of regional water policies in isolation from the other sectors of the region's economy.

One point which must be borne in mind when considering the current situation as regards the management of water resources is that of the structural changes which have taken place in the primary sector of direct

users of the water resource. Over the past decade, structural changes have occurred which have led to the impoverishment of the primary sector, thus affecting the capacity of irrigation subscribers to pay the various taxes and rates; irrigation fees have been particularly vulnerable to this situation. Thus, the water administration agency has not had the necessary funds to carry out an adequate conservation and maintenance programme nor has it been able to make new investments.

2. Social factors

Some considerations regarding the characteristics of the farmers in the irrigated area are in order. In the first place, it should be mentioned that these farmers are predominantly descendants of Italian and Spanish immigrants who originally settled in the area. These people came to the region with a good knowledge of grape-growing and wine-making, as well as of fruit growing and vegetable farming. Not only did they have a thorough familiarity with these activities, i.e., an incorporated technology, but they also brought with them the genetic material necessary to carry them out.

The rural population has quite a high level of formal education and an interesting age distribution. Unfortunately, there has been a substantial exodus of young manpower, as a direct result of the current economic crisis. One factor which has limited the economic and social feasibility of staying in the region, for a large number of farmers, has been the lack of organizational activity at the commercial level.

A significant feature of this region has been a tendency among the farmers and their families to stay on in their traditional occupations. Several indicators point to this, such as a strong propensity to make improvements on their properties, provided they have the resources to do so; apparent acceptance of the social context in which they live, and an atmosphere of harmony as regards the management of water resources.

To summarize, we may say that the inhabitants of the region are anxious to find a way out, economically, so as to be able to pursue their activities. Thus, there is a good potential for finding a solution and getting back on the way to economic recovery.

3. Hydrological factors

As mentioned above, the water system comprising the three main watersheds in the province of Mendoza is made up of a combination of surface and groundwater. In this interdependent system of surface and groundwater, the General Irrigation Department must implement a comprehensive management system, pursuing long-range objectives of efficiency of use and conservation of the resource. Some features of the system have seriously hampered this management effort.

a) Knowledge of the system

In the first place, the lack of knowledge regarding the physical system --both surface and underground-- is clearly a limitation. With regard to knowledge regarding the distribution of surface waters, the administration has not felt the need to find out in detail how the water distribution system works, as regards channeling capacity, efficiency and so forth. This has been due, fundamentally, to the fact that this aspect of management has been left to the Waterway Inspection Offices. This lack of information has hampered the administration in its efforts to set priorities for improvement and maintenance projects among the different zones.

More knowledge is also needed about the behaviour of groundwater and the potential advantages of different management tools. There is, in particular, a need for more thorough knowledge of certain coefficients that would make it possible to draw up a groundwater model, so as to manage the aquifer within a range of certainty. The lack of knowledge about the behaviour of the groundwater is a limitation which hampers the administration's efforts to manage this resource.

b) Groundwater recharge

The possibility of recharging the aquifer as a management tool has not yet been considered. This is an unexplored area, as the administration does not have the experience necessary to estimate the possible volumes of water which could be incorporated into the aquifer, or the costs, in terms of investment, operation and maintenance, that would be involved. Groundwater acts, in fact, as an underground reservoir which makes it possible to regulate the volumes of water to be pumped out for irrigation. Considering the high

percentage of the irrigated area which receives supplementary water from the ground, this possibility for artificial recharging can be a very valuable tool in the comprehensive management of the system.

c) Salinization of groundwater

It is necessary to check the increasing salinization of groundwater. There has been a growing intrusion of saline waters from the phreatic or false aquifer towards the main or deep aquifer, through the confining strata; this phenomenon has been very marked in large areas of the eastern section of the northern watershed of Mendoza, where the quality of the deep aquifer is deteriorating sharply. There is evidence that this process of salinization is due, fundamentally, to the poor construction of wells for extracting water, neglect of same, natural deterioration of pipes, and other factors. The high density of wells in the more intensively farmed areas is playing a major role in allowing for the intrusion of saline waters in the deep aquifer. It is well known that once aquifers such as this one become salinated, it may take several millennia for the waters to recover an adequate quality level. The conclusion that may be drawn from this situation is that a process of salinization has begun which is essentially irreversible and which is jeopardizing the potential of this structure, which is crucial to the overall management of the waters of the region.

d) The threat of structural changes

Finally, some limitations are inherent to the implementation of structural changes in the system. There are two instances where it has been shown that the establishment of regulatory dams causes serious problems in the water distribution system: the El Carrizal dam in Mendoza and the Ullun dam in San Juan. Once a regulatory dam is built, there is a natural settling of solid materials in suspension, which means that the diverted waters do not carry sediments in suspension. Hence, because they have gained kinetic energy they are considerably more likely to cause erosion in canals and irrigation systems. This erosion washes away the natural cover of muds and clays in the canal beds, increasing permeability, which in turn increases deep percolation of the water feeding the phreatic or surface aquifer and creates problems of waterlogging. The authorities of the General Irrigation Department are

currently studying the possibility of building the Potrerillos dam, which would facilitate or allow for the regulation of the surface water of the Mendoza River. It must be mentioned that so far no measures have been taken to assess the impact which construction of such a dam would have on the traditional, unsurfaced irrigation system of the northern watershed of Mendoza, through this so-called "clear-water problem".

To conclude this section, we may say that several hydrological factors affect and limit the range of action of the water administration agency. The most important of these factors are the lack of knowledge about certain important aspects of the system and the resulting lack of administrative tools for establishing controls and dealing with the problems mentioned above.

B. Internal factors affecting management

The administration of the Mendoza irrigation system has an impact beyond the provincial and national borders. Although this is the most advanced irrigation institution in the country, it has remained fairly static for approximately the past thirty-five years. This is mainly due to the fact that this agency was designed for a certain period in time and a certain development model; when unforeseen changes occurred which called for the taking on of new responsibilities and duties, the administration did not make the adjustments required by circumstances.

Specifically, the organization concerned with irrigation in the province of Mendoza is not operating as should in order to carry out a comprehensive irrigation management programme. The main limiting factors are: a) the legal structure pertaining to irrigation; b) the information system; c) the budget and rate system; d) the organizational structure; e) user participation, and f) institutional co-ordination.

1. The legal structure

Three main limitations are built into the legal structure. In the first place, there is the inflexibility of the system applied for granting water rights, which does not allow, except in very special cases, for changes in the source of supply. This means that a concession granted for a given waterway cannot be changed. In the second place, the law includes the principle of inherency, whereby water-use rights are considered inseparable from land ownership. This

principle raises certain problems, as it does not allow a concessionaire to use the resource on the most productive lands, nor does it encourage a rational use of water within the farm.

With respect to the use of groundwater, up to 1974 there was a legislative vacuum on the question. During that year, provincial laws Nos. 4035 and 4036 were enacted; these represent a significant advance, since they attempt to put some order into the anarchy which existed in regard to the exploitation of groundwater. This legislation, however, only provides a partial solution to the problem, as it does not envisage joint management of surface and groundwater.

2. The information system

The quality of decision-making depends directly on the quality and quantity of information available; the quality of information, in turn, depends on its relevance, accuracy and timeliness. Up to now, the General Irrigation Department has worked with an information subsystem based on the registry of concessions and the cadastre. This system is adequate for the first stage in the development of water use, when water is not a limiting factor. However, when water becomes a constraint on economic growth, steps must be taken to enhance efficiency in its use, both on the part of the administration and on the part of the user, and this requires a much more complete information system.

In the particular case of irrigation in the province of Mendoza, the second stage was reached at least thirty-five years ago; however, the information system has not been changed accordingly.

3. The budget and rate system

A modern budget must be a tool for achieving several different purposes, such as planning, management and control. Within this context, the current budget structure of the water administration agency has certain shortcomings. In the first place, the budget does not allow for a natural connection to be made with the planning process, as it does not provide for any linkage between long- and medium-term goals and annual goals. In the second place, it is not a tool for ascertaining the level of efficiency of operation of the various functional units or zones.

In the third place, the existing structure does not allow for the formulation of a budget having logical foundations. Objectives and production goals are not stated, so that it is difficult to identify human and material requirements. Finally, the budget does not provide for explicit mention of those in charge of programmes or for monitoring of substantive aspects; no way is provided for identifying those responsible for the different activities to be carried out, and thus there is no way of finding out if the objectives are being met. Likewise, it is difficult to tell what is the scope of the activities being carried out or how much they cost.

All this leads to the establishment of control systems which emphasize formalities, as a result of which the actual substantive work of the organization is slow and inefficient.

With regard to the existing rate structure, there is a difference in the treatment of users of surface water and users of groundwater. Although most of the users are irrigation farmers, there are also other types of users (industrial, power generation, water supply to population centres, etc.), and these also receive different treatment.

In every case, the rate systems serve taxation purposes, i.e., the concept of price is not used. This means that if a user keeps his farm and wishes to keep the water right or concession, he is obliged to pay the rate, regardless of whether or not he uses the resource.

The rate system has certain limitations. In the first place, the rate structure is not designed to allow for comprehensive development of ground and surface waters. Moreover, because, for legal reasons, the rate constitutes a tax, there is no incentive to the user to rationalize his operation. The system does not envisage differences in the treatment of users based on the purpose for which the water is used. Finally, as there is no specific provision for covering the costs of other services which are complementary but different (such as soil recovery, flood control, pollution control), irrigation users must absorb these costs, and this is not fair.

4. The organizational structure

A water organization designed to facilitate the use of the resource for agricultural purposes must be prepared to carry out efficiently several primary functions. These are listed below, with mention being made of the

degree to which the General Irrigation Department is actually carrying them out: a) management of surface waters: this is being done, although there is much room for improvement; b) management of the groundwater resource: this is not now being done; c) working towards comprehensive management of surface and groundwaters: this is not being done; d) preserving and recovering soils: this is barely being done; e) preventing and attenuating pollution of water resources: this is being done in a very limited way, because of the jurisdictional scattering of agencies involved, and f) preventing and attenuating flood damage: this is done by other bodies.

With regard to the first five functions, there is evidently a need to adjust the organizational structure to current requirements, and to make the changes necessary to cover those activities which are not being properly carried out.

5. User participation

User participation is closely related to the organization of water management in the province. This question has taken on an identity of its own, because of the important role it has played in the development of water resources for irrigation in Mendoza.

Up to the 1950s, irrigation depended mainly on surface water. The economic situation could be characterized as prosperous, and physical efficiency in water management was not a primary concern; as a result, smooth co-ordination with the General Irrigation Department was not necessary. There was no significant subdivision of lands, and concessionaires lived mainly in the rural areas.

From the 1950s onward, the shortage of surface water led to the exploitation of groundwater. The variables of the context also changed: the economic situation became unstable, as crises were more frequent, more profound and more prolonged; waterway management became more complicated, for a variety of reasons, including the increasing subdivision of land tenancy; as urbanization proceeded, urbanization took over large areas of irrigated land; industrial development gave rise to problems of pollution, and so forth.

As a result of all the above, waterway management became a more complex task, requiring more assistance and greater co-ordination between the users and the General Irrigation Department.

6. Institutional co-ordination

The functional reorganization of the General Irrigation Department calls for strong institutional co-ordination. In the first place, there is a need for co-ordination among the Provincial Executive Power, other agencies that are under different jurisdictions (national or municipal), and the private sector directly or indirectly concerned with water matters. At present, there is virtually no co-ordination with other water agencies. In the second place, there is a need for co-ordination at the internal level, particularly as regards the Waterway Inspection Offices.

In view of the structural transformation which is taking place in the social and economic system of the province, it is essential that all agencies work in co-ordination, including those concerned with agriculture, which is the main water user and is affected by the action of agencies such as EMSE, through its rate policy.

Chapter IV

EVALUATION OF WATER RESOURCE MANAGEMENT

In order to evaluate, over time, the management of the irrigation water system, it is necessary to find out whether or not its explicit and implicit objectives have been reached at each stage in the history of the institution. Since these objectives have changed over time, it is important to identify the different periods in its history, so as to identify the objectives pursued at each stage, and thus determine to what degree they were fulfilled, from an essentially qualitative standpoint.

To analyse the management of the overall system, we have identified two stages: the first, which is characterized by the expansion and consolidation of irrigated oases through the grape-growing and wine-making industry, and the second, marked by the beginning of the use of groundwater, which opened up new horizons of production.

A. Stage one: the expansion and consolidation of irrigated oases

The political project reflected in the Water Act was based on a clear concept of the progress achieved by a stable community, with authority, which held its government in its hands and controlled its land, its water and its agricultural wealth. The emerging agricultural society, influenced by the Enlightenment, was able to establish certain means and tools for encouraging the expansion of irrigation and facilitating the adjustment of the immigrant community, which continued developing the model which became firmly grounded in the province, i.e., grape-growing and wine-making.

1. The initial context

Among the factors which determined the initial development of the province, it is worthwhile stressing the impact of the wave of immigrants and the building of the railroad to Mendoza, which in its beginnings clearly had a surplus of surface water. The existence of these conditions, in a context of firm land ownership and the rule of law, allowed for the emergence of a stable society.

The system of government and water management was built on a broad base of participation, safeguarded by the principle of double decentralization. Thus, the irrigation user was not tied down by red tape that might have discouraged him from expanding the irrigation frontier. Moreover, the State was used as a tool to promote expansion through the construction of infrastructure works with public funds.

Finally, there is a central element which explains the success of the Mendoza agricultural model, and this is the significant growth of demand for the products of the irrigated areas from the booming city of Buenos Aires. This constant demand explains why the region directed all its production to the domestic market.

As a result, Mendoza's agriculture was highly successful. In general, it managed to take over the desert through the use of surface water and the establishment of stable irrigation farming. A satisfactory solution was found to the problem of managing surface waters for irrigation, while user participation, both in policy-making and in direct management, reached its highest level.

2. Achievements

The major achievements may be summarized as follows: 1) three large irrigated oases (north-central-south) were established, totalling around 270 000 hectares of which 110 000 were planted in grapes (around 1950); 2) diversion infrastructure was built on four rivers, including primary and secondary canal systems, totalling around 8 000 km in length; 3) land ownership was transferred from the descendants of Spaniards and subsequent locally-born Argentinians to the descendants of the immigrants, and 4) a good distribution of wealth was achieved --a fact attested to by the large number of farms (around 21 000) and of wineries (1 000).

B. Second stage: beginning of the use of groundwater

1. Initial conditions

The second stage began with a barely diversified model, based fundamentally on winegrowing, which led to a certain inflexibility. The model is a closed one, and its production is directed almost exclusively at the domestic market. In a way, this isolated the province from the outside world and excluded it from competition on the international markets. Internally, it is a heavily protected model, which has fallen into a vicious circle, so that grape production for wine-making is the most profitable alternative, but a highly unstable one. This is evidenced by the fact that, despite the many crises of overproduction which had already occurred during the first stage, because the State intervened to assist it, this activity again became more profitable than any of the alternatives, and this in turn accentuates reliance on a single activity.

2. Trends in economic activity

During the 1960s, there was a boom in the use of groundwater, simultaneously with the growth of agrarian-based industries, such as canning, oil-making and cider-making. With the growth of industry, the first signs of environmental pollution appeared, as waterways used for irrigation began to receive industrial waste.

Towards the mid-1960s, there was a significant drop (around 40-50%) in the mean flow of the different rivers of Mendoza, a situation which lasted for six consecutive years. To this situation was added the establishment of a tax relief system for all types of investment, including drilling for underground water, rural electrification and implementation of perennial crops. This led to overinvestment in vineyards, which in turn gave rise to the crisis which continues today. The objectives pursued during this stage had to do with political and social change, and included principles such as that of social justice. On the economic scene, a process of import substitution was put underway, which provided a powerful incentive to development of the regional economies. In the case of Mendoza, this meant the continued expansion of the pre-existing model. Thus, we may say that during this stage, the objective was

an implicit development project which stressed the agricultural alternative, especially winegrowing.

As regards the use of water resources, recourse was had to the underground aquifers which, as we have already noted, have a great potential. A great capacity for drilling and setting up electrical facilities was developed, although those responsible had no access to studies and research on the potential exploitation and use of groundwater. The General Irrigation Department was far removed from all these developments; it continued with the management of surface waters, making very few changes from 1965 to the present time.

Except for the enactment of the Groundwater Act, the legal system remained unchanged during this period. Nevertheless, many new dimensions were added during this stage. Some of the issues which must be reviewed with an eye to the future are those concerning the comprehensive management of surface and groundwaters, environmental problems, and co-ordination with other agencies in the water system.

The central fact which must be borne in mind is that, as Mendoza's economy grows and economic and social conflicts arise (surplus production, subdivision of land, growth of the urban-industrial infrastructure), the user consortium (Waterway Inspection Offices) which played a major role during the first stage, because of its being responsible for consolidating the expansion of crops, is now losing influence. At present, it is more important to know what to do with production than to distribute water. This latter aspect has somehow become less important.

In this regard, the General Irrigation Department is engaged in an effort to reorganize the Waterway Inspection Offices by grouping them into units so as to enable them to work on a larger scale and find ways to preserve and operate the waterways while at the same time moving towards more dynamic models.

3. Achievements

The achievements of this stage may be summarized as follows: in the first place, the irrigated frontier was extended, basically through the use of groundwater; a good infrastructure of multiple-use reservoirs was developed, especially in the southern zone; the agroindustrial model (especially

winegrowing) experienced a sustained growth up to the beginning of the 1970s, although towards the mid-1970s a crisis began which still persists; the water management agency did not adjust to the changing situation, leaving unsolved problems such as those pertaining to joint management of ground and surface waters and water quality; user participation in the management of the system deteriorated, and damage has been done to the ecology.

Despite these limitations, significant goals were attained. For example, with the new growth, the irrigated area increased to approximately 370 000 hectares; the infrastructure for extracting groundwater rose to almost 20 000 wells, half of which are electrified, and the Groundwater Act was enacted in 1974, although, unfortunately, no progress has been made in its application. With regard to surface waters, five multiple-purpose reservoirs are being built which have a potential installed capacity of 300 MW and which make it possible to regulate the flows of three of the four rivers used for irrigation in the province.

Chapter V

CONCLUSIONS AND RECOMMENDATIONS

The development of irrigation in Mendoza is undoubtedly one of the most interesting cases in Latin America, because of its long history and advanced legislation, which contributed to the early success of the model and its unique management system, whereby a harmonious relationship is established between the farmers and the State, as regards the management of water resources.

It also presents a challenge, inasmuch as the efficient model conceived towards the end of the nineteenth century, which worked well into the twentieth century, must necessarily undergo some changes in order to deal with the problems now facing it in an essentially different context.

Following is a summary of what the authors consider to be the main problems currently affecting the water system and the elements and criteria which might be used to draw up a proposal designed to bring about an efficient transformation of the water management system.

1. Social and economic changes

In chapter III, we discussed the external factors which affect the management of the irrigation system. In this context, the most important question discussed was that of the exhaustion and loss of competitiveness of the closed economic model (directed only at the domestic market) currently in force. This model has led to a stagnation of production, a high degree of idle capacity in terms of the supply of irrigated land and agrarian-based industrial capacity, and technological backwardness, with a loss of external competitiveness.

In response to this, the State has sought solutions biased towards problems of supply, creating periodical crises in the system, and venturing

into functions which are beyond its competence, thus further accentuating the centralization of decision-making.

The first criterion which the public sector should adopt is that of emphasizing the demand for products from the irrigated areas. Thus, any increase in the supply of irrigated land should follow the trends of demand.

The second criterion to be borne in mind has to do with the strategy for expanding supply. In our view, this should be done by increasing efficiency in the distribution and use of water rather than by building more infrastructure.

These main lines of action will be more effective in a context of stable policies and greater operational flexibility, which can be enhanced by decentralizing State activity.

2. The adoption of new management technologies

The central problem facing the water system is the lack of technology and tools for achieving efficiency in management. In summary, our main views and recommendations are the following:

In the first place, the legal framework should be adapted to current conditions. To this end, the users and the administration must adopt the concept of efficiency in the use of the resource.

Principles should be adopted which allow for comprehensive management of water resources, with a view to making optimum use of space and time; to this end, concession systems, rate systems and other aspects must be reviewed. Finally, a series of studies (technical, economic, social and administrative, for example) should be carried out in order to make it possible to forecast changes of context and to legislate accordingly.

Secondly, information systems must be reviewed, inasmuch as the requirements for such systems increase when water becomes a limiting factor and expansion is pursued on the basis of an increase in efficiency of use.

To this end, the administration must develop a single information system which can be updated constantly, which provides for a natural integration of information regarding surface and groundwater, and which is flexible enough to incorporate new information requirements.

The third consideration to be borne in mind is the budget system, which must allow for the comprehensive management of water resources and must become a tool of planning, management and control. If a new budgeting concept is

adopted, the budget can become an integrated information system which will facilitate planning, management (execution) and evaluation of execution.

The fourth point is that the rate system must be revised so as to obtain the resources needed to do the job, on the one hand, and, on the other, to allow for an efficient allocation of the resource and achieve the desired effect of redistribution. The current system is a form of taxation, and its main objective is to achieve financial self-sufficiency; it is neutral in that it does not pursue the objective of redistribution nor does it encourage users to seek efficiency. If the objective of efficiency is to be sought, a new rate structure will have to be devised, so as to introduce the concept of price.

3. User participation

One of the factors which has most affected the social body of our country is the deterioration of citizen participation in efforts to deal with the problems which affect their daily lives.

User participation in the Mendoza water system has undoubtedly provided a successful model. What is needed now is a further improvement of this model so as to bring it in line with new circumstances. The challenge now is to seek alternatives that will make it possible to take a big step forward in terms of quality. At present, the administrative authority of the General Irrigation Department is implementing a change which would make it possible to: a) allow for greater participation of users; b) help consolidate decentralization in water management, and c) go beyond the idea of a consortium designed only to manage surface waters towards that of a consortium concerned with the management of groundwater, as well as with the complex situation of irrigation farming.

The change consists, basically, of regrouping the 720 user consortia of the system into about 20 macroconsortia, which would administrate between 15 000 and 20 000 hectares each. This change, which is fully underway, represents a major organizational effort.

4. Administrative co-ordination

In our discussion of internal limitations to management, in chapters III and IV, it was mentioned that the General Irrigation Department limited its action to the management of surface waters. It was also noted that there was a lack

of co-ordination in decision-making among the existing agencies. This situation should be reversed, with a view to achieving and consolidating a comprehensive management of the resource, in the realization that there is no institutional "prescription" for achieving co-ordination in decision-making. Co-ordination can often be carried out through simple ad hoc bodies, thus avoiding the proliferation of State structures and allowing for greater flexibility and adaptability to the changing issues of modern times.

5. Ecological and environmental balance

The State has direct responsibility for anticipating and preventing irreversible ecological and environmental damage to the water system, and this can only be achieved through an integrated approach. In this regard, the system is threatened by three environmental hazards. The first is the problem of salinization. As mentioned previously, the indiscriminate expansion of the use of groundwater has initiated a gradual process of salinization of the deep aquifer. It is urgent that action be taken to stop and reverse this process. Hence, it is essential to work towards joint management of surface and groundwaters within an overall vision of the system whereby this and other problems can be dealt with in integrated fashion. This calls for an integration of administrative, institutional, economic and legal aspects, so as to achieve comprehensive management.

The second danger is the deterioration of the quality of life as a result of pollution of the water and the encroachment of urbanization and industry on the irrigation system.

Although we have not dealt with this question in this report, it is worthwhile mentioning it, as it is one more example of the complications which will undoubtedly become aggravated in future, and of the complexity of the interrelationship of the elements of the system. The environmental issue has revealed the weakness of the traditional agencies responsible for administering one use of the resource, when the subject itself calls for the integrated participation of all agencies using the system, of those who have suffered the problems, or both.

Finally, and no less important, there is the danger of a rapid deterioration of the traditional irrigation system, the magnitude of which cannot yet be foreseen, as a result of the erosion of "clear waters" which

would be generated by a reservoir such as the Potrerillos dam. In view of this risk, it is important to plan carefully for all activities that must be carried out simultaneously with the building of this dam, in order to minimize the social cost of the impact of the "clear waters".

6. Training and transformation of the system

In order to make it possible to manage the water resources efficiently, it is necessary, first of all, to have a qualified staff that can bring about the changes required by the new circumstances with which the administration is currently faced. Hence the fundamental importance of implementing a training programme designed to improve existing skills in the administration of water resources.

With regard to irrigation management, two levels of training are needed in order to carry out a transformation of the sector: a) training of technical and professional staff of the irrigation administration agency, and b) training of the irrigation users.

In the first case, the best technique is to train the staff on the job, through courses and seminars, so that a large number of staff members in each organization realizes the need for change.

In the second case, the best course is to provide an extension service supplemented by short courses on technical subjects, with visits to demonstration areas.

CELA/INCYTH periodically offers a graduate course on the comprehensive management of water resources. This is a residential course, of three months' duration, which is offered to administration and middle-level technical staff of Latin American agencies concerned with these matters.

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