

A case study of land reform and coastal land transformation in southern Sonora, Mexico

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Abstract

This paper examines the coastal *ejido* (collectives of peasant landholders) sector's response to the 1992 amendment to Article 27 of Mexico's Constitution, which for the first time legalized the sale and rental of *ejido* lands. Our analysis is based on a case study of southern Sonora, Mexico. The results indicate a shift in land tenure from the *ejido* to the private sector and a corresponding conversion of coastal lands to shrimp aquaculture ponds. Our analysis suggests these land-tenure and land-use changes, and the implications of these changes for the coastal *ejido* sector, vary depending on the historical, geographic and socio-economic characteristics of the *ejido* communities.

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Introduction

Throughout the 1990s free market policy reforms swept through much of the Latin America. In many regions these reforms have been successful at ushering in foreign capital and increasing productivity (e.g. Paus et al., 2003; Jaramillo, 2001; Gwynne, 1996). However, there has been widespread concern about the potential environmental and social costs of this success (e.g. Barbier, 2000; Green 1996; Southworth and Tucker, 2001; Sanchez, 2003). Rapid economic growth, often facilitated by privatization and liberalization policies, has taken place in many regions without proper safeguards and controls and has contributed to increased environmental degradation, economic marginalization, and social inequity (e.g. Klepeis and Vance,

2003; Lewis, 2002; Adger, 1999; Barbier, 2000; Gwynne, 1993).

In this study, we examine some of the consequences of Mexico's free market reforms of the 1990s for coastal communities. We focus on the amendment to Article 27 of the 1917 Mexican Constitution, which ended the *ejido* land redistribution program and allowed *ejidos* (collectives of peasant landholders) to sell, rent and mortgage their previously inalienable lands. Our study links the reform of Article 27, a critical component of a package of neo-liberal reforms, to land-tenure changes and to the pattern of growth of the shrimp farming industry along the coastal zone of southern Sonora, Mexico, one the largest farmed shrimp producing regions in the country. In addition, we examine the implications of the reforms and the growing shrimp farming industry for the coastal *ejidos*. Specifically, we address the following questions: (1) How have the coastal *ejidos* responded to the reform of Article 27? (2) How have the privatization and liberalization reforms of the 1990s, together with the growth of the shrimp farming industry affected land

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tenure in the coastal zone? (3) Has the reform of Article 27 lead to an increase in *ejido* participation in shrimp farming? and (4) What are the implications of these land-use and land-tenure changes for the coastal communities?

In the following sections we provide an overview of Article 27 and the shrimp farming industry in Mexico, describe the study site and data sources, and present our analysis of the region. We conclude with a brief summary and discussion of the implications of our findings.

Background

Article 27 and the ejido sector

Article 27 of the Mexican Constitution was first written in the aftermath of the 1910 Mexican Revolution in response to peasant rebellions against the inequitable distribution of land and wealth. Prior to the revolution, 1% of the population owned 97% of the land while 96% of the population was landless (Diaz-Cisneros, 1983). Article 27 was intended to end this inequity by establishing the *ejido* sector and declaring all land ultimately the property of the nation. While private property was allowed in principle under the *ejido* land reform program, it established a legal limit on private land holdings of 100 irrigated hectares or the “non-irrigated equivalent.”¹ Furthermore, Article 27 mandated that the state reserved the right to expropriate private land holdings when they exceeded the legal limit and to reclaim *ejido* lands when they were improperly managed.

In the 1990s the Salinas Administration introduced a series of privatization and liberalization policies aimed at integrating rural Mexico into the global economy. Central to this package of reforms was the amendment to Article 27, which established a new Agrarian Law that made five fundamental modifications to the *ejido* land-reform program. First, it ended the government’s obligation to provide land to landless peasants. Second, it established a certification and titling program, PROCEDE (Program for the Certification of *Ejido* Land Rights and the Titling of Urban House Lots), which enabled members of *ejido* communities (*ejidatarios*) to obtain transferable certificates of ownership for their land. Third, it gave *ejidos* the legal right to sell, rent, or mortgage their land. Fourth, it removed the government requirement that the *ejidatarios* work their land personally in order to maintain rights over it. Fifth, it promoted joint ventures between the *ejido* and private sectors (Ley Agraria, 1992).

The PROCEDE program grants certificates of ownership for both individual parcels (*certificados parcelados*) and communal lands (*certificados uso común*) after an extensive survey and documentation of land borders. These certificates, while transferable, are not equivalent to private land titles. *Ejidatarios* need to apply separately for full domain (*Dominio Pleno*) to officially privatize their land. Whether or not *ejidatarios* want to privatize their land, PROCEDE can offer benefits. First, it can help settle land border disputes between *ejidos* and outsiders as well as legalize internal divisions between individual parcels within the *ejido*. Second, the PROCEDE certificate can be used as collateral. Under the new law, *ejido* land cannot be permanently taken away from an *ejido*; however, in the case of a default of a loan lenders can take over the management of the land until their funds are recuperated (Ley Agraria, 1992).

A fundamental goal of the 1992 reform of Article 27 was to increase productivity and efficiency in the rural economy by allowing the market to allocate resources. The reform was also intended to increase investment in the *ejido* sector by encouraging private-*ejido* partnerships and creating greater credit opportunities for the *ejido* sector by providing them a legal form of collateral. However, critics argued that the new law would lead to the mass sale of *ejido* lands, a return to the pre-revolution *Latifundista* (large estates) era, and increased poverty in the land-reform communities (Collier, 1994; Stanford, 1994).

Although it is still early to fully assess the consequences of the new Agrarian Law, the majority of studies to date suggest that it is not leading to dramatic changes in rural Mexico (e.g. Johnson, 2001; Yetman, 2000; Cornelius and Myhre, 1998; Murphy 1994; Zabin, 1997). Scholars have argued that the change has been minimal because many of the official restrictions that Article 27 had placed on *ejidos* have never been widely enforced (DeWalt and Rees, 1994; Heath, 1992; Zabin, 1997). For example, prior to the 1992 reform of Article 27 up to 70% of the *ejido* lands were illegally rented out in some regions of the country (DeWalt and Rees, 1994). Heath (1992) argues that because farmers were able to circumvent the land reform restrictions, historically there have not been significant productivity differences between *ejido* farmers and small private farmers, and therefore, the new Agrarian Law would not likely result in significant productivity increases in the rural economy. Johnson (2001) further argues that because the *ejido* sector has not been constrained by a lack of access to collateral credit, the new Agrarian Law has not significantly influenced *ejidatario*’s investments in land. Meanwhile, only a handful of empirical studies have shown that the new Agrarian Law, together with other privatization and liberalization policies, is contributing to significant changes in the lives of *ejidatarios* (Lewis, 2002; Wiggins et al., 2002). Most of the research to date

¹Article 27 defines “non-irrigated equivalent” as follows: One hectare of irrigated land is assumed equal to 2ha of rain-fed agricultural land, 4 ha of pasture land and 8 ha of grazing land.

on the impacts of the new Agrarian Law has focused on the agricultural and forestry sectors.

In this study, we examine the effects of the reform of Article 27 on the coastal *ejido* sector, a group that has received little scholarly attention despite the dramatic consequences the recent political and economic changes could have for these communities. Studies by DeWalt (1998), DeWalt et al. (2002) and Cruz-Torres (2000), the only studies to our knowledge that address the coastal *ejido* sector and the new Agrarian Law, use data collected primarily at the state level to argue that the legal reforms of the 1990s have transformed the shrimp aquaculture industry in Mexico. DeWalt et al. (2002) conclude that the legacy of the *ejido* land-reform program coupled with the new Agrarian Law has resulted in a Mexican shrimp farming industry where the resource-poor *ejido* farmers are maintaining a leading role. Furthermore, DeWalt et al. (2002) suggest that the aquaculture industry could play an important social development role for the *ejidos*. In contrast, in our study, we use household and farm data to argue that the reform of Article 27 has contributed little to increasing the *ejido* involvement in shrimp farming and that the outlook for the coastal *ejido* sector in the post-reform period does not look promising. There are at least two reasons why our local-level assessment of the coastal *ejido* sector might lead to different conclusions than regional studies in this area. First, our fieldwork reveals that state and national data on shrimp farming are often not complete or accurate. Second, socio-economic differences among *ejidos* even within small geographical regions can make generalizing about the *ejidos* difficult.

Shrimp farming

Over the last two decades shrimp farming has developed into a global multi-billion dollar industry. Primarily an export industry, it provides a major source of foreign exchange for many countries in the developing world. However, the rapid growth of shrimp farming has generated much criticism over potentially negative social and environmental consequences (e.g. Barbier and Cox, 2002; Naylor et al., 1998, 2000; Boyd and Clay, 1998; Stonich et al., 1997; Biksham and Finger-Stich, 1996; Cruz-Torres, 1992a, 1996). The capital-intensive nature of much of shrimp farm production often puts poor local coastal communities at a disadvantage over wealthy and powerful individuals or corporations and in many regions has contributed to increased inequalities and led to violent conflicts over coastal-resource use (e.g. Stonich and Bailey, 2000; Bailey, 1988; Barraclough and Finger-Stich, 1996; DeWalt et al., 1996). Furthermore, much of the nutrients, organic matter, fertilizers, and other chemicals that are applied to shrimp farms to maintain high shrimp stocking densities are ultimately released to the estuaries as waste and

contribute to the degradation of water quality and coastal ecosystems and to the deterioration of local livelihoods (e.g. Boyd and Clay, 1998; Phillips et al., 1998; Primavera, 1991; Primavera, 1993; DeWalt et al., 1996; Barraclough and Finger-Stich, 1996).

The industry was first introduced to Mexico in the 1980s as a rural development strategy designed to expand the economic alternatives of the rural *ejido* sector (Cruz-Torres, 1992b). This initial effort built on the experience of government run experimental stations and those of other regions around the world. However, it did not emerge as a major industry in the nation until 20 years later. Scholars have attributed the slow start of shrimp farming in Mexico to the historical legal structures of the coastal *ejido* and fishing sectors, which prevented significant private investment in the industry (Miller et al., 1988; DeWalt et al. 2002). Until recently, the coastal *ejido* and fishing sectors of southern Sonora held exclusive legal rights over most of the coastal resources critical for shrimp farm development—most importantly land. However, with limited access to credit, coastal *ejido* and fishing communities lacked the resources and technical expertise to develop shrimp farms.

The 1992 reform of Article 27 was one of a series of reforms over the last decade that began to open the coastal resources to the private sector. Similar to the reform of Article 27 that allowed for the privatization of *ejido* lands, the 1992 modifications of the General Fisheries Law legalized for the first time in over 60 years direct private investment in the shrimp industry. In addition, the amendment to the Fishing Law removed longstanding rules that restricted the capture and cultivation of shrimp to the cooperative and *ejido* sectors. The combination of the new Agrarian and Fishing Laws allowed the private sector to enter independently into the aquaculture industry while the economic reforms of the same period provided added incentives for private participation.

For example, the Mexican government enacted a series of policies that encouraged the private sector to invest in shrimp farming. As DeWalt (1998) describes in detail, these new policies included: (1) modifications to the Foreign Investment Law, allowing up to 100% foreign ownership of shrimp aquaculture facilities, (2) fiscal reforms that provided individuals and groups exclusively involved in aquaculture a 50% exemption on their income tax, (3) reimbursements on value-added tax when the producer pays duty on the imported inputs and (4) accelerated depreciation or write-offs of the initial infrastructure investment. In addition, the signing of the North America Free Trade Agreement in 1994 (NAFTA) reduced trade barriers on exports and duties on aquaculture inputs (SEPESCA, 1993).

At the same time that government programs encouraged the private sector to enter into the new aquaculture

industry, the *ejido* sector felt the hardships of drastic cuts in government assistance programs and a sharp decline in credit available from development banks. Historically, high and volatile interest rates and a lack of collateral have left the *ejido* sector credit-constrained (Naylor et al., 2001). The Mexican government had previously compensated for these constraints by providing subsidized loans for traditional *ejido* activities such as agricultural farming and fishing, primarily through the rural development bank, BANRURAL. However, the restructuring of BANRURAL in 1989 has made it increasingly difficult for *ejidos* to secure loans (Naylor et al., 2001).

In the following case study, we explore how shrimp farming facilitated by the reform of Article 27 is transforming the social and biophysical landscape of southern Sonora and assess the implications of these changes for the coastal *ejido* sector.

A case study: Coastal zone of southern Sonora, Mexico

Study region

The coastal zone of southern Sonora spans the deltas of the Yaqui, Mayo and Fuerte rivers of northwest Mexico that drain into the Gulf of California. The study region consists of a 250 km long strip of coast between the Lobos Estuary in the north and the Agiabampo Estuary in the south and extends 5 km inland (Fig. 1). It is located along an important waterfowl and shorebird migratory flyway that consists of a series of marshes, estuaries and lagoons that maintain a rich diversity of marine and coastal ecosystems and support a large group of fishing communities (Valdés et al., 1994).

Until the mid-1970s most of the coastal lands of southern Sonora were federal territory. The few exceptions include a limited number of *ejido* plots that were established during the Cardenas Administration in the 1930s, and several larger parcels of land the government granted to indigenous communities during the 1940s. The first mass distribution of coastal lands to *ejidos* took place in the late-1970s under President Luis Echeverría. In some cases the coastal lands were granted to communities that had a long history of living in the coastal zone, but never had formal *ejidal* rights over the land. Most of the land re-distributed during this period was believed to have little productive use. However, by the early 1990s with the rise of shrimp farming the coastal lands that were once perceived as wastelands began to be seen as potential gold mines. The second major coastal land distribution was carried out in the late 1980s under president Carlos Salinas as part of the Integral Agrarian Program of Sonora (PAIS) and established the first “aquaculture *ejidos*” in the region.

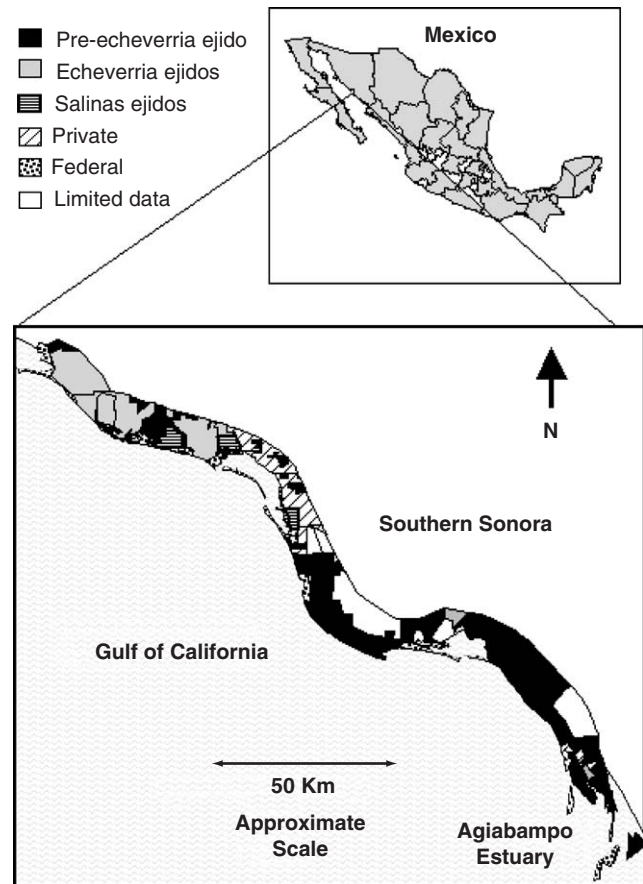


Fig. 1. Coastal zone of southern Sonora, Mexico. Land use distribution shown for 1992.

The historical distribution of land tenure in the region is specified in Fig. 1.

Methods

Our analysis in this case study is based on fieldwork carried out between January and November of 2001. We conducted 131 formal interviews with *ejidatarios* from 41 different coastal *ejido*² communities (controlling approximately 70% of the *ejido* land area in the study region) and 88 formal interviews with private and *ejido* shrimp farms (representing approximately 92% of the shrimp farms operating in 2001). We conducted two to five interviews in each *ejido* community. One of these interviews was with a member of the official community leadership. The community interviews focused on basic household economic data, coastal resource use,

²In this study, we use the term *ejido* to include agrarian communities (*comunidades agrarias*). Agrarian communities are distinct from *ejidos* in that agrarian communities were formed based on pre-Hispanic rights to lands, whereas *ejidos* did not need to demonstrate any historic rights to land parcels. Although the history and rights of the agrarian communities differ somewhat from the *ejidos* these differences are not significant for the purposes of this analysis.

involvement in and perceptions of shrimp aquaculture, and their response to the new Agrarian Law. Interviews with shrimp farmers focused on farm management practices, land-tenure issues and yield and profit data. Formal and informal interviews were also conducted with landless coastal fisherman and major financial and social institutions involved in the shrimp farming industry, including development banks, state regulatory agencies and *ejido* organizations.

In addition, we reviewed government archives, which contained historical, land-tenure and socio-economic data on each of the *ejidos* within the study region (58 *ejidos* total). In some cases the data in the government records were missing or incomplete. In particular, several *ejidos* that were identified in government records as part of the PAIS program were not on record in the official registry office. We digitized and compiled the official government land-tenure maps for each *ejido* in a GIS. In most cases, these maps were professionally surveyed PROCEDE maps; however, for those *ejidos* that had not entered PROCEDE we digitized the old government maps that were often hand drawn. In cases where the borders of different *ejidos* in the old and new maps overlapped we used the border from the new maps.

To document the growth in shrimp farming we combined data from shrimp-farm interviews, government records, Landsat satellite images (for 1986 (MSS), 1992 (TM), 2001 (ETM)) and field surveys where we identified the exact location of each shrimp farm using a geographical positioning system (GPS). We used the satellite images to visually identify shrimp farms in each period. The size and date that these farms were first developed were verified through farm surveys. We analyzed differences in *ejido* responses to Article 27 and shrimp farming using analysis of variance (ANOVA) for continuous variables and the χ^2 test for discrete counts (e.g. number of *ejidos* that had developed shrimp farms). We also conducted multiple logistic regression analysis, however, the results are not reported here as they simply confirm the results of the χ^2 tests.

Results and discussion

Land-tenure changes

Our data indicate that the structure of the land tenure along the coast of southern Sonora has dramatically changed since the 1990s reforms (Fig. 2). Three major changes have taken place. First, virtually all of the *ejidos* have entered into the PROCEDE process and have obtained their certificates of ownership. Second, much of the communal land has been divided into individual parcels. Third, *ejido* lands have begun to be rented out and sold to the private sector.

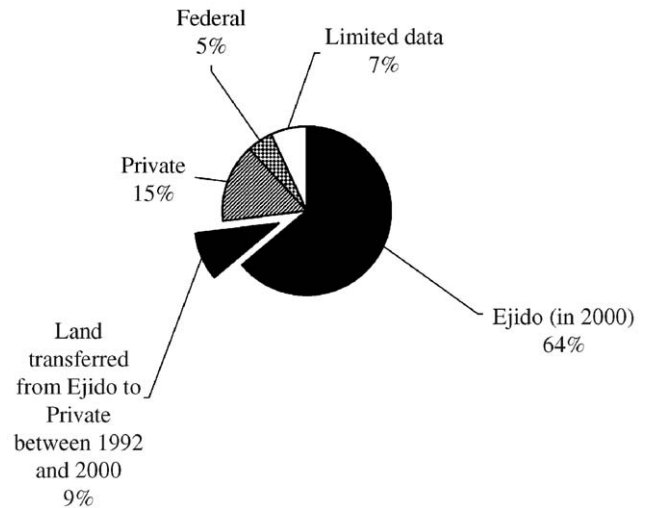


Fig. 2. Land tenure in the coastal zone in southern Sonora 1992–2000. Source: compiled by the authors from *ejido* files at the Agrarian Registration office in Hermosillo, Sonora. These data do not officially consider the National Laws governing the near coastal zone, unless these region were identified on the official registry maps as federal lands.

These changes in and consequences of land use and tenure are not uniformly distributed across the study area, but rather vary with the historical, geographical and socio-economic characteristics of the specific *ejido* sector communities. To facilitate our analysis of the variation in *ejido* responses to the 1990 reforms, we divided the coastal *ejidos* in our study region into three groups according to time period in which the communities were first established. We define these groups as the Pre-Echeverría, the Echeverría and the Salinas communities. Pre-Echeverría populations include all *ejidos* that existed as communities prior to the Echeverría Administration in the 1970s. Echeverría communities are *ejidos* that were formed during President Echeverría's Administration. The Salinas communities include all *ejidos* formed during the Salinas Administration.

Our data indicate significant socio-economic and geographical differences among these three *ejido* groups (Table 1). The Pre-Echeverría communities, which control 78% of the *ejido* sector land in the study region, are located primarily in the less developed southern portion of the study area (Fig. 1). These *ejidos* consist predominantly of indigenous communities and have a long history of living in the coastal zone and relying heavily on fishing and other coastal resources for their livelihood. In contrast, the Echeverría and particularly the Salinas *ejidos* tend to be dominated by populations who live in less rural settings away from the coast and who have traditionally had little direct economic links with the coastal zone. Furthermore, the Salinas *ejidos* have no agricultural land and have on average only one-

Table 1
Comparison of the three types of *ejido* communities^a

	Pre-Echeverría	Echeverría	Salinas
Average number <i>ejidatarios</i>	143	55	39
Average area of land per <i>ejidatario</i> (ha) ^b	37	43	5
Average % of land that is communal ^b	77	55	100
<i>Ejid</i> os whose members live predominantly in urban center (%) ^c	25	79	100
<i>Ejid</i> os that are predominantly indigenous (%) ^d	69	21	14
<i>Ejid</i> os that predominantly fish for living or subsistence (%)	79	10	0
<i>Ejid</i> os that have agricultural land (%)	69	43	0

^aSource: authors' interviews and data compiled from Reforma Agraria National documents in Hermosillo, Sonora. Unless otherwise noted *p*-values for all <0.0001 (*N* = 58).

^bANOVA test of significance (*p* < 0.01).

^cUrban defined as population centers greater than 5000.

^dAnalysis limited to interviewed *ejidos* (*N* = 43).

fifth the land area per member as the Pre-Echeverría and Echeverría communities.

The communities in each of these three land-tenure groups welcomed the PROCEDE program as a means of settling border disputes with neighboring landowners and securing their land rights. However, 30% of the Pre-Echeverría communities have still not completed the program on account of internal land disputes that need to be resolved independently before PROCEDE will survey and provide titles.

Although all of the coastal land was originally distributed as communal property, over the last 6 years the Pre-Echeverría and Echeverría *ejidos* have begun to divide their land into individual parcels. *Ejidatarios* expressed several reasons for their decision to parcel out their communal lands including the desire to protect themselves from the corruption they found under the *ejido* leadership. In the words of one *ejidatario*, they wanted “to know what was theirs.” Some of the larger *ejidos* have divided land into sectors to be managed separately by small groups of 5–15 people. Others have turned to parceling specifically to acquire *Dominio Pleno* and ultimately to sell the land. In contrast to the Pre-Echeverría and Echeverría communities, all of the Salinas *ejidos* have maintained their land as common property. None of the Salinas *ejidatarios* we interviewed expressed any desire to parcel or sell their land. The most common reasons that the Salinas *ejidatarios* gave for not wanting to de-collectivize their land was that they feared that the land could be taken away from them if they acquired individual title.

The vast majority of *ejidatarios* we interviewed expressed a reluctance to privatize and sell their land explaining that the land was an important source of security—“something to pass on to their children.” Despite this reluctance, all of Echeverría *ejidos* and over 30% of the Pre-Echeverría *ejidos* have sold or rented out a portion of their lands to the private sector (Table 2(a)). This transfer of land has taken many forms, but it is predominantly under 30-year rental contracts. In most

Table 2
Response of *ejido* sector

	Pre-Echeverría	Echeverría	Salinas
(a) To Article 27 Reform ^a (%)			
PROCEDE ^b	69	92	100
<i>Dominio Pleno</i> ^c	12	36	0
Sold land ^{d,e}	36	84	0
Received offers to buy <i>ejido</i> land ^{c,e}	54	50	4
Want to sell <i>ejido</i> land ^{d,e,f}	9	17	4
(b) To shrimp aquaculture ^a (%)			
Private shrimp farm on <i>ejido</i> land ^{c,g}	31	29	0
Shrimp farm owner ^{e,h}	25	50	73
Shrimp aquaculture risky ^{c,e,i}	18	33	78

^aSource: compiled from author surveys and the Reforma Agraria documents from Hermosillo, Sonora office. Unless otherwise noted the χ^2 test of significance *p*-values for all <0.001 (*N* = 58).

^b χ^2 test of significance *p*-values for all <0.05.

^c χ^2 test of significance *p*-values for all <0.01.

^d“Sold” also includes all lands that have been contracted for long-term rental 15+ years.

^eRefers to % if respondents from household surveys in each group (*N* = 131).

^fNot significant.

^g“Private shrimp farm on *ejido* land” refers to lands that were *ejido* prior to reform and have a privately owned.

^h“Shrimp farm owner” refers to *ejidos* where part or all of the *ejido* own their own shrimp farm. This could also include *ejidos* that have a privately owned and *ejido* owned farm on their land. Note that 100% of the *ejidos* we interviewed said that they wanted or had plans to develop a shrimp farm in the future.

ⁱ“Shrimp aquaculture risky?” refers to the *ejido* response to this question. Responses were given as yes, no or a little. Here we report those that responded yes only.

cases, the long-term rental contract is signed as an interim agreement until the *Dominio Pleno* is acquired for the out-right sale of the land. Although the process of applying for and acquiring *Dominio Pleno* is slow, it has been pursued by many *ejidos* in the region. In 45% of the Echeverría *ejidos* and in 19% of the

Pre-Echeverría *ejidos Dominio Pleno* has been acquired for part of the land. However, in no cases have the *ejidos* opted to privatize their entire land holding and dissolve the *ejido* unit.

Land-use changes

Our survey results indicate that most of the *ejidos'* responses to the new Agrarian Law, including the division of communal land and the sale or rental of land, have been motivated by a desire to enter into the shrimp farming industry. Here we briefly describe the growth of shrimp farming industry in the study region and then explore how the reform of Article 27 is influencing where shrimp farms are developing in the region.

When shrimp farming began

Shrimp farming was first introduced to southern Sonora in 1978 as a research activity in the Technological and Research Center of the University of Sonora (CITCTUS). Subsequently, in the mid-1980s the government began to promote shrimp farming through a series of subsidized pilot projects in a few coastal *ejidos*. Although these pilot projects were short-lived due to poor management, the Sonoran government still saw promise in encouraging shrimp farming in the region as a means to diversify the economic opportunities for these communities. As a result the Sonoran Integrated Agrarian Program (*Programa Agraria Integral de Sonora*, PAIS) program was promoted to address the peasant demand for land and employment by establishing four aquaculture “parks” for the *ejido* sector. The parks consist of groups of *ejido* plots developed as separate shrimp farms but with shared fundamental infrastructure such as pumps, canals and electrical facilities.

Despite these early efforts to promote shrimp farming, the industry did not begin to grow at a rapid rate until the mid 1990s (Fig. 3). Between 1994 and 2001 over

10,000 ha of new shrimp ponds were constructed compared with less than 1000 ha that were developed between 1988 and 1993. Much of the development prior to 1998 was led by the Salinas *ejidos* as part of the aquaculture park system, while development after 1998 was dominated by the private sector.

Where shrimp farms develop

In our study of the factors affecting where shrimp farms are developed we only include data related to those shrimp farms that were not part of the PAIS program. We limit our analysis in this way because the location of the PAIS shrimp farms was centrally determined to be on the Salinas *ejido* lands. The PAIS program is not ongoing, and therefore will not influence the future growth pattern.

Although it is difficult to assess the influence of the reform of Article 27 independent of the various economic and institutional changes implemented in the 1980s and 1990s, our data suggest that the new Agrarian Law has been a pivotal component of this package of reforms in influencing the pattern of land-use change in southern Sonora. We illustrate this effect with a comparison of the tenure of lands where shrimp farms were developed before and after the reform of Article 27.³ To conduct this analysis we divided the entire study region into 250 m × 250 m grid cells and then using a stratified random sampling approach we selected 5000 cells and assessed the relationship between land tenure and shrimp farm locations. We repeated this analysis for the pre- and post-reform periods. We then used contingency tables and the χ^2 to test if land tenure and shrimp farm location during these two periods were independent (Table 3). This analysis suggests that in both the pre- and post-reform periods land tenure is not independent of shrimp farm location. However, the results indicate that prior to the new Agrarian Law shrimps farms on non-*ejido* lands occurred more often than would be expected (if land tenure and shrimp farm location were independent) while after the reform they were found on *ejido* lands more often than would be expected (if independent). This suggests that the land reform has influenced the pattern of shrimp farm growth (Fig. 4).

To explore the pattern of development in more depth we examined the influence of six factors on shrimp farm development on *ejidos* lands (Table 4). The first three factors are related to the Reform of Article 27 and include: (1) possessing a PROCEDE land certificate, (2) possessing *Dominio Pleno* certificate and (3) having sold *ejido* land. The results indicate that possessing PROCEDE certificates is not significantly correlated with shrimp farm development. However, as expected, we

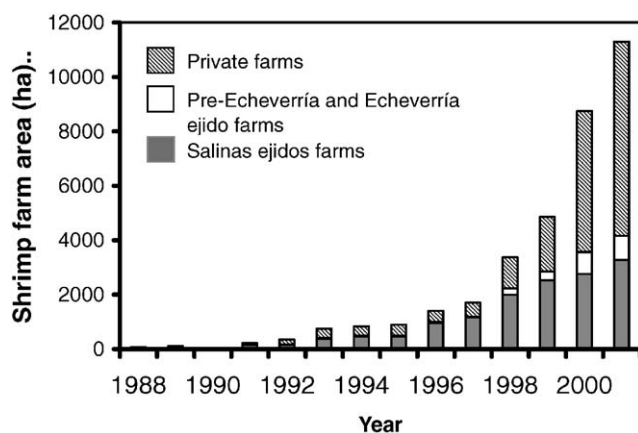


Fig. 3. Shrimp farm growth by sector between 1988 and 2002.

³For this analysis we define “pre-reform” as prior to 1995 because the PROCEDE titling process did not begin in the region until 1995.

Table 3
Contingency table to assess the relationship between land tenure and shrimp farm location in pre-and post-reform periods

	Observed		Expected			
	Farm	No farm	Total	Farm	No farm	Total
(a) Pre-reform						
<i>Ejido</i> land	27	3915	3942	43	3899	3942
Non- <i>ejido</i> land	27	975	1002	11	991	1002
Total	54	4890	4944	54	4890	4944
(b) Post-reform						
<i>Ejido</i>	203	3739	3942	187	3755	3942
Non- <i>ejido</i> land	32	970	1002	48	954	1002
Total	235	4709	4944	235	4709	4944

The analysis is based on a grid of the study region with grid cells of 250 m × 250 m. This grid cell size is less than half the size of the smallest shrimp farm. The data on shrimp farm location was compiled from satellite images and GPS identification. The χ^2 analysis is based on 5000 randomly selected cells from the grid under pre- and post-reform conditions. In each case there are less than 5000 because we discarded cells when there was significant overlap in land tenure or land-use type, with water bodies, or lay outside the study region (greater than 50%). The total number of cells in the pre- and post-reform periods is both 4944 by chance not by design. These data just consider the existence of a shrimp farm not the number or relative area of farms per cell. $\chi^2 = 23.9$, p -value < 0.0001. $\chi^2 = 6.8$, p -value < 0.01.

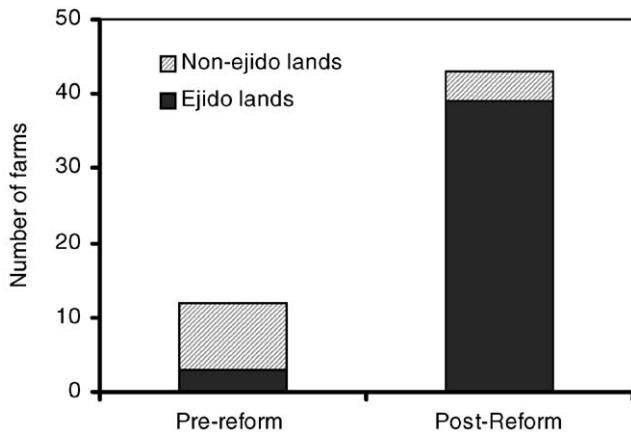


Fig. 4. Shrimp farm development before and after the reform of Article 27. χ^2 test of significance. $p < 0.001$.

found that both possessing *Dominio Pleno* and having sold land are significantly correlated with the shrimp farms on *ejidos* lands. As will be discussed in more detail in the following section, we had hypothesized that most of the shrimp farms being developed are by private farmers who have bought land from *ejidos* and want to insure the legal purchase of the land via the transfer of the *Dominio Pleno*.

Additional variables that we considered include the location of land relative to the coastal water, whether the *ejido* had irrigated agricultural land, and whether the *ejido* was predominantly indigenous. As expected, we found that lands that border the water, and thus have

Table 4
 χ^2 calculations: analysis of shrimp farm development

	Shrimp farm on <i>ejido</i> land		
	No	Yes	Total
<i>Procede</i>			
No	3	1	4
Yes	19	10	29
Total	22	11	33
Not significant			
<i>Dominio pleno</i>			
No	18	6	24
Yes	3	5	8
Total	21	11	32
$\chi^2 = 3.6$, p -value = 0.06			
<i>Sold land</i>			
No	19	3	22
Yes	3	8	11
Total	22	11	33
$\chi^2 = 11.65$, p -value = 0.001			
<i>Indigenous</i>			
No	14	7	21
Yes	8	4	12
Total	22	11	33
Not significant			
<i>Land border water</i>			
No	16	3	19
Yes	6	8	14
Total	22	11	33
$\chi^2 = 6.53$, p -value = 0.01			

These data represent shrimp farm development that were not part of the government initiated PAIS program. See text for more details.

direct access to this critical resource for shrimp farming, are more likely to have shrimp farms developed than those lands farther from the water. As we had further hypothesized, we found that *ejidos* with near coastal agricultural land within the irrigation district are less likely to have shrimp farms. We expect this is because agriculture is perceived as a more secure land-use option. Finally, although we had expected that indigenous communities would be less likely to have shrimp farms on their land because of the historical tensions between the indigenous and non-indigenous populations, we did not find any evidence to support this hypothesis.

There are several additional factors that are likely to influence where shrimp farms are developed that we have not included in our analysis. Perhaps the most important are the biophysical characteristics of the land such as soil type, land cover, and the quality of the nearest water sources. We are currently examining these factors in a parallel study of land-use change in the region.

Participation in the shrimp farming industry

The coastal *ejidatarios* are participating in shrimp aquaculture as employees on shrimp farms or other

associated industries, by renting or selling their land, or as shrimp farm owners. Our data indicate that over the last 10 years the *ejidatarios*' involvement in the shrimp farming industry has shifted from being primarily shrimp farm owners to land renters and sellers. In 1996 almost 70% of the shrimp farm area was owned by *ejidos*: by 2001 this figure had dropped to 30%. This shift appears to be due to the fact that except for the initial government support provided to the Salinas *ejidos* through the PAIS program, the *ejido* sector has found that limited access to credit and technical support has made it difficult to enter into the industry on their own.

Over the last decade, the development of *ejido*-run shrimp farms in the Pre-Echeverría and Echeverría communities has been controlled by the new market rules established in the early 1990s. For communities eager to enter into shrimp farming there are three options: (1) obtain credit on their own from a private or public bank, (2) go into partnership with a private entrepreneur, or, (3) sell or rent part or all of their land to acquire the funds to initiate the farm development. In reality, not all of these options are viable. For example, our surveys suggest that the PROCEDE titles, which most of the *ejidos* hold, have not been sufficient to acquire credit. The second option of entering into joint ventures with the private sector is often not looked on favorably. In our survey, several *ejidatarios* attributed their reluctance to enter into joint ventures to the reluctance of private farmers to report or share profits. As a result, many Pre-Echeverría and Echeverría communities that want to enter shrimp farming are left only with the option to sell or rent their land.

Our analysis indicates that 80% of the Pre-Echeverría and Echeverría *ejidos* that have developed their own shrimp farms have sold part of their land. Although selling land appears to be a significant factor for *ejido* shrimp farm development, it is not a sufficient condition. While every *ejido* we interviewed expressed the desire to develop a farm, only 36% of the *ejidos* that had sold land had developed shrimp farms. As a result, most of the growth in the industry in recent years has been dominated by the private sector on lands that belong to or once belonged to Pre-Echeverría and Echeverría *ejidos* (Table 2(b), Fig. 3). In 2001, of the farms on the Pre-Echeverría and Echeverría *ejido* lands 72% were private farmers who had bought *ejido* land, 9% were private farms on rented land, 6% were joint ventures between the private and *ejido* sector and only 13% of the farms were *ejido* owned.

Implications for coastal *ejidos*

The coastal *ejidos* that operate their own shrimp farms have done so with varying success. The distribution of shrimp farm profits earned by *ejidatarios* over the last 4 years is highly skewed (Fig. 5). While a few have

earned up to 16,000 US dollars (USD) in a year, most earned little or no net profit and have gone into debt. This large spread in profits is primarily the result of annual variations in yield due to disease problems, natural disasters, and management differences between farms. In 2000 and 2001 at least two-thirds of the *ejido*-shrimp farms in the region had outbreaks of viruses including White Spot and Taura Viruses that reduced the quality and yields of shrimp production and resulted in no profit distributions to the *ejidatarios*. In 2000, a White Spot outbreak destroyed most of the shrimp harvest of many of the *ejido* sector farms leaving them unable to pay back their loans for that year. As a result, they struggled to get loans for the 2001 production cycle. Those that were able to acquire loans received their credit late and were forced to delay their planting until late in the shrimp season. Then in 2001, faced with a hurricane that damaged shrimp ponds, many of the *ejidos* were pushed even further into debt, making it difficult to obtain loans for the 2002 season.

After several consecutive years of poor shrimp harvests, some in the *ejido* sector have begun to worry about the risks of shrimp farming; however, this concern is not universal. While 78% of the Salinas *ejidatarios* we interviewed saw aquaculture as a high-risk industry, only 17% of the Pre-Echeverría communities expressed similar concerns (Table 2(b)). Ironically, it is the Pre-Echeverría communities that potentially have the most at stake if the industry continues to grow at the current rate, because the environmental impacts of the spreading of shrimp farming industry pose a potential threat to the ecosystems these communities have traditionally depended on.

Regional studies in Mexico indicate that although shrimp farm effluents contribute less than 2% of the total anthropogenic nutrient loads (nitrogen and phosphorous) to the coastal waters, locally these effluents are having adverse effects on coastal ecosystems (Osuna

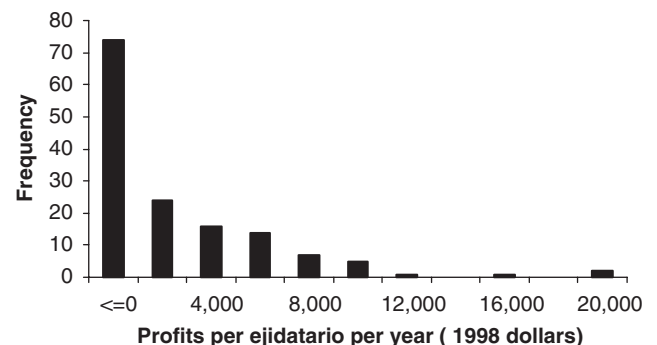


Fig. 5. Distribution of *ejido* shrimp farm profits 1998–2001. Source: author's survey. These data are in part based on recall and in part based on farm records. Where we relied on recall data we collected data from at least two independent sources. The average area of farm per *ejidatario* is 2 ha. 1998 nominal exchange rate 9.2 Pesos/1 USD Deflated by US GDP Deflator.

et al., 1997; Galvan and Fernandez, 1998). In southern Sonora, the dominant source of surface water pollution is the untreated urban and agricultural runoff that releases organic matter, fertilizers and pesticides into a series of estuaries along the coast (Harrison, 2003); however, there are other smaller and more isolated lagoons and estuaries in the region that have historically remained mostly free of these point and non-point sources of pollution. Many of these more pristine water bodies are located in coastal regions bordering Pre-Echeverría and Echeverría communities. Shrimp aquaculture farmers have sought out these less polluted water bodies for the location of their shrimp ponds. As a result, as the density of aquaculture farms in some regions rise, the shrimp pond effluents may threaten both the health of the shrimp industry and the estuarine fisheries on which many Pre-Echeverría communities livelihoods depend.

Despite this threat, most of the *ejidatarios* we interviewed from Pre-Echeverría communities still maintain high hopes for the potential fortune that aquaculture may hold for them. Many from our survey explained with great enthusiasm that shrimp farmers could expect profits of up to \$8000/ha/year, well above the average profits earned by *ejido* sector farms in the area (Fig. 5). Unfortunately, the enthusiasm expressed for shrimp aquaculture in these communities seems to be blind to the inherent socio-economic and environmental risks that the industry brings with it.

Conclusion

The results from this study suggest that the series of privatization and liberalization reforms promulgated in the 1990s have influenced the shifts in land tenure and land use along the coastal zone of southern Sonora. In particular the new Agrarian Law has facilitated the rapid growth of the shrimp farming industry by providing the legal basis for the division of communal lands and the transfer of lands from the *ejido* to the private sector. Prior to the reforms, all of the coastal *ejido*-sector lands were held collectively with few if any illegal rentals and shrimp farms were predominantly built on non-*ejido* lands. Today coastal lands are being parceled out and changing hands rapidly as private shrimp farm development spreads over previously *ejido* lands.

The findings presented here do not explain the land-use and land-tenure decisions in the region. A number of factors, which have likely influenced the timing and rate of shrimp farm growth, have not been addressed directly in this study. For example, an extended drought in the region is likely pushing many agricultural farmers away from wheat farming, the traditional crop of the region, and toward aquaculture as a means of income diversification. In addition, increased fishing pressure on

estuarine and other coastal fisheries may be leading traditional fishing communities to seek alternative income opportunities in the shrimp aquaculture industry. While these and other issues are critical for understanding the reasons behind coastal land-use decisions, they go beyond the scope this case study. This analysis has focused on understanding how the reform of Article 27, a critical part of a package of reforms in the 1990s, has influenced whom and where shrimp farms are developed and the implications of these changes for the coastal *ejidos*.

The analysis suggests that, contrary to expectations, the reform of Article 27 has not contributed substantially to the *ejido* sector involvement in the shrimp farming industry in Sonora. Mexican officials promoted the reform of Article 27 as a means of strengthening the *ejido* sector, making it more productive and efficient by removing restrictions and ending their dependence on government subsidies. However, our results indicate that while the reform has facilitated the rapid growth of shrimp farming, the involvement of the coastal *ejidos* has been limited. Despite an almost unanimous interest in entering shrimp farming less than 10% of the *ejidos* have participated in the post-reform shrimp farm development. The majority of the existing *ejido* shrimp farms were created as part of the government subsidized PAIS program among the Salinas aquaculture *ejidos*. We attribute the lack of non-Salinas *ejido* participation in this growing industry at least in part to the fact that, contrary to expectations, many coastal *ejidos* have found that the PROCEDE land titles have not been sufficient to secure loans for shrimp farming and few joint ventures between the private and *ejido* sector have been realized.

Although it is difficult to predict in the long run whether or not on average the coastal *ejido* sector will be better or worse off as a result of the reforms and the introduction of the shrimp farming, our results suggest that the future for the coastal communities in southern Sonora looks difficult. Although a handful *ejidos* have made large profits as shrimp farm owners or found seasonal or temporary employment on shrimp farms, and others have received cash for land sales, the coastal zone of southern Sonora is still rapidly changing. If the present pattern of shrimp farm growth and shifts of land tenure continue at their current rates, in a few years many in the coastal *ejido* sector may find that their hopes of earning riches from shrimp farming have disappeared along with much of their traditional coastal lifestyles.

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