The Impact of Policy and Environmental Factors in Sustainable Agricultural Development[1]

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ABSTRACT

In order to assess farming systems under the current and expected conditions a Multiperiod Linear Programming Model (MLPM) was applied. Some relevant results are. First, MLPM strongly reflects changing profitability in both temporal and spatial dimensions. Second, some comparative advantages indicate that it is possible to combine economic growth and conservation of natural resources in the region. Third, revenues can be increased with the international market; however, this implies more intensive capital use and higher risks. These are some barriers that can lead the expected change to some negative impacts. The smallholder sector can be negative affected increasing inequality. Second, production for domestic market will decrease which will impact the poor consumer sector and food security.

Introduction

The purpose of this study was to analyze strategies for sustainable development dealing with opportunities and constraints in arid lands. This study attempted to examine how environmental, economic, political and social factors influence regional development. Research was conducted in western central Sonora located in the northwest of Mexico. This is an arid zone of the Sonoran desert. The most relevant barriers can be described as socioeconomic and environmental factors.

The Political and Economic Context

At the macrolevel Mexico's development has been characterized by its instability and uncertainty. Since 1940 to the present the Mexican economic growth, can be classified in at least six different periodic recessions (Cardoso and Levy 1988).

(1) The period 1940-1954 is characterized by erratic growth rates, currency devaluation, and price instability.

(2) From 1955 to 1970 an exceptional economic development occurred with an average growth rate of 6.7% and annual inflation rate 3.8%. This is the so-called "Mexican miracle". However increasing inequality and income distribution between social groups and different regions were two major problems.

(3) From 1971 to 1977 industrial production rose and agriculture deteriorated. In addition, external debt increased from 6.6 to 21 billion, the exchange rate was devaluated from 12.5 to 22.6 pesos and inflation rate reached 15%.

(4) From 1978 to 1982 occurred the oil boom, the economy rose at an average of 8%. However in 1982 Mexico precipitated in a deep recession, astronomical foreign debt reached 80 billion dollars, the exchange rate felt to 83.5 pesos and yearly inflation rate rose to 60%. By august 1982 Mexico was declared in bankruptcy. The protectionist model was unsustainable. The main arguments were that protectionist model induced price distortions

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and economic inefficiency due to subsidies, tariffs and market imperfections. External and internal pressure guided Mexico to switch form protected economy to open economy (Janvry and Sadoulet 1989).
(5) From 1982 to 1993 the transition from the protectionist model to liberalization was extremely hard. For example the exchange rate felt from 83.5 pesos to 3390 pesos in 1994. In the agricultural sector government reduced subsidies, guaranteed prices, and other programs. During the period 1982-1988 the agricultural outputprices felt 35% compared with the generalized Mexican index prices, public and private investment in agriculture and credit decreased by 20% and 43% respectively. The gap between poor and rich people expanded. Two dramatic examples are that the number of poor people rose from 41 million in 1988 to 46 million in 1994 while the wealthiest group of 24 people own a fortune of 45 billion dollars nearly 50% of the foreign debt.
(6) Lastly, perhaps the worst recession was the beginning of the transition of NAFTA. In 1995 the annual inflation rate jumped from 7% to 52%, the exchange rate increased from an average of 3.39 pesos per dollar to 6.38 pesos, the interest rate increased from 17% to 61%[2].

To deal with these recurrent crisis the Mexican government has designed a long run economic strategy. This can be the intensification of the Structural Adjustment Program. The three most relevant and controversial programs are the following.

First, NAFTA represents a radical change aimed to promote efficiency and competitiveness through Mexican's comparative advantages. Second, the modification of Article 27 is focused on land privatization to encourage efficiency and competitiveness in the *ejido* system (Wilson and Thompson 1995; Thompson and Wilson 1994a, 1994b; Wilson and Thompson 1993; Diario Oficial de la Federación 1992). Third, *Procampo* is government program attempting to support farmers in the transition to NAFTA, from 1993 to 2007, by the following ways. First, providing direct subsidy to farmers in some output prices. Second, to encourage cropping pattern change toward crops with the highest profitability. Third, to compensate Mexican farmers for distortions in some world prices. This is due to the fact that farmers in many developed countries receive some subsidies (SARH 1995; 1994).

The Ecological Context

By the late 1940s agricultural expansion and intensification occurred in one extreme arid lands of the Sonoran desert, the so-called *Costa de Hermosillo*. In fact groundwater extraction for agriculture started since 1948. Intensive drilling of wells and expansion of irrigated lands increased rapidly. By 1951 the federal government prohibited the drilling of more wells in order to regulate groundwater exploitation. Two years later the irrigation district "Costa de Hermosillo" was created to control water use. Despite of the effort of the authorities groundwater overexploitation grew up (Valenzuela 1982).

The highest pumping rate was reported during the 1960s. In the main aquifer water withdrawal reached an annual average of 1200 million M^3 of water. In contrast the recharge was only 350 million M^3. Flores (1992) reported that the overdraft from 1940 to 1980 caused the water table to fall in about 1.3 M per year, reaching a depth of 60 M below the sea level in the depression cone. Figure 1 shows the groundwater withdrawal and recharge from 1950 to

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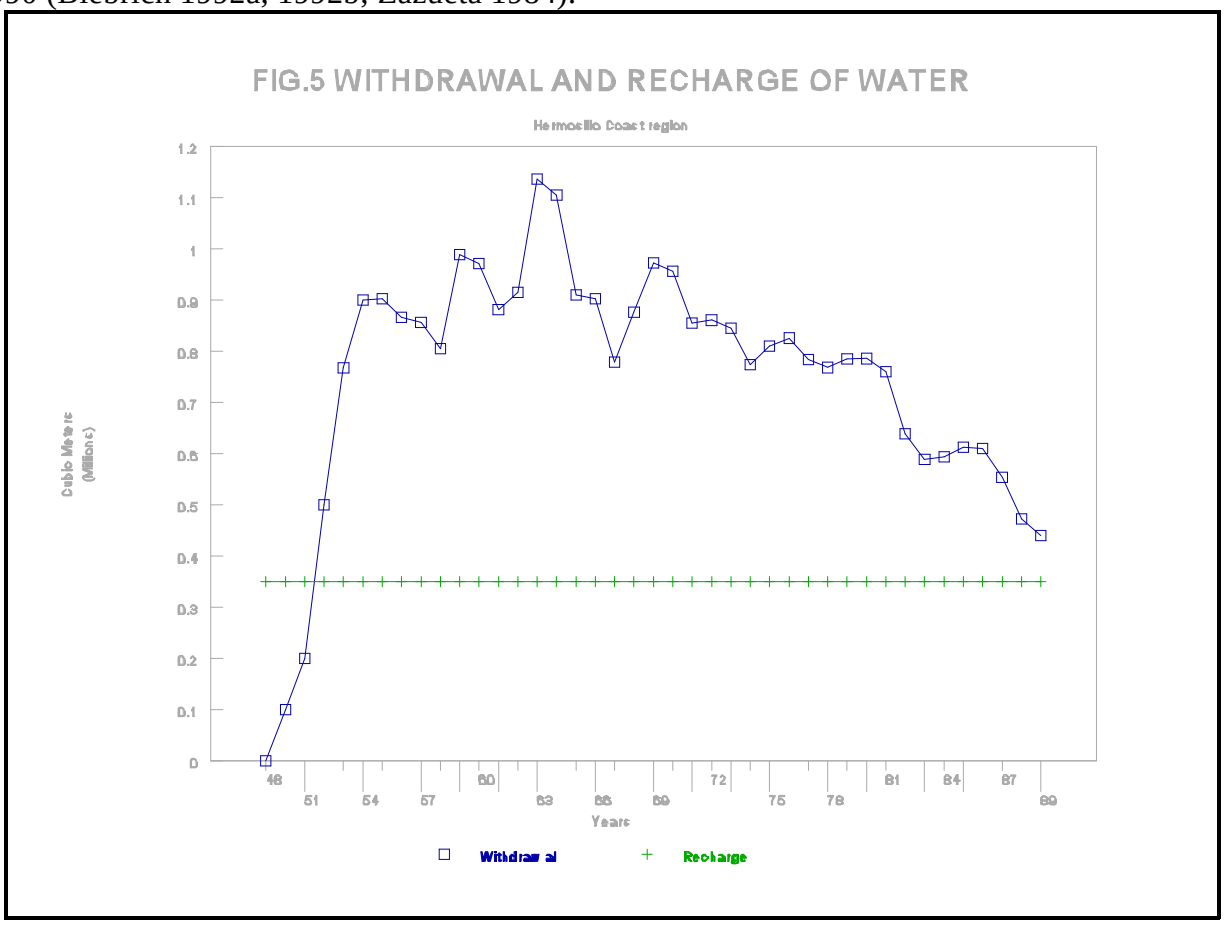
Source: Consulado General de Mexico en N.Y., Secretaria de Hacienda y Credito Publico (SHCP) and Instituto Nacional de Estadistica Geografia e Informatica (INEGI).

1990 (Biebrich 1992a, 1992b; Zazueta 1984).



In order to reduce the ecological problems the strategy designed by the Mexican government and the local farmers include two major points. First, the main goal was to reduce 50% of the groundwater withdrawal from 800 million M^3, to 400 million M^3. This is to achieve the safe-yield by the end of 13-year period beginning in 1977. Second, change the location of 105 wells (located close to the gulf of California) with salt water problems or with high risk of salination. However these goals have not been accomplished completely. Water withdrawal in 1994 was about 450 million M^3 and only 30% of the wells have been already relocated (Distrito de Riego #51; McFarland 1978; Cummings 1974).

Problem Statement

The conjunction of both macroeconomic and ecological problems led the regional agriculture to one of the worst crisis during the second half of the twentieth century. By the early 1990s numerous farmers declared bankruptcy or they were under bank intervention. There is not precise information for this specific region, although, some authors reported that about 83% of the Sonoran farmers had financial problems (Wong and Salazar 1995; Salazar and Nuñez 1993). Puente (1992) reported that the marginal agriculture of the Costa de Hermosillo had to improve efficiency and competitiveness otherwise it will be no longer economically viable.

Based on the information discussed we can ask the following question. Given the political instability of Mexico, the unpredictable of the arid environmental conditions and the

demographic pressure of the study area, is sustainable development possible?

Specifically, the following objectives were formulated: (1) to evaluate farmers' strategies in confronting or taking advantage of the natural resource limitations, and policy changes; (2) to examine opportunities and constraints for agricultural sustainable development; (3) to examine the expected impact on the farming systems related to the changes on the open market that are anticipated with NAFTA.

Toward Sustainable Development

Sustainable development refers to improve and to maintain the well-being of people and ecosystems. The concept of sustainable development is a controversial issue, there is an apparent contradiction in the concept of sustainable development because something must change while some conditions must remain constant (Carew-Reid 1994; Sage 1994). In this study sustainable development is examined based on Lanworthy (1991) proposition that system exploitation is economically viable if generates sufficient income to meet at least the minimum subsistence needs for the participant members. However, for non-market resources, sustainable use will be the promotion of practices that do not degrade the ecosystem. This implies the use of resources at rates equal or lower than the rate at which they could be continuously generated (Gordon 1993; Colchester 1990)

Methodology

Field Research. The field data were gathered in a survey conducted in 1994 in western central Sonora. This survey included interviews of 16 farmers as key informants and their staff (technical consultants and field workers). Farmer interviews were complemented with field crop observation during the spring and summer crop seasons. To deal with socioeconomic, spatial and temporal variability this study was organized as follows.

To capture socioeconomic diversity farmers were classified in two groups. (1) The private sector, which included only farmers from the private sector; (2) The social sector, which included farmers from both types of land tenure *ejido* and *colono* systems.

To capture physical variability the study area was divided into the following four micro zones. (1) south, (2) center, (3) north, and (4) northeast. This geographic division is mainly based on farmers' experience.

This sampling technique is in concordance with the representative farm approach. Many authors agree that the farm approach is a useful method to minimize aggregation errors. This approach involves aggregating the resources of a homogeneous zone and modeling the aggregated data as a single large farm (Onal and Mccall 1991; Onal and McCarl 1989; Hazel and Norton 1986; Buckwell and Hazell 1972).

Model selection and description

In order to assess changes in farming systems and the impact of NAFTA on regional development the Multiperiod Linear Programming Model (MLPM) was selected. One of the main concerns was how to deal with risk analysis in linear programming. However, some authors have found that adding some constraints, in linear programming without risk analysis, may result in similar optimal solutions as fewer constraints with risk analysis. Rotations constraints are relevant elements of the model to deal with financial and climatic risks (Musser et al. 1986; Duloy and Norton 1983).

Three types of basic equations are grouped into the sector model; (1) The objective function in this study represents gross revenues and they are function of the quantities sold of

all products. The objective function of MLPM provides a link between periods and also maximizes the present-day value generated during the whole planning period.; (2) Resource endowments; (3) miscellaneous equations, which represent basically rotations constraints. The last two equations are described in more detail in the next section. The model can be specified as follows:

Objective function:

max Z = cx

S.T.

1) Ax < b1 Sum of variable inputs requirements is less than or equal to fixed amount of capital available.
2) Wx < b2 Sum of variable water requirements less or equal to fixed amount of water available.
3) D - E < 0 Rotation constraints
4) G - G < 0 Linking row for perennial crops

Where:

Z = Is a scalar value which represents the objective function value (in pesos).
c = Is a (n x 1) vector which represents returns (in pesos). Positive values represent output values and negative values represent input values.
A = Is a (m x n) constraint matrix which represents the quantity of the **i**th resources required to produce one unit of the **j**th activity (hectares).
x = Is a (n x 1) vector which represents the level of the **j**th farm activities. The x's values are conditioned to be non-negative.
b = Is a vector of resource endowments (hectares of land or available annual volume of water).
W = Is a constraint matrix which represents the quantity of water required to produce one unit of the **j**th activity.
D & E Represent the proportion of crops from different classifications (D-perennial and E-annual crops)
G = Links perennial crops between periods. The assumption is that any planted area with perennial crops will remain the same during the whole planning horizon.

Application of the Model

The analysis was divided in two scenarios. The first scenario estimates the optimization of cropping patterns under the current conditions of production. *Procampo* subsidies include the following amount and alternative crops for the study area: wheat $330 pesos/ha, corn $330 pesos/ha and cotton $1300 pesos/ha. Perennial crops received only one initial incentive of $350 pesos/ha. In addition, some temporary regional subsidies to the input prices are 28% to electricity and 35% to diesel (SARH 1995, 1994, 1991; SFA 1995).

The second scenario includes the following economic and ecological expected changes. *Procampo* subsidies are excluded. In addition some macroeconomic factors have been adjusted (table 1).

Table 1. Interest, Discount and Exchange Rates in Two Scenarios

Scenario	Interest %	Discount %	Exchange dollar/peso
First	17	17	3.25
Second	9	6	3.90

Because of the high inflation rate and instability during the first scenario the discount rate is a relatively high (17%) as a contingency allowances. In the second scenario both discount rate and inflation rate were considered lower than in the first scenario expecting more economic stability (table 2.1).

The planning horizon is ten years. Perennial crops, such as citrus and grapes included in this analysis, extend beyond the planning horizon. However based on the uncertainty and instability, I selected a ten-year planning horizon. The strategy to deal with this problem is the use of a residual value by the end of the planning horizon (Zerbe and Dwight 1994; Barry, Hopkin and Baker 1988; Gittinger 1982).

Only irrigated agriculture is possible in the this dryland. The source of water for agriculture is groundwater. Four aquifers are reported in the whole region. Two aquifers are located upstream of the city of Hermosillo and the other two are located in the coastal areas of the Gulf of California. However, water available is not longer able to supply water demand (table 2).

Table 2. Recharge and Pumping Water of Regional Aquifers*

Aquifer	Recharge	Withdrawal	Differences
Zanjon	82	95	-13
Mesa del Seri	62	73	-11
Costa Hermosillo	350	450	-100
Sahuaral	70	118	-48
Total	564	736	-172

*Source: Arambula and Palomino 1992.

The first scenario is represented by the actual water withdrawal. The second scenario is represented by the water recharge. This is based on two assumptions: (1) In order to be sustainable water pumping has to be equal or less than recharge. (2) Water available for agriculture is fixed. The latter implies the need for discovering new sources of water for the increasing demand of the growing population. These assumption is based on the argument that there should be alternative ways to deal with future water shortage in urban consumption.

Results and Discussion

Policy and environmental changes may lead to dramatic transformations in sustainable development of western central Sonora. The impact of these changes can be both positive and negative. Some of the main consequences are the following.

Advantages

At the regional level, the economic viability of agricultural system can be better off as a result of the liberalization of the Mexican economy (table 3). This is one of the great transformations that is expected in the study area. Results of economic growth are mainly related to changes in cropping pattern and changes in price-cost ratios.

Table 3. Changes in revenues between two scenarios and four regions

	1st	2nd	Change	% Change
South	947176	1266953	319777	0.34
Center	757309	1137422	380114	0.50
North	756811	1260145	503335	0.67
N East	896534	1508583	612049	0.68
Average	839457	1293276	453818	0.54

These results indicate positive trend in the four microregions. Estimated solutions indicate that the northeastern area has highest potential for economic growth. These differences are associated with some environmental opportunities and farmer strategies to cope with uncertainty and instability of both policy and ecosystem constraints.

Another relevant positive change is that the level of water pumping can be reduced to reach the safe yield, and still it is possible to achieve agricultural growth. However, the condition for ecological viable treaty is that water withdrawal must be reduced in at 30% to meet the rate of water recharge. To achieve this condition international cooperation, enforcement, and resource management should be also part of the strategy. These economic and ecological results are relevant to understand the application of NAFTA at the regional level.

Cropping pattern change is a key component of farming system strategies to cope with resource and institutional changes. Controversial results were found in this point (table 4). On the one hand, results indicate that vegetable and fruit crops tend to increase area of production while most of the crops tend to decrease the area of production. This is the generalized expected shift. On the other hand, wheat the traditional grain crop of the study area also shows the tendency to conserve the level of crop production. The latter is one of the unexpected and unpredicted results (Gonzalez, et al. 1993; Hinojosa-Ojeda 1993; Sanderson 1987).

Table 4. A comparison of model Estimations and Official Data*

	Official Data 1993-96 Mean (ha)	M. Estimation Scenario 2th. (ha)		Change (ha)
Perennial %	**0.32**	**0.37**		**0.05**
Table Grapes	5613	6000		387
Wine Grapes	7367	5932		-1435
Orange	5739	6000		261
Pecan Trees	2206	1186		-1020
Forage	5391	4694		-697
Others	3141	800		-2341
Total	**29457**	**24612**		**-4845**
Winter %	**0.5**	**0.5**		**0**
Wheat	22870	24846		1976
Chickpeas	11060	7883		-3177
Others	12847			
Subtotal		**46777**	**32729**	**-14048**
Vegetable %	**0.06**	**0.10**		**0.04**
Summer Veg.	1215	2551		1336
Winter Veg.	4067	3983		-84
Subtotal		**5282**	**6534**	**1252**
Summer %	**0.1**	**0.02**		**0.01**
Cotton	3006			
Corn		3822		
Others	2895			
Subtotal		**9334**	**2166**	**-7168**
Total	90849	66041		-24808

*Distrito de Desarrollo Rural # 144, 1996-1990.

Farmers of the study area in general are very open and eager to adopt changes with economic incentives. Wheat production is the best example to show the farmer attitude and agricultural regional adjustment in two ways. First, the price was increased dramatically as a result of the higher international prices and devaluation of the peso. For example in 1994 wheat price was 612 pesos per ton while in 1996 the price went up to about triple (prices ranged from 1600 to 2100 pesos per ton). Second, in 1994 about 75% of the planted area of this cereal was flour wheat for the domestic market. In contrast, in 1996 the planted area with this grain was 75% of durum wheat for the international market. In addition durum wheat is more resistant to adverse conditions and has higher potential yield than flour wheat, which has been the dominant variety demanded by Mexican consumers.

This trend has several implications for economic development. First, it indicates that farmers have the opportunity to increase incomes. Second, it will help to increase employment, because export production crops require more labor than domestic market crops.

Third, it will contribute to increased foreign exchange earnings.

Disadvantages

In spite of the positive results there are many barriers for achieving sustainable development. Many authors question the current Mexican policy because market forces, population growth, technological change, as well as NAFTA in particular and the structural adjustment in general are driving irremediable to environmental degradation (Calva 1993, 1992; Ritchie 1993; Hewitt 1992; 1978; Shiva 1991; Hardin 1968). In fact, there are numerous environmental, economic, social and political constraints at both regional and national level that will limit the success of the current strategy.

Intensification of capital use is a major problem in the application of the new strategy due to the following reasons. The smallholder sector especially the *ejido* and *colono* are the most vulnerable groups. This farmer groups do not have resources to apply technological change and credit is far from their possibilities. Another reason is the higher risk represented by fruit and vegetable production in both production and marketing. The consequence of these barriers is that inequality and distribution of income could be worst.

Increasing agricultural exports implies reduction of production for the domestic market. This is relevant at both the regional and national levels because it will affect poor consumers and food security.

Finally, this results can not be generalized to the rest of Mexico. The new strategy can seriously harm areas with comparative disadvantages (Stanford 1994). In Mexico, about 70% is rainfed agriculture and most of this area has traditionally been marginalized by government programs. Again, the social and economic equity issues raise by promoting the most productive subsector.

One of the lessons to be learn is that NAFTA will impact in different ways and more regional studies are required. According to Hutchinson et al. (1992) the ultimate objective is to identify policies and practices affecting vulnerable groups that can be changed.

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