Cash crops, smallholder decision-making and institutional interactions in a closing-frontier: Calakmul, Campeche, Mexico

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Abstract
In Mexico, since the revolution of 1910, agricultural development for subsistence and market has been a priority of diverse stakeholder groups, particularly farmers. Within the last ten years, Mexican federal agricultural policy shifted from a paternalistic to an enterprise model. This shift resulted in benefits for a few farmers while placing most producers at risk of economic failure. In addition to the impacts on the household economy, these policies influence land use and land cover. This paper explores the dynamics of chili production and how these dynamics are influenced by household and policy factors in the municipality of Calakmul in Campeche, Mexico. Jalapeño chili is the foremost market crop in Calakmul, until recently a development frontier for Mexico, and now the site of the largest biosphere reserve in that country and a landscape where priorities for forest conservation meet those for agricultural development. An integration of qualitative and quantitative methods enables a more complete understanding of this important and expanding land use in the region.
Keywords: *Mexico, agricultural decision-making, land use, market crops*

Resumen
En México, desde la revolución, el desarrollo agrícola para la subsistencia y el mercado ha sido una prioridad para diversos grupos, especialmente los agricultores. Durante la última década la política federal mexicana en relación a la agricultura ha cambiado de uno marcado de paternalismo hacia un modelo empresarial. Este cambio benefició a un grupo pequeño de agricultores, pero exponía la mayoría al riesgo de un fracaso económico. Por encima de los impactos en la economía doméstica, esas políticas impactaron en el uso del suelo y la cobertura de la tierra. Este estudio explora los dinámicos de la producción de chili y cómo ellos son influidos por los factores y políticas domésticos dentro el municipio de Calakmul, en Campeche, México. El chili jalapeño es el producto principal del mercado de Calakmul, desde hace poco en la frontera de desarrollo de México, pero ahora la ubicación de la reserva bioesférica más grande de México, y un paisaje en el cual las prioridades de conservación confrontan aquellas del desarrollo. Una integración de métodos cuantitativos y cualitativos permiten un mejor entendimiento de este importante y ampliando uso de suelo de la región.
Palabras clave: *México, toma de decisiones agrícolas, uso de suelo, cosechas del mercado*

Introduction: changing expectations of communal lands in Mexico

With the affirmation of the North American Free Trade Agreement (NAFTA) Mexico fully altered its expectations of the *ejido*, the country's foremost communal land tenure institution (DeJanvry, Sadoulet, and Gordillo 1997; Randall 1996; Liverman 1992). It was no longer fiscally possible or desirable for the federal government to support generally low-yielding semi-subsistence farmers on ejidos, and Article 27 of the Mexican constitution was reformed. Among other changes, this reform allowed peasants to own land previously held in common. The possibility of privatization, it was hoped, would allow *ejidatarios* to access private credit or to use land as collateral, generating incentives to modernize and intensify agricultural and/or forest production. The impacts of the Article 27 reform have been varied but they signal that the Mexican government now desires rural people to do more than survive; rural people are expected to profit.

Rural smallholder land use and structural forces have long been explored in the geographic fields of cultural and political ecology. A rich body of empirical and theoretical work investigates agricultural change and decision-making in peasant societies (Roy Chowdhury and Turner 2006; Laney 2002; Turner and Ali 1996; Turner and Brush 1987; Brookfield 1972, 1964, 1962; Brookfield and Brown 1963). In addition, the role of exogenous political-economic institutions that enable and/or constrain smallholder households is analyzed in human-environment research (Robbins 2004; Zimmerer and Bassett 2003; Brookfield, Potter and Byron 1995; Blaikie and Brookfield 1987; Hewitt 1983; Watts 1983). Commodity markets are among some of the most important institutions to arise in and transform frontier settings (Keys 2005; Keys and McConnell 2005; Batterbury and Bebbington 1999; Finan 1998; Barlett 1980; Gudeman 1978).

In the southern Yucatán peninsular region (SYPR), the interaction between farming households and (supra) regional institutions influences land use in ejidos and shapes future land cover. The liberalization of the Mexican economy in the 1990s saw the implementation of agricultural policy instruments that focused on market agriculture in addition to increasing subsistence yields. For smallholders residing in the southern Yucatán's ejidos, jalapeño chili (*Capsicum annuum*) is the most significant agricultural crop that is cultivated specifically for the market. The cultivation of chili depends on smallholder decision-making, in turn linked to neoliberal agricultural policies and the expansion of the commodity's market in the region. The 1990s also witnessed an increasing internationalization of conservation interests in the Mexican forests, following the designation in 1989 of Calakmul, the country's largest biosphere reserve, in southeastern Campeche (Miller, Chang and Johnson 2001; Acopa and Boege, 1998). The establishment of the Calakmul Biosphere Reserve (CBR) was accompanied with concomitant state and non-governmental organization (NGO) efforts to promote sustainable and/or intensive agriculture in areas bordering the reserve. The confluence of structural reform, agricultural policies and environmental movements in this region hold important implications for land use in the CBR region, including chili cultivation. This paper analyzes the spatial allocation and dynamics of chili cultivation in ejidos adjacent to the CBR, with particular attention to farmer decision-making regarding this commercial land use in the context of prevailing environmental and institutional transformations. Such analysis integrates quantitative and qualitative research methods, and provides valuable insights into a land use that is arguably the most economically profitable agricultural option for local farmers in a region beset by biophysical and economic limitations to improving livelihoods.

The study area: land change in the southern Yucatán peninsular region

Encompassing parts of the states of Campeche and Quintana Roo, the SYPR (Figure 1) passed through various periods of land use, including intensive occupation by the ancient Maya civilization that declined after 900 AD (Haenn 2002; Turner, Klepeis and Schneider 2002; Klepeis and Turner 2001). The post-colonial Mexican state extracted *chicle* and tropical hardwoods from the SYPR's forests beginning in the 1800s, and in the twentieth century settled this forested "frontier" through ejidal land grants, initiating the recent agricultural expansion in the region through tropical deforestation (Klepeis and Turner 2001; Snook 1998). Left with few options for participation in a handful of failed, large-scale state agricultural projects, the region's new colonists began to use lands to cultivate subsistence and cash crops that generally allowed them only an economically impoverished existence. Increasing land pressures led to high rates of deforestation, placing the region on international lists of 'hot spots' of tropical deforestation, and led to the creation of the 723,128 ha Calakmul Biosphere Reserve (CBR) in 1989 (FAO 1999; Achard *et al.* 1998; Primack *et al.* 1998; Roy Chowdhury and Turner 2006). Regional deforestation continued, however. Roy Chowdhury and Schneider (2004) calculate a 0.61% annual deforestation rate (0.29% after adjusting for successional regrowth) in 1987-1997 based on satellite imagery-derived land-cover change detection in a study area of 15,900 km^2. The highest annual rates of this deforestation (up to 1.58%) pertain to a 3,300 km^2 sub-region, the *zona chilera*, where ejidos practicing market-oriented chili cultivation predominate (Turner, Geoghegan and Foster 2004: 133; Keys 2004a; Keys 2004b).

In the zona chilera and elsewhere in the SYPR, *milpa* (swidden or slash-and-burn agriculture for maize, beans and squash) remains the main subsistence agricultural activity (Klepeis and Vance 2003; Turner *et al.* 2001). In more recent years, Mexico has emphasized outward-looking, export-based agricultural sectors, consigning one group of cultivators to produce relatively low value crops (generally maize and beans) for the national market and another group to cultivate winter vegetables, fruits and beef for a high-paying market (Sanderson 1986). The farmers migrating to Calakmul largely represented the former group, yet, they devised ways to earn money on their own, incorporating agricultural practices from their source communities as large-scale state projects in Calakmul failed. In 1975, three farmers reached Calakmul from Veracruz, where they had practiced chili cultivation. Once settled in the SYPR, these farmers began to cultivate chili, hoping to develop a market crop that earned them regular, if at first modest profits. Despite initial and current obstacles, chili cultivation expanded rapidly. In the zona chilera, 85% of the farmers currently cultivate chili, while ninety-two percent of farmers have attempted chili cultivation at least once (Keys 2004b). To sell the chili, farmers enlisted market intermediaries (locally known as *coyotes*) for their connections to the national market.

After the signing of the NAFTA and GATT, Mexico's ejidos experienced the effects of neoliberal reform and its attendant policy institutions, including those designed for agricultural commercialization and intensification. Researchers have analyzed the effect of policies such as the PROCAMPO agricultural subsidy in the SYPR (e. g. Abizaid and Coomes 2004; Klepeis and Vance 2003). There remains a need to examine such policies specifically for the commercial (chili) sector, while explicitly considering the role played by other local policies and projects: those targeting environmental conservation. Beginning in the 1990s and continuing today, international, state and non-governmental organizations (NGOs) promoted conservation alternatives such as apiculture, allspice and other non-timber forest product economies, "green" fertilizers and/or mechanization for agricultural sedentarization, agroforestry and reforestation programs. Along with agricultural policies, such conservation initiatives also influence smallholder parcel

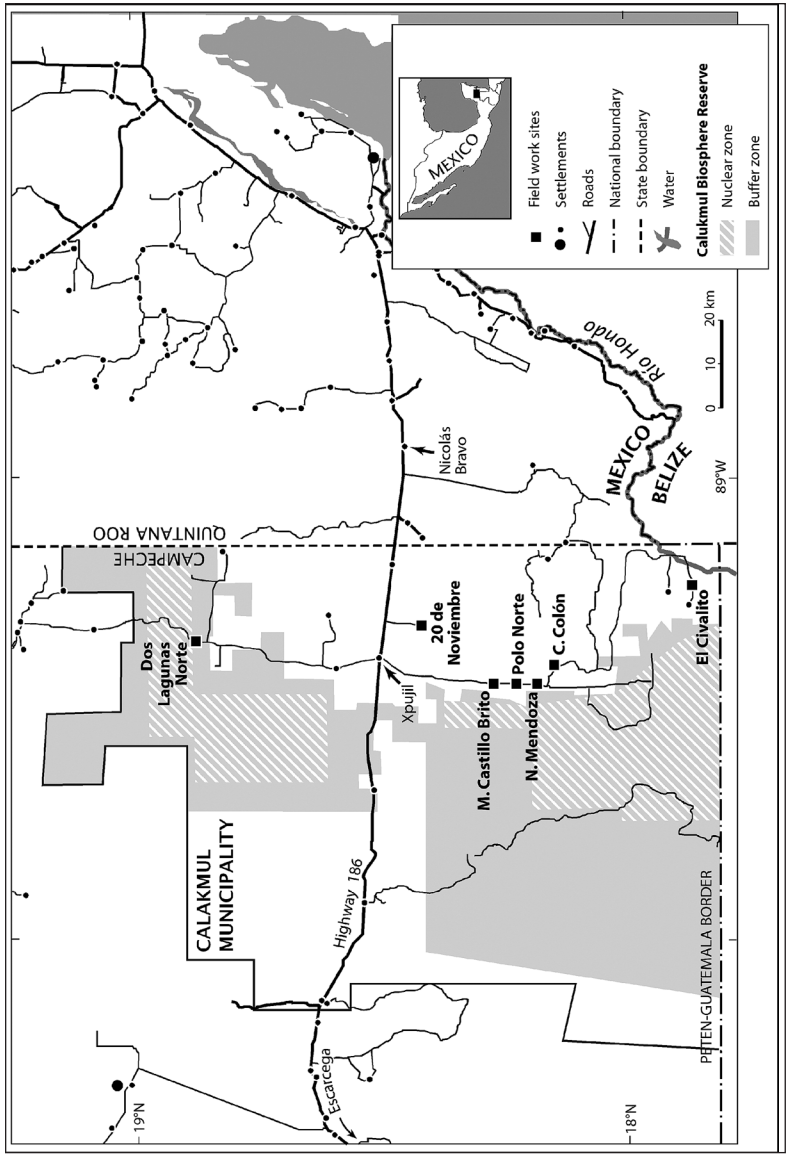

Figure 1: The study area (source: Turner, Geoghegan and Foster 2004: 6)

allocations to chili by providing livelihood alternatives and potentially altering household decision-making, local producer relationships or networks of socio-political capital.

It is within this context that we investigate how policy instruments emerging from the liberalization of the agricultural and environmental sectors along with household socioeconomic factors influence smallholder chili cultivation in Calakmul's ejidos. We first present a qualitative analysis of the various household, institutional and biophysical factors that influence farmers' chili-related decisions, and detail the expansion and practice of chili cultivation in five ejidos in Calakmul's zona chilera. This qualitative study is then complemented with quantitative analysis to link statistically the specific areal extent of chili cultivated by farming households to the households' demographic and socio-economic characteristics, and engagement with larger socio-political structures, including agricultural and conservation programs. The combination of qualitative and quantitative methods allows for an in-depth and more complete picture of the dynamics of chili cultivation, and reveal which of the factors identified by the qualitative study meet the test for statistical significance in explaining aspects of chili cultivation. The data for both the quantitative and qualitative analyses were collected in collaboration with the LCLUC-SYPR research project based at Clark University (see Turner, Geoghegan and Foster 2004), between August 1999 and May 2002.

The decision to cultivate chili: a qualitative approach

We collected qualitative data to understand what factors either encouraged or discouraged farmers to cultivate chili. These data included biophysical variables, other land uses and crops, household demography, social and human capital, tenancy, and relationships to and understanding of marketing structures. In addition to comparing different types of chili farming (mechanized vs. slash and burn) these data allowed the comparison of chili farmers to non-chili farmers. Data were analyzed using descriptive statistics and then grouped according to the relative importance of particular decision factors, based on the percentage of farmers citing those factors. This qualitative model identifies the multiple factors that farmers interact with at all stages of the chili-to-market network.

Figure 2 illustrates the percentage of farmers who have attempted chili cultivation at least once along the southern road of Calakmul.

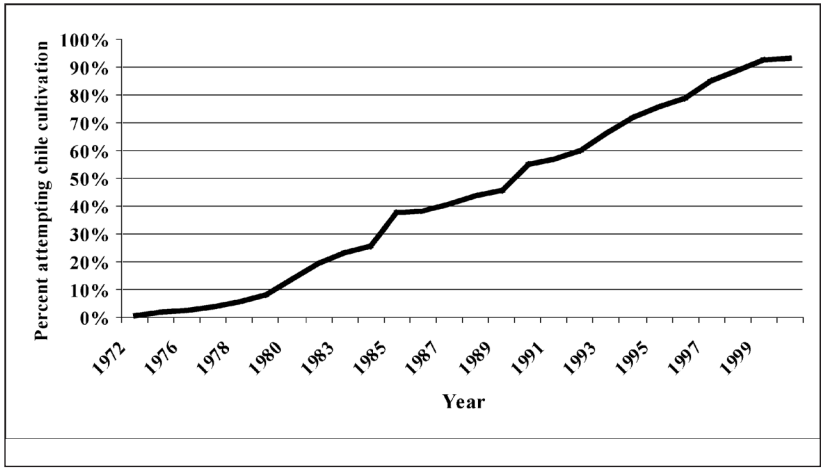

Figure 2. Percentage of farmers attempting chili cultivation at least once, 1972-1999.

The introduction of chili in southern Calakmul represents a major change in land use and land cover in the region. While 92% of zona chilera farmers have attempted chili cultivation, it is important to note that once introduced, chili seems to remain as a crop of choice among farmers. Of the group of farmers who attempted chili cultivation at least once, 93% cultivated chili in the 1999-2000 growing season. Although beset by biophysical, economic, and cultural barriers to success, chili cultivation seems in some cases to be the only viable commercial agricultural activity in Calakmul.

Most farmers report that multiple factors drove their initial decision to cultivate chili (Table 1). Only two farmers reported government programs as key in their decision to experiment with chili, illustrating how chili cultivation began due to the efforts of a handful of risk-taking farmers rather than as a result of structural programs. As the first farmers began to experience success with chili cultivation, others followed. Of the top nine reasons farmers gave for entering chili cultivation, five indicate the influence of witnessing another's success or experimentation. Once chili becomes part of a farmer's portfolio, however, government policies and subsidies may play an important role in influencing how much land is allocated in its production, as the quantitative analysis will demonstrate.

Rank	Reason	Number responding "yes"	% responding "yes"
1	Most of community engaged	130	81.3
2	Neighbor engaged in practice	125	78.1
3	Someone in family engaged	108	67.5
4	Experiment	77	48.1
5	Unnamed person encouraged them	67	41.9
6	Household cultivated in source community	34	21.3
7	Government credit	2	1.3
8	Other	2	1.3
9	Coyote credit/urging	1	0.6

Table 1. Reason for Engaging Commercial Chili Cultivation (N=160)

Factors influencing continued chili cultivation

While initial reasons for cultivating chili tended not to represent institutional factors—perhaps other than the pull of the market—continued cultivation is intimately tied to biophysical, actor-based, and structural forces. The following paragraphs summarize factors described by farmers as important in chili cultivation in Calakmul. This distillation of farmer responses in surveys demonstrates that the success of the chili-to-market network in a given year depends on multiple factors. For example, while estimated market prices proved especially important in 1999 and 2000, other forces weighed heavily as well on farmers. We find the availability of subsidies from PROCAMPO and other sources especially relevant. While government spending is rarely directed toward chili specifically, most farmers claim to use these funds to pay for labor and material inputs

to cultivation.

Biophysical factors

These factors influence farmer decision-making and chili success in primarily three ways. First, soil condition and the quality of vegetation indicate to the farmer estimated fertility for cultivation. Fertility is of primary importance to swidden farmers who tend to have less available capital than mechanized farmers to apply agrochemicals and water. Second, the incidence of chili pests and diseases presents a cost to farmers, either as the capital required to purchase pesticides, or if money is unavailable for their purchase, through lessened profits from low-yield, infested fields. Finally, some years witness extreme events such as hurricanes, drought, or fires that can destroy chili fields wholly. While none of these events occurred during the 1999 growing season, farmers did report that some previous seasons had been total failures in terms of chili cultivation.

Household factors

Household factors influence the chili farming cycle by setting the numbers of household members available to work on chili fields, the possibility of household emergencies (e. g. hospitalization) that may influence chili resource allocations, and the household's expertise in chili farming. In addition, households demonstrate different aspirations and goals for participating in the market as a seller of chili, as a seller of labor, or by not participating in the agricultural cash economy, opting for other livelihood strategies. Finally, the amount of cash available to farmers at key moments in the agricultural cycle influence the ability to combat pests and diseases, hire labor/water delivery during cultivation, and hire labor at harvest times.

Local Social Factors

Local social factors influence the chili cycle by limiting the amount and quality of hired labor in or nearby the community and the quality and availability of other farmers' advice when difficulties arise in chili cultivation. Rumors also abounded in the field in terms of what prices farmers should expect and influenced harvest and seeding decisions.

Extra-Local Factors

Extra-local social relationships were derived primarily in established relationships of trust and coercion with market intermediaries who marketed 98.5% of chili from the region. Farmer-intermediary relationships conditioned future cultivation because it showed farmers either the continued ability to receive reasonable prices from chili or that the chili market was an unreliable source of income.

Market factors

This institution may be ultimately the most important factor in farmers' decisions to cultivate chili and how much chili to cultivate. It is also the factor about which farmers possess the least knowledge. The prices set by the distant market in Mexico City condition the prices offered by market intermediaries and ultimately set the farm gate price. Farmers plan for the market by estimating expected prices based on the previous year's prices, advice from farmers, and from early reports from intermediaries who arrive early to the region from other parts of Mexico.

Political factors

Government and NGO policies influence farmers in two ways. First, the payout of subsidies, whether intended for chili or not, provides cash to farmers during critical times of the chili cycle. Without these payouts many farmers reported that they would have been unable to continue chili cultivation. Secondly, government and NGOs introduce policies designed to serve as alternatives to chemical intensive, and sometimes swidden, chili cultivation. Programs designed to sedentarize can provide farmers with mechanized land, organic fertilizer, or other inputs that enhance cultivation.

Farmer's reliance on these government programs for continued chili farming stems from the high costs associated with cultivation (Table 2). Frequent and severe pest outbreaks (Keys 2004a) combined with labor shortages at key times (felling trees, fumigation and harvest) demand that farmers possess cash to pay for material and service.

	All Farmers		Mechanized farmers		Milpa Farmers	
	$ Mean	$ Median	$ Mean	$ Median	$ Mean	$ Median
Material	1,739	1,089	1,764	1,419	1,625	961
Labor cost	2,371	1,538	2,444	1,909	2,185	1,379
Transportation	638	379	806	504	519	347
Total cost	4,749	3,421	4,986	4,084	4,305	3,267

Table 2. Cash expended on chili plot by farmers, 1999-2000 (N$/ha.)

Absent savings—which most Calakmul farmers lack—farmers use government payout programs to support chili cultivation until after the harvest. While the market promises rewards it does not provide cash advances, in part due to the unstable nature of commodity futures, and in part due to the unreliable nature of market intermediary-farmer relationships. Furthermore, farmers who possess mechanized land tend to incur greater costs than swidden-only farmers, because of the higher costs of initial land preparation (e. g. disking), as well as higher costs associated with agro-chemical inputs.

While nearly all farmers interviewed expressed a desire for mechanized chili and other agricultural plots, 31% had these fields in the southern zone of Calakmul in 1999-2000. Farmers attained mechanization through a combination of government programs and private ventures. Notably, innovative farmers in one of the ejidos studied parlayed future PROCAMPO earnings into the down payment on a tractor that they used to prepare their own fields and rented out to other farmers in the region. Thus, with the aid of a program aimed at ensuring staple crops, farmers gained access to the means to produce landesque capital. Chili cultivation relies in part on structural factors, especially in terms of predicted market performance and in terms of the provision of cash for farming expenses. At the same time farmers relied on household factors, such as labor availability, relationships with intermediaries, and experience with cultivation.

The regression model: quantitative analysis of chili cultivation area

The preceding section explicated the dynamics of chili production in the Calakmul region, detailing the various factors facing smallholders that invest in this market crop. In order to further analyze the decision to allocate land in this crop, we now undertake a

multivariate regression analysis to quantify the role of household and structural factors in chili parcel allocations, and test for statistical significance. The data used in the regression model were derived from 29 in-depth household surveys in two case study ejidos, supplemented for some (institutional) variables by state and NGO records. Both communities were established by 1980 adjacent to the CBR's buffer zone along the reserve's southeastern and northeastern borders, respectively, however they reflect different levels of marginalization with respect to state-funded village development projects in recent years (1990-1999). A dummy variable differentiates households pertaining to the northern, more marginalized ejido (dummy=0) from those in the southern ejido located in the zona chilera (dummy=1). The southern ejido was colonized largely by mestizo (mixed Indian and Spanish ancestry) immigrants from the state of Tabasco, and the northern ejido by Chol (Indian) immigrants from Chiapas. The two ejidos are comparable in terms of their total land area (the northern, ca. 4,340 ha and the southern, 3,979 ha), but vary in their assigned household entitlements (northern, 60 ha and southern, 20 ha).

The dependent variable of primary interest is hectares of household land parcels in chili. Household decisions about this commercial land use, however, are made within the context of decisions regarding other uses such as subsistence production (summer or winter cycle milpa), pasture, traditional fallows ("natural" successional forest), improved fallows such as agroforestry/reforestation, and/or semi-sedentarized swiddens enabled by "green" fertilizers such as *Mucuna pruriens* (locally, "Nescafé") or *Canavalia ensiformis*. A seemingly unrelated regression (SUR) technique allows for correlation of residuals among these interdependent land use decisions (dependent variables), however, we report only the results for chili land allocation in this paper. Roy Chowdhury and Turner (2006) report on the implications of household agency and structural forces for a typical portfolio of multiple land uses.

The importance of the explanatory variables used in the model is suggested by our fieldwork and in the larger literature on household agricultural decision-making and/or spatially explicit land cover change (Roy Chowdhury 2006a, 2006b; Robbins 2004; Zimmerer and Bassett 2003; Laney 2002; Turner and Ali 1996; Bassett 1988; Blaikie and Brookfield 1987; Turner and Brush 1987). Several independent variables capture household characteristics, including land tenure (years with ejidatario rights and land entitlements), demographics (family size and labor-consumer ratio), quality of life (a composite variable capturing housing, appliances, vehicles and local infrastructure/services), ethnicity (indigenous/mestizo), and household economic strategies, such as participation in farm labor markets and off-farm wage jobs, dependence on forest extraction (a composite variable capturing nature and frequency of forest use), and the previous year's household earnings from chili. Other independent variables used in the regression model include subsidies for agricultural crops (e.g., subsidized ha in PROCAMPO), "green" land uses (e. g., subsidized ha in green fertilizers through the state *Roza-Pica-Siembra* program or NGO agroforestry projects), or for quality-of-life improvements (e. g., through PROGRESA/Oportunidades educational grants or *Alianza para el Campo*); access to extension services and credit (e.g., total PRONASOL loans tapped in past decade by household), and aspects of sociopolitical capital of the household (e. g., links to ejidal societies, inter-ejido alliances and regional "green" cooperatives) or its ejido (e.g. ejido-level state development/conservation spending over 1991-1999).

Results: role of household and institutional factors in chili allocations

The regression model captures a high level of explained variance (about 95%) in land area under chili in the two ejidos studied. Summary statistics of variables used are detailed in Table 3, along with their parameter estimates derived from the regression

	Mean	Std. Dev..	Min.	Max.	Standard Coefficients Model R^2=0.5997, x^2=626.12
Dependent Variable: Chili hectares	0.75	0.71	0	2.5	
Constant	---	---	---	---	-0.33
Explanatory household and institutional factors					
Native speaker of Spanish (mestizo) (dummy)	0.59	0.50	0	1	-4.88**
Tenancy (yrs with ejidatario rights)	15.00	6.02	8	25	0.636
Land entitlement (ha)	59.31	13.61	40	80	1.353
Family Size (no.)	6.34	2.44	2	11	-1.452
Labor/consumer ratio	0.33	.23	0.13	1	-0.003
Neither buy nor sell labor (dummy)	0.14	0.35	0	2	-3.322***
Only sell labor (dummy)	0.24	0.44	0	1	-0.036
Only buy labor (dummy)	0.24	0.44	0	1	1.855*
Net worth of livestock holdings (N$)	8153.28	24090.33	175	130595	2.52**
Income from chili in past year (N$)	6566.90	8399.34	0	32400	5.589***
Sources of off-farm wage income (qualitative index)	2.93	3.17	0	12	2.189**
Intensity of forest use (qualitative index)	3.79	1.99	1	8	2.979***
Total PROCAMPO inscription (ha)	4.36	2.03	1.5	9	2.063**
Roza-pica-siembra inscription (ha)	1.62	1.05	0	4	2.783***

Table 3. Summary statistics, estimated parameters and significance of independent variables in regression model of land allocation to chili (N=29, Parameters=21)
Cells list standardized coefficients. *p=0.10, ** p=0.05, *** p=0.01

	Mean	Std. Dev.	Min.	Max.	Standard Coeffcients Model R^2=0.5997, x^2=626.12
Inscriptions for assisted improvement of fallows through agroforestry/reforestation (ha)	0.69	1.61	0	8	-0.624
Quality of life improvement subsidies (N$)	4588.97	3508.93	0	8190	2.946***
Total PRONASOL loans received (N$ 1990-9)	1051.72	646.21	0	2500	-1.625
Access to extension services (qualitative index)	3.93	1.60	1	7	-5.183***
Links to intra/inter *ejidal* unions, municipality	1.79	1.02	1	5	1.324
Links to NTFP cooperatives (qualitative index)	3.21	1.67	1	7	2.039**
Ejido (dummy)	0.45	0.51	0	1	-1.62

Table 3 continued.

model. The discussion of the results focuses primarily on those variables statistically significant at the five percent level or better. In analyzing the implications of agricultural and environmental institutions on chili cultivation in Calakmul, the mediating role of internal household characteristics must be taken into account. The following sections focus first on the quantitative relationship between household socioeconomics and chili area, and then assess the relevance of the institutional factors of interest in this paper.

Model results indicate that indigenous (Chol) households tend to have larger areas devoted to the cultivation of chili on their land parcels. These results are counter-intuitive, since the majority of chili-producing ejidos are in the zona chilera, where mestizo families predominate. While chili cultivation may have originated in and prevails in the mestizo-dominated *zona chilera*, these results indicate that other communities and ethnicities may often match or exceed household chili allocations in the chili-pioneering mestizo ejidos. Household labor strategies are a strong predictor of chili area. As noted in the preceding qualitative section, chili cultivation in the region almost invariably involves hiring laborers to assist with different phases of the crop cultivation cycle. The results of the regression model reflect this local reality, showing that households that neither sell nor hire labor are strongly linked to smaller areas under chili. Model results also suggest synergies between livestock and market cultivation: households that have higher net worth of livestock holdings are strongly linked to greater areas under chili. As expected, area under chili is strongly and positively related to chili-derived earnings in the previous year. Interestingly, households that plant greater areas in chili also appear to tap more sources of off-farm wage income, reflecting other methods of income diversification b

model. The discussion of the results focuses primarily on those variables statistically significant at the five percent level or better. In analyzing the implications of agricultural and environmental institutions on chili cultivation in Calakmul, the mediating role of internal household characteristics must be taken into account. The following sections focus first on the quantitative relationship between household socioeconomics and chili households diversify their livelihood strategies, and the intensity of forest extraction is positively and significantly related with chili area in land parcels.

Once the above household socioeconomic factors are accounted for, the remaining model results paint a picture of how the region's emerging institutions influence area in chili cultivation on ejidatario land parcels. The regression model shows that area under chili increases significantly with increasing inscriptions in PROCAMPO, larger quality of life improvement subsidies, and inscriptions in the state RPS agricultural sedentarization program, indicating that such funds may be diverted to chili-related expenses and/or activities, or that chili farmers in the region diversify their livelihoods by tapping environmental projects and subsidies. Interestingly, household PRONASOL loans do not significantly influence chili allocations, perhaps reflecting the fact that most chili farmers tap the credit program for unexpected expenses (e.g. medical) rather than as a mechanism for financing market cultivation. Extension appears to be negatively linked to chili area, likely because this qualitative index also captures a wide variety of extension services that target environmental programs rather than chili cultivation. Interestingly, intra- and inter ejido unions are not significant in determining household chili allocations, but a household's links to local cooperatives for non-timber forest products (NTFPs) appears to have a positive and statistically significant relationship to chili area, a relationship that will be investigated in future studies. The results also show that once all the above household and structural factors are accounted for, the ejido to which a household belongs (ejido dummy) has no significant impact on chili allocations.

Summary and conclusions

Much has been written in both scholarly and popular publications on the neoliberal shift in Mexican economy and its implications for the ejido sector. We have presented a study of market cultivation in the ejidos of the southern Yucatán since Mexico's structural shift. In the SYPR, market chili cultivation came to span 7,500 ha in 1999. This cultivation was initiated by individuals, but continues with the help of government programs and depends entirely on the market for economic success. In particular, we examine how agricultural and environmental policies, market structures, and household socioeconomics influence smallholder chili cultivation in local ejidos. We explicate market chili cultivation through qualitative research, detailing the complex interactions between biophysical, individual, and social factors and demonstrating how the decisions to cultivate a cash crop—one of the goals of liberalization of the ejido sector—rely on multiple relationships. While quality of soils can influence farmers' choice of what and how much land to use that year, factors such as the availability of labor and institutional programs sway cultivation decisions. A quantitative analysis identifies the dominant household and institutional factors influencing the hectares of parcel land allocated to chili in smallholder land parcels. The results of a regression model indicate that household factors and regional institutional structures account for a large proportion of overall explained variance in land allocated to chili. The results specifically identify the importance of household labor strategies, ethnicity, livelihood diversification through livestock holdings, forest extraction and wage jobs, agricultural subsidies and even green environmental institutions in driving larger areal allocations to chili on ejidatario land parcels. These data add detail to the story of market farming in Calakmul. By combining

hypothesis-testing and qualitative assessments, this research furthers explanation of the ways in which human-environmental interactions occur at the local level.

The results discussed in this paper illustrate one aspect of the economic transition underway in the southern Yucatán, a transition originating in the region's ejidal sector and focused on market cultivation. As the region's ejidatarios experiment with the market crop chili in this formerly subsistence economy, they also tap multiple opportunities for livelihood diversification made possible in part by emerging agricultural and environmental policies and projects. Our findings and those of the larger project with which we have collaborated reveal the importance of understanding the dynamics of decision-making by the local agents of land use: smallholder farmers. In a landscape such as the SYPR where environmental goals compete with the need for local and regional economic development, smallholder decisions must be further contextualized within prevailing (and sometimes conflicting) policy institutions in both the agricultural and conservation sectors.

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References

Abizaid, C. and Coomes, O. T. 2004. Land use and forest fallowing dynamics in seasonally dry tropical forests of the southern Yucatán Peninsula, Mexico. *Land Use Policy* 21: 71-84.

Achard, F., H. Eva, A. Glinni, P. Mayaux, T. Richards and H. J. Stibig, (eds.) 1998. *Identification of deforestation hot spot areas in the humid tropics*, Trees Publication Series B, Research Report No. 4, Space Application Institute, Global Vegetation Monitoring Unit, Joint Research Centre, Brussels: European Commission.

Acopa, D. and E. Boege. 1998. The Maya forest in Campeche, Mexico: Experiences in forest management at Calakmul, in R. D. Primack, D. B. Bray, H. A. Galletti and I. Ponciano (eds.), *Timber, tourists, and temples: Conservation and development in the Maya forest of Belize, Guatemala, and Mexico*, pp. 81-97. Washington, DC: Island Press.

Barlett, P. F. 1980. *Agricultural decision making: Anthropological contributions to rural development*. New York: Academic Press.

Bassett, T. 1988. The political ecology of peasant-herder conflicts in the northern Ivory Coast, *Annals of the Association of American Geographers* 78: 453-472.

_____. 1964. Questions on the human frontiers of geography, *Economic Geography* 40: 283-303.

_____. 1972. Intensification and disintensification in Pacific agriculture: A theoretical perspective, *Pacific Vienpoint* 13: 30-48.

Blaikie, P. and H. C. Brookfield (eds.) 1987. *Land degradation and society*. London: Methuen.

Brookfield, H. C. 1962. Local study and comparative method: An example from Central New Guinea, *Annals of the Association of American Geographers* 40: 283-303.

Brookfield, H. C. and P. Brown. 1963. *Struggle for land: Agriculture and group territories among the Chimbu of the New Guinea highlands*. Melbourne: Oxford University Press.

Brookfield, H. C., L. Potter and Y. Byron. 1995. *In place of the forest: Environmental and socio-economic transformation in Borneo and the eastern Malay peninsula*, Tokyo: United Nations University Press.

De Janvry, A., A. Gordillo and E. Sadoulet. 1997. *Mexico's second agrarian reform*. San Diego: Center for U.S.-Mexican Studies at UCSD.

FAO. 1999. *State of the world's forests, 1999*. Rome: Food and Agricultural Organization of the United Nations.

Finan, T. J. 1988. Market relationships and market performance in Northeast Brazil. *American Ethnologist* 15(4): 694-709.

Gudeman, S. 1978. *The demise of a rural economy*. London: Routledge Press.

Haenn, N. 2002. Nature regimes in southern Mexico: A history of power and development, *Ethnology* 41(1): 1-26.

Hewitt, K. 1983. *Interpretations of calamity*. Boston: Allen and Unwin.

Keys, E. 2004a. Jalapeño chili cultivation: An emergent land use in SYPR, in B. L. Turner II, J. Geoghegan, and D. Foster (eds.), *Integrated land science and the southern Yucatan: Final frontiers*, pp 207-220. Oxford: Clarendon Press.

_____. 2004b. Chili cultivation in the southern Yucatan region: Plant-pest disease as land degradation, *Land Degradation and Development* 15(1): 397-409.

_____. 2005. Market intermediaries link farms to markets: Southeastern Mexican examples, *The Geographical Review* 95(1): 24-46.

Keys, E., and W. McConnell. 2005. Global change and the intensification of agriculture in the tropics, *Global Environmental Change, Part A* 15: 320-337.

Klepeis, P. and B. L. Turner II. 2001. Integrated land history and global change science: The example of the southern Yucatán peninsular region project, *Land Use Policy* 18(1):

27-39.

Klepeis, P. and C. Vance. 2003. Neoliberal policy and deforestation in southeastern Mexico: An assessment of the PROCAMPO program, *Economic Geography* 79(3): 221-240.
Laney, R. 2002. Disaggregating induced intensification for land-change analysis: A case study from Madagascar, *Annals of the Association of American Geographers* 92(4): 702-726.

Liverman, D. M. 1992. Global warming and Mexican agriculture: Some preliminary results, in J. M. Reilly and M. Anderson (eds.) *Economic issues in global climate change: Agriculture, forests and natural resources*, pp. 332-352. Boulder: Westview,

Miller, K., Chang, E and Johnson, N. 2001. *Defining common ground for the Mesoamerican Biological Corridor*, Washington, D.C.: World Resources Institute.

Primack, R. B., D. Bray, H. A. Galletti and I. Ponciano (eds.) 1998. *Timber, tourists, and temples: Conservation and development in the Maya forests of Belize, Guatemala, and Mexico*, Washington, D.C.: Island Press.

Randall, L. M. (ed.) 1996. *Reforming Mexico's agrarian reform*. Armonk, NY: M. E. Sharpe.

Robbins, P. 2004. *Political ecology: A critical introduction*. Oxford: Blackwell.

Roy Chowdhury, R. 2006a. Driving forces of tropical deforestation: Role of remote sensing and spatial models, *Singapore Journal of Tropical Geography* 27: 82-101.

_____. 2006b. Landscape change in the Calakmul Biosphere Reserve, Mexico: Modeling the driving forces of smallholder deforestation on land parcels, *Applied Geography* 26(2): 129-152.

Roy Chowdhury, R. and L. C. Schneider. 2004. Land-cover/use in the southern Yucatán peninsular region, Mexico: Classification and change analysis, in B. L. Turner II, J. Geoghegan and D. Foster (eds.) *Integrated land-change science and tropical deforestation in the Southern Yucatán: Final frontiers*, pp. 105-141. Oxford: Clarendon Press.

Roy Chowdhury, R. and Turner II, B. L. 2006. Reconciling agency and structure in empirical analysis: Smallholder landuse in the southern Yucatán, Mexico, *Annals of the Association of American Geographers* 96(2): 302-322.

Snook, L. K. 1998. Sustaining harvests of mahogany (*Swietenia macrophylla* King) from Mexico's Yucatán forests: Past, present, and future, in R. B. Primack, D. Bray, H. A. Galletti and I. Ponciano (eds.) *Timber, tourists, and temples: conservation and development in the Maya forest of Belize, Guatemala, and Mexico*, pp. 61-80. Washington, D.C.: Island Press.

Turner II, B. L. and S. Ali. 1996. Induced intensification: Agricultural change in Bangladesh with implications for Malthus and Boserup, *Proceedings, National Academy of Sciences* 93(25): 14984-14991.

Turner II, B. L. and S. B. Brush (eds.) 1987. *Comparative farming systems*, New York: The Guilford Press.

Turner II, B. L., S. Cortina Villar, D. R. Foster, J. Geoghegan, E. Keys, P. Klepeis, D. Lawrence, P. Macario Mendoza, S. Manson, Y. Ogneva-Himmelberger, A. B. Plotkin, D. Pérez Salicrup, R. Roy Chowdhury, B. Savitsky, L. Schneider, B. Schmook and C. Vance. 2001. Deforestation in the southern Yucatán peninsular region: An integrative approach, *Forest Ecology and Management* 154(3): 343-370.

Turner II, B. L., J. Geoghegan and D. Foster (eds.) 2004. *Integrated land-change science and tropical deforestation in the southern Yucatán: Final frontiers*, Oxford: Clarendon Press.

Turner II, B. L., P. Klepeis and L. Schneider. 2002. Three millennia in the southern Yucatán peninsular region: Implications for occupancy, use, and carrying capacity, in A. Gómez-Pompa, M. Allen, S. Fedick and J. Jimenez-Osornio (eds.) *The lowland Maya area: Three millennia at the human-wildland interface*, pp. 361-387. New York: Haworth Press,

Watts, M. 1983. *Silent violence: Food, famine, and peasantry in northern Nigeria*. Berkeley: University of California Press.

Zimmerer, K. and T. Bassett (eds.) 2003. *Political Ecology: An integrative approach to geography and environment-development studies*. New York: The Guilford Press.