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Agricultural data base for the sustainable use of water in the Ojos Negros valley, Baja California, Mexico

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Abstract
An agricultural data base for the Ojos Negros valley, in Baja California, Mexico, 40 km east of Ensenada, has been developed. In the past 30 years, irrigated agricultural development based on the pumping of groundwater has produced climatic, ecological, economic, and social changes in the valley. The agricultural data base represents a cross-sectional view of the economic activity in the valley; it allows the simulation of the effect of pumping at increasing depths on the profit margins of the local actors. The local actors are proprietors (ejido and other individuals) and renters (companies and individuals). Currently, the mean water table depth is 30 m; simulated depths were chosen at 40, 50, and 60 m. Results indicate that the profit margins of renters is greater than those of proprietors. The profit margins of operations, when all actors (proprietors and renters) are considered, will decrease from 27.92% at 30 m to 23.24% at 60 m. Moreover, the profit margins of the ejido proprietors will decrease from 10.92% at 30 m to 8.91% at 60 m. The number of ejido proprietors whose profit margin will be reduced to less than 5% will increase from 11 at 30 m to 18 at 60 m. With aquifer depletion continuing unchecked, the ejido proprietors will find it increasingly difficult to farm the land and will eventually resort to renting to the agroindustrial companies. If this trend persists, eventually only company renters will operate in the Ojos Negros valley, and the social fabric of the valley will have been changed completely. Aquifer regulation under the principle of sustainable development appears to be the only way out of this predicament.

INTRODUCTION

The Ojos Negros valley is located 40 km east of the city of Ensenada, in Baja California, Mexico (Ensenada is located 100 km south of the U.S.-Mexican border at San Diego-Tijuana). The valley consists of approximately 100 km^2 of aluvial terrain, of which about 30% is intensively farmed by irrigation systems which have been developed over the past three decades. The water for irrigation is obtained exclusively from the pumping of groundwater. Beltran (1997) has estimated that the annual yield exceeds the annual recharge by about 6.5 hm3 (Beltran, 1997). This difference has resulted in the gradual lowering of the water table, which at one time (c. 1970) was close to the surface, but now lies at depths averaging 30 m toward the center of the aquifer.

The cost of pumping is proportional to its depth; therefore, it is necessary to evaluate the effect that the increasing cost of pumping can have on the agricultural system on a medium- and long-term basis. To this end, it is necessary to develop an agricultural data base which can be eventually integrated with a hydrogeologic model. The objective is to determine the influence of the cost of pumping on the profits derived from the agricultural enterpise.

The data base is a necessary prerequisite for the operation of the hydrogeologic model. It represents a cross-sectional view of the economic activity of the valley, which would be directly affected by pumping from increasing depths. Groundwater depletion is a pervasive problem; the lessons learned from the Ojos Negros experience can be readily replicated in other regions throughout the world.

BACKGROUND

The history of the Ojos Negros valley goes back to 1871, when the discovery of gold in the region caused the settlement of many newcomers from other parts of Mexico and the United States (Ponce et al, 2000). Around the turn of the twentieth century, livestock raising followed mining as the most important economic activity and, after 1970, irrigated agriculture started to develop in earnest.

Now (2000), irrigated agriculture is the most important economic activity in the valley, with 3099 ha operated with sprinkler, drip, and central pivot systems. The predominant crops are forage and vegetables. Forage consists of alfalfa, barley, maize, and oats; the main vegetables are green onion, watermelon, cilantro, onion, and radishes. In the past 6 years, there has been a tendency for the replacement of forage for vegetables; the latter constitute now more than 53% of the irrigated area. Apparently, this tendency is due to the fact that vegetables use less water and, therefore, less energy, than forage. Moreover, the vegetables are irrigated with water-conserving drip systems, while the foraje is irrigated with conventional sprinkler systems.

Another tendency of the last few years is the gradual change in the relative importance of the local actors or players. Prior to this change, the members of Ejido Real Del Castillo (ejido is a Mexican agricultural community, established by the law of 1938; its members are referred to as ejidatarios). were the only local actors. Nowadays, changes in the law (beginning in 1994, with President Zedillo) and transborder dynamics encouraged by the North American Free Trade Agreement (NAFTA) have led to the the existence of the following four actors: (1) ejido proprietors, (2) other individual proprietors, (3) renting agroindustrial companies, and (4) individual renters.

Although the ejidatarios which personally operate the ranchos (an ejido property) are still in the majority, the current tendency is for the increase in the number of renters, both companies and other individuals. Particularly in the last two years, the presence of agroindustrial companies of mixed U.S.-Mexican capital has been markedly felt, with an increase in total investment and associated increase in the economic activities. Prior to the advent of irrigation, the water table was close to the surface to the west of the valley, following the course of Ojos Negros Creek, tributary of El Barbon Wash, which drains the valley (Ponce et al., 1999). This made possible the existence of wetlands and riparian areas and sustained the natural vegetation of the interfluves (chaparral vegetation). With irrigation, the water table was depleted well below the root zone, the extensive wetlands and riparian areas all but disappeared, and the natural vegetation was replaced by the artificial vegetation which typically characterizes intensive agriculture.

Paralleling the change in land use, there has been a change in the local climate, caused by an increase in evapotranspiration as a consequence of the transport of great quantities of water from the groundwater system to the surface water system. In the past 35 years, the difference between maximum July temperature (summer) and minimum January temperature (winter) (referred to as the range) has decreased by 9^{o}C, which indicates a process of humidification, albeit apparently temporary (while pumping goes on), of the local climate. Furthermore, precipitation has increased by 50% from 1960 to 1990 (Ercan, 1999). The climatic, ecological, economic, and social changes that are taking place in the Ojos Negros valley deserve a detailed study to determine their effects on the sustainability of the valley and the latter's relation to the use of resources, among them, water, soil, air, and native flora and fauna. The agricultural data base is a fundamental element of this study, since it represents the cross section which leads eventually to the diagnostic. The overall objective is to redirect the Ojos Negros valley along the path of sustainable development.

METHODOLOGY

The study methodology consists of the following steps:

Formulation of the agroeconomic spreadsheet

The spreadsheet consists of the following columns: user, plot number, total area (ha), number of pumps, ownership, type of crop, irrigation system, cultivated area (ha/yr), unit crop yield (kg/ha), annual yield (kg/yr), unit water consumption (m3/ha), aquifer yield (m3/yr), unit water cost ($/m3/m), pumping depth (m), water cost ($/m3), total water cost ($/yr), materials ($/yr), salaries ($/yr), rent ($/yr), total production cost ($/yr), unit crop price ($/kg), gross production ($/yr), subsidy ($/yr), total gross production (gross production plus subsidy) ($/yr), net production ($/yr), efficiency (net production/gross production) (%), capital ($), and profit margin (net production/capital) (%).

Data collection with Mexican federal agencies (SAGAR, CNA, CFE)

The following data for relevant crops were obtained from the Agriculture Ministry (SAGAR): (1) unit water consumption (m3/ha), (2) unit salaries ($/ha), and (3) unit crop price ($/kg). The following data were obtained from the federal water agency (CNA): (1) hydrogeologic data such as well and pump type, quantity, pumping schedule and yield, and depth to the water table. Energy bills for each plot and user, for the period 1996-99, were obtained from the federal energy agency (CFE).

Interviews with local actors

The local actors were interviewed during the months of June and July 2000 with the objective of gathering first-hand information on the agricultural operations. The following interviews were made: 30 ejido proprietors, 2 individual proprietors, 4 company renters, and 7 individual renters, for a total of 43 interviews. The interviews were limited to plots of the Ejidos Real del Castillo and Sierra Juarez which pump the Ojos Negros aquifer, located south of Cerro Portezuelo (Ponce et al. 1999).

Spreadsheet calculations

The data obtained from CFE (cost of electricity), CNA (depth of pumping), and SAGAR (crop water demand) were analyzed with the objective of estimating the unit cost of pumping, which was determined to be 0.01 Mexican pesos/m3/m (equivalent to 0.0011

$/m3/m). The spreadsheet was used to calculate the efficiency and profit margin of the various local actors for the present conditions (30-m average pumping depth), and for postulated mean water table depths of 40, 50, and 60 m.

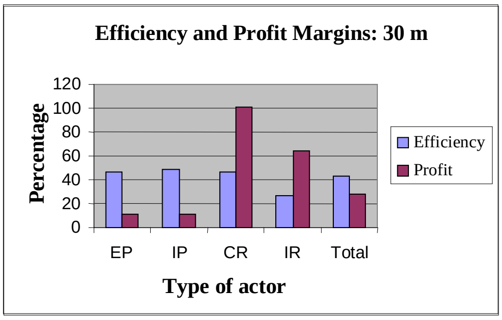

Figure 1. Efficiency and profit margins of local actors at mean pumping depth of 30 m.

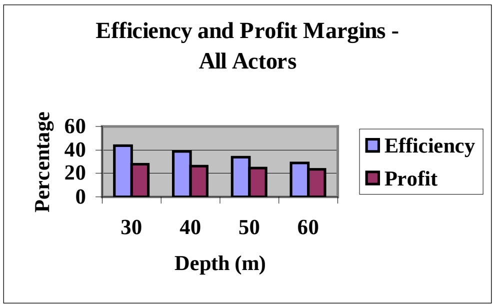

Figure 2. Efficiency and profit margins for all local actors as a function of pumping depths.

RESULTS

Figure 1 shows the efficiency and profit margin of the operations of the local actors at a mean pumping depth of 30 m. The code EP represents ejido proprietors, IP individual proprietors, CR company renters, and IR individual renters; Total is the weighted average for all actors. It is observed that the profit margin of the renters (CR and IR) is much greater than that of the proprietors (EP and IP). For comparison, the profit margin of company renters is 101.15%, while that of the ejido proprietors is 10.72%. Efficiency of all actors (labeled Total) is 43.5% and profit margin is 27.92%.

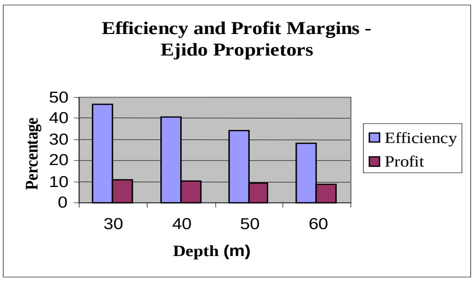

Figure 3. Efficiency and profit margins of ejido proprietors as a function of pumping depths.

Figure 2 shows efficiency and profit margin of all local actors at simulated mean pumping depths ranging from 40 to 60 m (30-m value is included for comparison). Figure 3 shows efficiency and profit margin of ejido proprietors (EP) at simulated mean pumping depths ranging from 40 to 60 m. Both efficiency and profit margin are shown to decrease with increasing pumping depth. Profit margin of all actors decreases from 27.92% at 30-m depth to 23.24% at 60-m depth. For comparison, profit margin of ejido proprietors decreases from 10.72% at 30-m depth to 8.91% at 60-m depth.

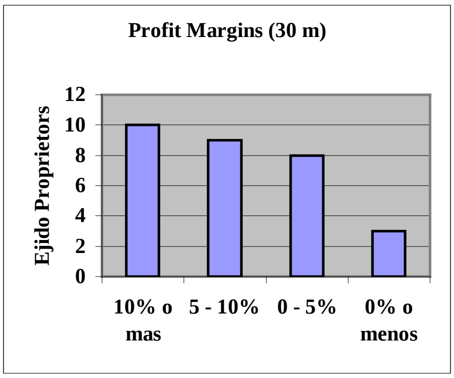

Figure 4(a). Profit margins of ejido proprietors at 30 m.

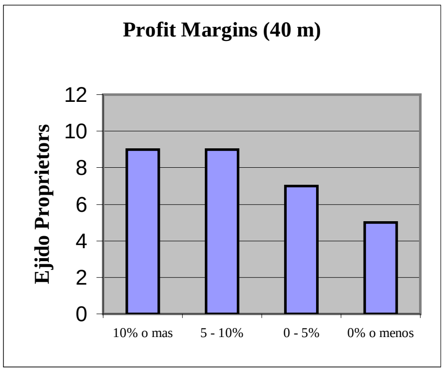

Figure 4(b). Profit margins of ejido proprietors at 40 m.

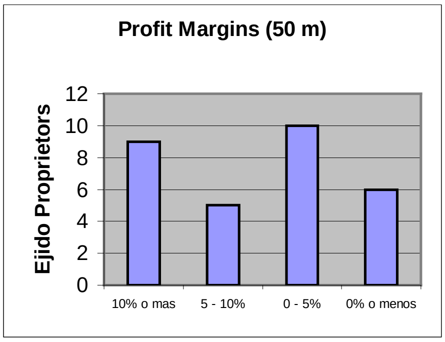

Figure 4(c). Profit margins of ejido proprietors at 50 m.

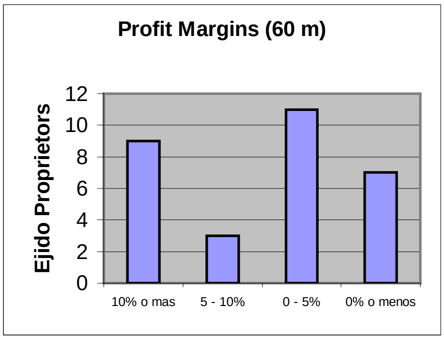

Figure 4(d). Profit margins of ejido proprietors at 60 m.

Figure 4 (a) to (d) shows profit margins of Ejido proprietors (EP) in different categories, for 30-, 40-, 50-, and 60-m pumping depth, respectively. It is observed that at 30-m depth, eleven (11) ejido proprietors have profit margins below 5%; at 60-m depth, this number increases to eighteen (18) ejido proprietors (with marginal profits, i.e., less than 5%).

The preceding agroeconomic analysis, backed by hydrogeologic data, confirms the current sociological and land-use trend in the Ojos Negros valley. Ejido proprietors (EP) are finding increasingly difficult to make a profit from their operations. Many of them, either the less efficient or the less willing to continue farming, are now opting to rent to agroindustrial companies. The latter operate with greater capital and profit margins and are, therefore, able to continue the aquifer depletion with little effect on their economies. If this trend persists, eventually only company renters will operate in the Ojos Negros valley, and the social fabric of the valley will have been changed completely.

The alternative is to monitor and regulate the aquifer, to allow and encourage its replenishment, and to assist the ejido proprietors, the traditional owners of the land, in increasing their effectiveness and competitiveness of their farming operations.

SUMMARY AND CONCLUSIONS

An agricultural data base for the Ojos Negros valley, in Baja California, Mexico, 40 km east of Ensenada (which is 100 km south of the U.S.-Mexico border), has been developed and implemented in spreadsheet format. In the past 30 years, irrigated agricultural development based on the pumping of groundwater has produced climatic, ecological, economic, and social changes in the valley. The valley is an important source of income to the state, with substantial transborder effects within the framework of the North American Free Trade Agreement (NAFTA). The agricultural data base represents a cross-sectional view of the economic activity in the valley. It will eventually be linked with a hydrogeologic model to study the use of the water resource under the principle of sustainable development.

The agricultural data base allows the simulation of the effect of pumping at increasing depths on the profit margins of the local actors, i.e., on the economic health of the valley. Currently, the mean water table depth is 30 m; simulated depths were chosen at 40, 50, and 60 m. The local actors are proprietors (ejido and other individuals) and renters (companies and individuals).

Results indicate that the profit margins of renters is greater than those of proprietors. The profit margins of operations, when all actors (proprietors and renters) are considered, will decrease from 27.92% at 30 m to 23.24% at 60 m. Moreover, the profit margins of the ejido proprietors, the traditional owners of the land, will decrease from 10.92% at 30 m to 8.91% at 60 m. The number of ejido proprietors whose profit margin will be reduced to less than 5% will increase from 11 at 30 m to 18 at 60 m.

Under the present state of affairs, with aquifer depletion continuing unchecked, the ejido proprietors will find it increasingly difficult to farm the land and will eventually resort to renting to the agroindustrial companies. Renting has increased significantly in the past 5 years. The companies operate with greater capital and profit margins and are, therefore, able to continue the aquifer depletion with little effect on their economies. Aquifer regulation under the principle of sustainable development appears to be the only way out of this predicament.

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