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The Farming Systems of the Texizapan Watershed, Sierra de Santa Marta, Veracruz, Mexico

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Abstract

The main farming systems of the Texizapan watershed in southern Veracruz, Mexico (200-1,640 meters above sea level) were characterized through a formal survey in 1995. Farm-level data included an inventory of resources (human, land, and capital), their use, and resource flows (both intra- and inter-household). Field-level data, particularly on input use and production, were gathered for the two major crops, maize and coffee. Maize was the main food crop, grown by all households. Coffee was the main cash crop, but production was limited to higher elevations. The maize cropping system was relatively land extensive and labor intensive; all practices were entirely manual. External input use was relatively limited, emphasizing herbicides. Half the farmers reported using fertilizers, but levels were generally low and use of improved maize varieties rare. All farmers used burning as a land preparation practice prior to maize planting. Maize yields in the main season averaged less than a 1 t/ha. Maize was generally intercropped with beans and other crops, although intercrop yields also appeared low. Maize production in the minor season was more widespread than previously thought, although yields were extremely low. Given the low yields, high labor input, and limited external input use, returns to maize cultivation were low. Even so, maize cultivation was expected to continue in the study area, in view of the households' consumption needs and limited alternative income opportunities. Half the sample reported being net consumers of maize, and the need to purchase beans – the major protein source – was even more widespread. In view of the limited number of other food sources available locally and constraints on disposable income, the nutritional status of the households warrants closer attention. The major challenge facing producers was that of sustainably raising productivity to provide for consumption and other needs.

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Acronyms and Abbreviations

CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
CONASUPO	Compañia Nacional de Subsistencia Populares
INMECAFE	Instituto Mexicano del Café
INI	Instituto Nacional Indigenista (a government agency that provides various types of support to indigenous peoples)
Mx$	Mexican pesos. Average exchange rate for 1994: Mx$ 3.4 = US$ 1 (source: International Monetary Fund)
NAFTA	North American Free Trade Agreement
NGO	Nongovernmental organization
PROCAMPO	Programa de Apoyos Directos al Campo (government income support program implemented to ease the effects of price liberalization of agricultural commodities)
PSSM	Proyecto Sierra de Santa Marta
SEDESOL	Secretaría de Desarrollo Social

The Farming Systems of the Texizapan Watershed, Sierra de Santa Marta, Veracruz, Mexico

Introduction

The Sierra de Santa Marta is a remote, mountainous region on the Gulf coast of Mexico, in the humid tropical state of Veracruz (Fig. 1). Soil erosion and soil fertility loss seriously undermine agricultural productivity in the region and affect important off-site factors such as the availability of drinking water in nearby urban centers (e.g., Coatzacoalcos and Minatitlan), regional infrastructure (e.g., road maintenance), hydroelectric potential (e.g., the Texizapan reservoir), and the fishing industry (e.g., in coastal lagoons such as Ostión).

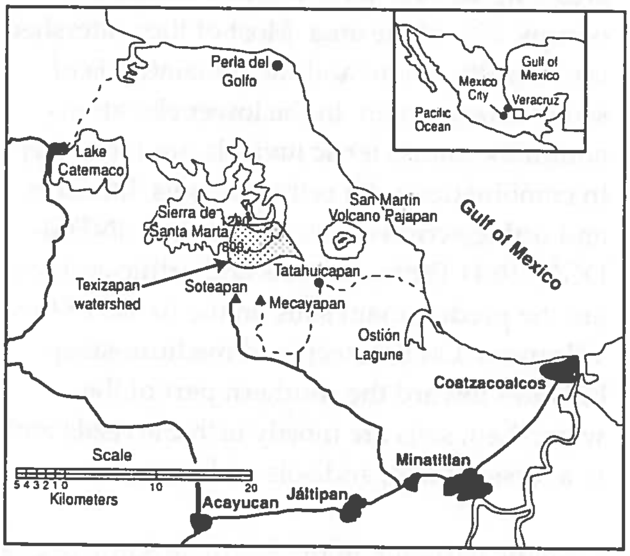

Figure 1. The Texizapan watershed in the Sierra de Santa Marta, Veracruz, Mexico.

Soil degradation can be severe when annual crops are grown on steep hillsides using practices that do not feature some kind of vegetative cover or surface mulch.[1] Such conditions bring together the erosive capacity of the elements, the high erodibility of the soils, and the limited soil cover provided by the annual crop. Perennial crops such as coffee – especially when grown under shade trees – generally provide better soil protection, forming a longer-lasting, more complete soil cover. However, in Veracruz, as in other areas in Mesoamerica, annual crops such as maize and beans provide most food requirements of the population. Resource-poor farmers are generally reluctant to stop growing these crops, even when others appear economically more attractive or environmentally less degrading. If we accept the fact that resource-poor farmers will continue to grow annual crops, reducing resource degradation becomes a research imperative.

The Proyecto Sierra de Santa Marta (PSSM) is a nongovernmental organization (NGO) engaged in the sustainable development of the Sierra, with an on-going partnership with CIMMYT and other stakeholders in the area. An area of specific interest within the Sierra de Santa Marta is the Texizapan watershed, located on the southeastern flanks of the main volcano. This watershed, which comprises a

[1] This is especially serious when fallow periods are substantially reduced. In traditional shifting cultivation systems, the soil degradation occurring during the years of cultivation is offset by a fallow long enough to rebuild the soil's productive capacity. Such a system generally collapses with increasing land pressure, as fallow periods are reduced and required adaptations in the other "traditional" crop management practices lag behind, wreaking environmental havoc in the transition years.

relatively compact and hydrologically (and physically) delimited area, was the subject of a research project funded by the Rockefeller Foundation and other agencies (PSSM 1994). Despite current development activities in the area, there was a lack of information about the agroecological and socioeconomic aspects of its production systems. The study whose results are presented here focused on those topics to accomplish the following:[2]

- Characterize the farming systems (farm level) in the study area.
- Describe the maize cropping systems (field level) within these farming systems.
- Quantify maize cropping practices in economic terms from the farmer's point of view.

This paper first describes the study area and highlights methodological issues that arose during the study. An overview of farming system characteristics follows, including household resource availability (mainly land, human, and livestock) and links with the economy at large. Next, maize cropping system practices and field-level economics are described. Finally, we summarize our main findings and conclusions.

Methodology

The Study Area[3]

Rising steeply from sea level at the Gulf of Mexico to more than 1,700 meters above sea level (masl) at its highest point, the Sierra de Santa Marta spans some 1,200 km^2. Partly because of this range in elevation, the region is home to a considerable array of climatic and soil conditions and diverse flora and fauna, and in 1988 the Sierra was classified as a Special Biosphere Reserve. More than 50,000 people live in the Sierra, mainly of indigenous Nahua and Zoque-Popoluca origin.

The watershed of the Texizapan-Xonuapan Rivers, referred to here as the Texizapan watershed, is located south of the Santa Marta volcano and west of the San Martín Pajapan volcano, between 18° 15' and 18° 19' latitude and 94° 45' and 94° 48' longitude. The watershed covers 5,923 ha (Fig. 1) and comes under the administrative aegis of the Municipalities of Mecayapan and Soteapan.

Like the Sierra of which it is a part, the study area has a complex, irregular topography ranging in elevation from 200 to 1,640 masl. Hills of medium height and mostly moderate slope (5-15°) occupy about 60% of the land area. Higher hills with slopes exceeding 15° occupy 25% of the area. Most of the watershed is of basaltic origin and the remainder is of sedimentary origin. In the lower elevations and in the south, ferric luvisols predominate, in combination with orthic luvisols, lithosols, and orthic acrisols (54% of the area) (INEGI-DGG 1984). Orthic acrisols and orthic andisols are the predominant soils on the flanks of the volcanoes. On the steep and medium-steep hillsides toward the southern part of the watershed, soils are mostly orthic acrisols and, to a lesser extent, andisols and lithisols.

Climatic variation in the Sierra de Santa Marta is related mostly to variation in orientation — toward the ocean or toward the interior — and elevation (González 1991), producing gradual climatic transitions and different ecological

[2] Preliminary (qualitative) results of this study were reported in Rodríguez (1996).
[3] This section draws heavily on Ramírez (1995). For further details on the Sierra as a whole, see PSSM (1994a) and PSSM-GEF-CIMMYT (forthcoming).

strata. Differences in elevation are also related to variation in temperature. Areas under 500 masl are hot, with an annual median temperature of >24°C, whereas areas from 800 to 900 masl are warm, with a median temperature of 22-18°C (González 1991). The median temperature falls to ≤18°C at 1,300-1,400 masl on the southern slope of the Santa Marta volcano. There are two temperature maxima during the year. The first and highest occurs during April and May; the second, somewhat attenuated by the rains, occurs in September and October.

The prevailing winds in the Sierra are the northeastern trade winds, but the area is subject to three other important meteorological phenomena: winter storms from the north (*nortes*) and the Atlantic, and southerly winds (*suradas*). The nortes cause the greatest disturbance in the weather system, bringing cold winds and low temperatures. Atlantic storms occur at different periods and are characterized by rain and mist that can last all day and night. During the dry season, the mountain slopes facing the interior feel the effects of the suradas: hot, dry winds, moving from within Mexico toward the coast.

The irregular topography of the mountains influences the behavior and direction of the local winds, which is reflected in the uneven geographic distribution of rainfall. The lowest precipitation levels (1,300 mm) are found in Soteapan, in the southwestern hills adjacent to the study area. Rainfall is higher toward the north and east of the Sierra. Hillsides exposed to the prevailing winds receive an estimated 2,500 mm of rainfall each year, on average. In the study area, the rainy season occurs from June to October. Rainfall usually peaks in September and temporarily stops during the occasional short summer drought. There is a marked dry season (March and April are the driest months).

Indigenous languages were the primary vehicle of communication among the population, although rates of indigenous language monolinguism were actually quite low[4]. Schools in the area were defined as bilingual, but in practice the main language was Spanish. School systems in the *ejidos*[5] were quite limited, and Ocotal Texizapan was the only ejido with complete primary education (Rodríguez 1996).

Lack of accessibility was a key issue in the watershed. Distances were long, roads rough, and vehicle access was generally limited to the dry season, if a vehicle was available at all. At the time of the survey none of the communities surveyed had access to electricity, telephone, mail, or telegraph services.[6] There were few stores: a small Conasupo[7] outlet in Ocotal Texizapan and a small local store in each of the other ejidos. There was only one health center among the four communities surveyed (Rodríguez 1996).

Housing in the area was basic, generally including a small house with a separate kitchen but without a latrine. Walls were made of wood, while floors were generally bare earth. Roofs were made predominantly of corrugated metal or vegetative material, especially bamboo and straw.

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4 Rates of (non-Spanish) monolinguism for the *ejido* communities were: Ocotal Grande, 5.1%, Plan Agrario, nearly 0%, Ocotal Texizapan, 14.1%, and Arroyo Texizapan, 17.9% (INI 1994, cited in Rodríguez 1996).

5 An ejido is a rural community formed as a result of the land reform that followed the Mexican Revolution.

6 Although the installation of electrical and communication services in the most accessible community – Ocotal Grande – had begun.

7 A parastatal agency marketing primary food commodities. Another Conasupo outlet was located just outside the watershed in Ocotal Chico, a community along the main route out of the area.

Methodology

The study area comprised four ejidos: Ocotal Grande, Plan Agrario, Ocotal Texizapan, and Arroyo Texizapan. The fifth ejido fully located within the watershed,[8] Encino Amarillo, was to have been included in the study, but social conflicts severely hampered the implementation of the survey within this community. Unfortunately, this ejido was the largest agricultural community in the study area (Table 1), and its exclusion led to a relatively small final sample size of 33 households. In the remainder of this paper, references to "the Texizapan watershed" are synonymous with the four above-mentioned ejidos, unless explicitly stated otherwise.

Most of the information presented in this study was gathered through a formal survey conducted during the dry season of 1995. The survey was mainly descriptive, and farm- and field-level data were obtained from the male household head.[9]

The sampling unit for the survey was the farm household. The sampling frame drew upon the most recent lists of *ejidatarios* and *avecindados*[10] available in the ejido. These lists were generally obtained from ejido authorities and where necessary were updated. An unweighted random sampling fraction of 18% was used, stratifying both by community and by type of land use right (ejidatarios and avecindado). This amounts to around 10 farm households per major ejido (only five for the smaller ejido, Arroyo Texizapan), with about an equal division between ejidatarios and avecindados in most ejidos.[11]

Table 1. Sampling frame for the survey of farmers in Texizapan watershed, Veracruz, Mexico, 1995.

Location (*Ejido*[a])	Population			Survey sample
	Ejidatarios	*Avecindados*	Total	
Ocotal Grande	31	29	60	11
Plan Agrario	44	6	50	9
Ocotal Texizapan	25	23	48	8
Arroyo Texizapan	9	18	27	5
Subtotal	**109**	**76**	**185**	**33**
Encino Amarillo	30	45	75	13
Total (including Encino Amarillo)	**139**	**121**	**260**	**46**

[a] Ejidatarios are residents of an *ejido*, a rural community that originated from the land reform that followed the Mexican Revolution, and they possess land use rights that can be transferred to their offspring. An *avecindado* lacks the ejidatario title. Avecindados are often those offspring of ejidatarios who did not inherit the title.

[8] In addition, a number of ejidos have only a fraction of their area within the watershed, and the remainder and respective communities are located in adjacent watersheds. For logistical reasons these were left out of the study. However, this illustrates the fact that many ejidos were originally established without taking into account natural divisions based on the topography and other characteristics of the area.

[9] With the exception of two households where the male household head was not available and the respondents were either the farmer's wife or son.

[10] An avecindado lacks the title to the land which is granted to a member of an ejido (an ejidatario). Avecindados are usually those children of an ejidatario who did not inherit the title.

[11] A notable exception is the ejido Plan Agrario, which is rather skewed toward ejidatarios. The number of avecindados in Plan Agrario was limited, possibly because this is the most recently established ejido and the only in which land titles have been formalized.

Three specific methodological complications warrant discussion:

- **The boundary of the farm household unit.** A "farm household" was defined as people living and eating together. Resources were generally managed within this unit but, in the study area, the delineation between households within the extended family was not always clear. For example, after marriage, sons might live in a separate house around the same homestead, manage their own maize field and resources, and therefore be considered to constitute an independent household. Regardless of this apparent independence, strong links persisted between the households and labor was frequently exchanged. Furthermore, while the parental household might officially own all the land resources, the user rights to these resources could be retained either by the parental household (e.g., in the case of their agricultural fields), ceded to the son's household (e.g., his maize field), or shared between them (e.g., jointly used pastures). The data here are presented on a household basis as much as possible, attributing resources on the basis of user rights.
- **Language issues.** The watershed was an indigenous area, and Spanish was not the first language of the people who live there.. Nevertheless, most farmers spoke and understood Spanish, albeit to different degrees. To further complicate matters, two indigenous languages (Popoluca and Nahua) were spoken in the study area, local names generally being in the respective indigenous language, as in the case of maize varieties. Notwithstanding, most information could be recompiled either directly in Spanish, through the indigenous language skills of the enumerators, and/or the help of translating family members.
- **Statistical issues.** The relatively small final sample size severely constrained the presentation and statistical analysis of the data, especially for subgroups of the sample. For ease of interpretation, we used percentages when referring to the sample population, although readers should note that the small sample size led to a single household accounting for about 3% of the sample. Where statistically significant differences exist they are highlighted, but in most cases the small sample size and variability of the data made it difficult to discern differences.

The Farming System

Farm Typology

Farming systems can be typified in a variety of ways, but two fairly universal classification criteria are size (area) and economic scale (Ellis 1988). We used these criteria to develop a typology in the following manner:

- **Area.** Farm area differed markedly, depending on the farmer's landholding status. Before the reform to Article 27 of the Mexican Constitution, access to land in these communities was determined by the legal status of the producer, who was either an ejidatario or avecindado. The title granted to ejidatarios gave them access to a determined amount of land – generally 20 ha in the study zone.[12] Lacking such a title, avecindados did not have direct access to the land. Nevertheless, through negotiation with the ejido and its respective ejidatarios, an avecindado could obtain the right to cultivate a small area, generally less than 5 ha, on a seasonal basis. In this study, we

[12] After the reform of Article 27 of the Mexican Constitution, they became the official owners of this land.

distinguish between "small farms" (≤ 5 ha, an implicit synonym for land held by avecindados) and "large farms" (≥ 20 ha, synonymous with land held by ejidatarios). We hypothesized that small farms would be relatively more land constrained, whereas large farms would be relatively more labor constrained, and both were expected to be capital constrained.

- **Economic scale.** The economic scale of the farm was determined largely by the presence or absence of the coffee crop and less by the maize crop: all farmers grew maize as their principal annual crop, mostly for home consumption. Coffee was the main market crop and represented the largest source of cash income, but its cultivation was limited to the higher (> 500 masl) slopes of the watershed. We hypothesized that coffee cultivation, especially given its relationship to cash income, influenced the possibility of acquiring inputs and ultimately the technological level of the farm. In other words, coffee farmers were likely to be relatively less capital constrained than farmers who did not grow coffee.[13]

The above generated a two-by-two breakdown (Table 2), resulting in four groups: 1) large farms without coffee; 2) large farms with coffee; 3) small farms without coffee; and 4) small farms with coffee.[14] Throughout this paper, we present information for the entire sample and, where relevant, for one or more of the subgroups. More than half the farms (61%) can be categorized as large; 55% have coffee.[15]

Land Use

The average area for farms in the Texizapan watershed was 13.3 ha. Nearly half this area (6 ha) was reportedly under some type of forest,[16] about 3 ha was cultivated by the household, another 3 ha was under pasture, and about 1 ha was loaned to others. However, these averages mask major differences between households. The biggest difference is related to overall farm size. Large farms (in the hands of ejidatarios) were about 20 ha, whereas small farms (held by avecindados) averaged 2-3 ha (Table 3). Agricultural land use on small farms without coffee averaged 1.6 ha per producer (all maize) and with coffee 2.7 ha (1.6 ha of maize and 1.1 ha of coffee), meaning most small-farm area (75%) was in agricultural production, whereas on larger farms an average 4 ha (£ 20% of the total area) was dedicated to agriculture. This suggests that agricultural production on small farms was relatively constrained by land, whereas on large farms it was constrained by other factors.

Maize was the critical food crop for the area and was cultivated by all households. Maize area averaged 2.2 ha per household. Only large

Table 2. Farming system typology, Texizapan watershed, Veracruz, Mexico (%).[a]

	Large	Small	Totals
With coffee	39	15	**55**
Without coffee	21	24	**45**
Totals	**61**	**39**	**100**

[a] Number of farms in sample: 33.

[13] It could be argued that the orange production concentrated in one community was a substitute for coffee as a market crop and should therefore be included in this indicator. However, although it potentially could be a substitute, marketing problems severely constrained this possibility.

[14] Note that the small sample size severely limits any farm typology, and that the present 2x2 breakdown already constrains statistical analysis.

[15] This may be an overestimation for the entire watershed because Encino Amarillo ejido (relatively large and excluded from this survey) does not grow coffee.

[16] The "forest" category includes both primary forest and secondary forest fallows.

farms without coffee cultivated a significantly greater area — an average of 3.4 ha — whereas small farms averaged only 1.6 ha. Large farms without coffee seemed to increase their maize area to achieve maize self-sufficiency and sell any surplus; an option that appeared less viable for small farms without coffee, given their land constraints.

Coffee was the most important cash crop, but was confined to the higher stretches of the watershed (above 500 masl) and grown by about half the households in the entire watershed. Coffee area averaged 0.9 ha per household across the sample. Small farms with coffee had about 1 ha; large farms with coffee had closer to 2 ha, suggesting that, next to ecological considerations, land constraints may have limited the area planted to the local cash crop on small farms. Coffee was still largely grown under a dense cover of shade trees, although a rise in coffee prices just prior to the study led some farmers to grow the crop in less shaded areas as well.

Oranges constituted another potential cash crop, but area averaged less than 0.1 ha per household. For historical reasons, the production of oranges was concentrated in areas without coffee and on larger farms – notably in Ocotal Texizapan, where over one-third of the sample farmers grew oranges.[17] Although oranges were intended as an alternative to coffee as a source of cash income, this potential was never realized because of marketing constraints: inadequate transport infrastructure and the high transportation costs inherent in bulky products and distant markets.

Pasture (mainly unimproved) was another important use of land, but pastures were concentrated in the few households with most livestock — primarily large farms without coffee. This suggests that, for larger farms, livestock provided an alternative to coffee as a source of cash income. Because of land constraints, this option was again less viable for small farms.

Table 3. Land use (ha), Texizapan watershed, Veracruz, Mexico, 1995.

			Farm type				
	Survey average	SD[a]	Small, no coffee	Small, coffee	Large, no coffee	Large, coffee	Prob.
Total land area	13.30	9.08	2.00a	2.65a	21.14c	20.00b	0.00
Agricultural land in production	3.17	1.44	1.56a	2.65b	3.79b	4.02b	0.00
Maize	2.18	1.01	1.56a	1.60a	3.36b	2.15a	0.00
Coffee	0.89	1.04	0.00a	1.05b	0.00a	1.87b	0.00
Oranges	0.09	0.30	0.00a	0.00a	0.43b	0.00a	0.00
Unimproved pasture	2.98	4.78	0.38a	0.00a	7.46b	3.31a	0.01
Forestry	6.02	6.65	0.00a	0.00a	6.82b	11.60c	0.00
Secondary forest (*acahual*)	2.62	3.47	0.00a	0.00a	3.82b	4.59b	0.00
Mixed forest (*monte*)	0.24	0.87	0.00	0.00	0.00	0.62	ns
Oak forest (*encinal*)	1.08	2.18	0.00a	0.00a	0.86ab	2.29b	0.07
Pine forest (*ocotal*)	2.07	3.56	0.00a	0.00a	2.14ab	4.11b	0.03
Loaned out	1.08	2.88	0.00	0.00	3.07	1.07	ns

[a] SD = standard deviation; ns = not significant. Figures followed by different letters are significantly different (Duncan 0.1, row comparison).

[17] Oranges were originally introduced in the area by a governmental development agency. Their program was limited to the Ocotal Texizapan and to ejidatarios because participants needed to have established land use rights (in view of the perennial nature of the crop). There are now about 22 ha of fully established orange groves in this ejido, about 1 ha per ejidatario.

Various forestry uses accounted for about half the area of the average farm, but again these were concentrated primarily in large farms. The main forestry area averaged 2.6 ha per household and was occupied by young secondary forest (*acahual*) that had grown on formerly cultivated parcels of land. Very little old, mixed, non-deciduous tropical forest (*monte*) remained, averaging less than 0.25 ha per household. Other forestry uses included roughly 1 ha per household under oak and 2 ha under pine. The oak and pine forest were the local climax vegetation for specific soils which were widely considered unsuitable for maize cultivation. The oak forests (*encinales*, dominated by *Quercus spp.*), were used primarily for wood extraction. Similarly, pine forests (*ocotales*, dominated by *Pinus oocarpa*) were used for extraction of fuel and construction wood, whereas the grassy undergrowth in these relatively open forests was used for pasture.

Land was quite commonly loaned out in the study area; one-third of the producers surveyed reported doing so.[18] Most often, the land was loaned to another family member, especially a son, and generally in these cases no rent was charged. The absence of a developed land rental market, as well as the relatively "extensive" (as opposed to intensive) land use, suggests the need to qualify the previously discussed land constraint faced by small farms.

Household Characteristics

General characteristics – The household head was generally male, 36 years old on average (range 17 to 71), and characterized by a low level of schooling (average of 1.5 years of school, and 55% of those surveyed never attended school). Even so, about 60% of the producers stated that they could read, and more than 80% of the households had a family member who could read. The ejidatarios (producers with large farms) tended be older than the avecindados (43 vs 26 years, $P \leq 0.00$). This related mainly to the fact that the ejidatario title was generally passed from father to eldest son when the father died or when he was no longer able to work his fields. The title could not be divided between sons, a regulation designed to prevent fragmentation of land holdings.[19] Males became responsible for their own fields at a very early age, averaging 18 years (ranging from 8 to 25), and prior to that most had worked in the fields of their fathers or male relatives.

One-fourth of the farmers had multiple dwellings on their homesteads. These separate houses were usually inhabited by adult children or by other relatives and their families. Most commonly the additional households had their own agricultural fields, but frequently the household members still helped out in the homestead owner's fields as well.

Household composition and family labor – The average family size in the sample was 5.7 persons (sd: 2.6). A "family" was defined as a group of persons who live and eat within the same household. On average, the family was composed of 2.8 adults, 0.8 youths (aged 10 to 16), and about 2.1 children (younger than ten). Adult men were mainly responsible for the agricultural field work and accounted for most potentially available labor. However, in 77% of the households surveyed, women helped the

[18] Or a little over half of the ejidatarios (11 of 20). Avecindados were unlikely to be loaning out their land, since it was already on loan to them.

[19] The recent changes to Article 27 have altered the status of ejidatarios considerably. Whereas ejidatarios once had only the right to use a specific piece of land, they have now become the rightful owners. This has implications for the transfer (temporary and permanent) of land both within and between households.

men during several agricultural operations. In 71% of the households, children also helped with agricultural production (Table 4). In coffee production, women and children generally participated only in harvesting, while their activities in maize production were more varied (see maize labor section). In most cases, the overall participation rates of women and children in crop production were similar for coffee and maize.

To approximate the amount of family labor potentially available for fieldwork, we converted the family household into labor units (one labor unit is the equivalent of an adult male potentially available full time for field labor).[20] On average, 2.6 labor units were potentially available for field work per household. Differences between farm types began to emerge when labor units were related to land resources — not too surprising, as the farm typology is partly based on the land resources. On average, households had 1.1 labor units per hectare in production (cultivated area with crops; sd: 1.1). This indicator of labor availability was much higher (1.7) for small farms and much lower (0.7) for the large farms ($P \leq 0.02$). In addition, labor availability was related to coffee cultivation, as coffee growers generally had a lower labor availability per productive hectare than farmers who did not grow coffee (within a similar farm-size class).[21] This difference was related primarily to the larger productive area of farms with coffee.

Table 4. Household participation in agricultural production, Texizapan watershed, Veracruz, Mexico, 1995.

	Participation of women		Participation of children[a]	
	%	n[b]	%	n
Households participating:				
In maize and/or coffee production	77	31	71	24
In maize production	70	30	68	22
In coffee production	93	14	78	9

[a] Excludes 6 households with no children and 5 missing cases. [b] n = number of cases.

Nonfamily labor – Farmers in the Texizapan watershed frequently supplemented family labor with nonfamily labor, either through labor exchange (*mano vuelta,* reciprocal labor) or by hiring day laborers. Labor exchange draws heavily on local resources, including the extended family, and is the traditional form of supplementing family labor in indigenous societies throughout Mexico. However, as societies develop economically, systems of labor exchange generally evolve into wage systems. Only 9% of the survey households relied solely upon family labor for all agricultural activities. The remainder resorted to labor exchange (76%) and/or paid labor (45%; note that 30% used a combination of both). Not surprisingly, the

[20] The potential labor availability per household (PLA) is estimated as:

$$PLA = \sum N_i * w_i * f_i$$

Where:

$_i$: Type of person (based on gender and age);

N_i: Number of household members of type i;

w_i: relative weight for members of type i (1.0 for adult males, 0.5 for adult females, 0.6 for male youths, 0.3 for female youths, 0.2 for male children, 0.1 for female children);

f_i: household specific correction factor for participation of members of type i in maize production (0 if they do not participate; 1 if they do).

The arbitrary weights (w_i) are intended to adjust for potential participation in relation to gender and age (like cooking, childcare, school etc) (Erenstein, personal communication; Upton 1996).

[21] Labor availability was 2.0 for small farms without coffee, 1.4 for small farms with coffee, 0.8 for large farms without coffee, and 0.6 for large farms with coffee.

decision to use nonfamily labor was strongly related to labor availability within the household: those who used only family labor had an average of 2.6 family labor units per hectare in production, while those who used nonfamily labor had an average of only 0.9 ($P \leq 0.00$).

Preferences for each type of nonfamily labor appeared to be related to the availability of cash. In producing maize, a food crop, farmers relied relatively more on labor exchange (76%) than the use of day laborers (30%), because labor exchange required no cash payment. Conversely, in producing coffee, a cash crop, the use of day laborers was relatively more common (71%) than labor exchange (41%). Farmers who used paid labor for maize production seemed to have a higher average annual gross cash income[22] (nearly Mx$ 5,000) than farmers who used only family labor (Mx$ 2,500; $P \leq 0.105$). Gross annual cash income was related predominantly to coffee production, the source of that cash, so use of day laborers was relatively more common in the coffee-growing strata of the sample, particularly on the large coffee-producing farms (three-quarters used day laborers).

Off-farm work – Short-term, seasonal migration of at least one household member, usually the producer or his son, was common in the area (33%). Off-farm work generally comprised manual labor located within one day's travel, and many workers stayed near or within the Texizapan watershed, working mainly in Ocotal Grande and in coffee production. About half the off-farm work was agricultural day labor such as weeding, harvesting cash crops like coffee and peppers, or pasture management (both in the watershed and in Perla del Golfo). The other half included nonagricultural work such as construction and other labor-intensive activities in the nearby cities of Minatitlan, Coatzacoalcos, Acayucan, and Chinameca. One farmer worked as a local extension agent *(promotor)* for the PSSM. Off-farm workers came largely from the stratum of small farms without coffee (nearly two-thirds versus less than one-third in the other strata); obviously related to the lack of cash-generating activities in such farms.

The labor migration was generally temporary — for less than a month — and occurred throughout the year. Longer-term outmigration to nearby cities appeared to be less common than had previously been the case. Lower outmigration seemed to be related to the reduced number of jobs in these areas,[23] as well as to the minimum educational requirements for most city jobs (Rodríguez 1996).

Livestock

Nearly 75% of the producers surveyed had livestock, but the actual number of animals per household was quite small, at just under two animal units (slightly more than one adult cow)[24] per household. Large farms without coffee had significantly more livestock, about 4 animal units — more than twice the number of any other group.[25] In the whole sample, the

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[22] Gross annual cash income is approximated by the summing gross income (in pesos) from off-farm work, Procampo payments, and sales of coffee, maize, beans, and animals.

[23] Both are oil cities that fared well in the boom years of high oil prices (see, for example, Chevalier and Buckles 1995).

[24] Animal (AU) units were calculated as follows (adapted from Gittinger 1982:174-175):
AU = adult cows + adult bulls*1.2 + young cows/bulls*.8 + calves*.3 + adult horses*1.1 + young horses*.67 + adult mules + young mules*.6 + adult pigs*.5 + young pigs*.3.
No sheep or goats were found in the survey. Animal units do not include poultry.

[25] The average number of AU for the other strata: small farms w/o coffee 0.8; small farms with coffee 0.9 and large farms with coffee 1.7. Overall average 1.9 (sd: 2.3)

maximum number of animal units was 9.1 per household, whereas only 8% (three households) actually had more than 5 animal units. Most producers had about the same number of animals as in the years leading up to the study, though one-third had experienced decreases in their herds due to animal deaths and income constraints. These data point to the predominantly crop-based nature of the farming systems in the watershed.

Equines (mainly horses, used primarily for transport) predominated in the livestock herd, comprising more than half.[26] Their importance for transport should not be underestimated, in view of the remoteness of the watershed and most agricultural fields, and is illustrated by the fact that about two-thirds of the households had at least one horse or mule. Also, as with labor constraints, farmers could alleviate an eventual transport constraint either by exchanging animals or renting them.

There was an average 0.6 animal units of cattle (cows, bulls, calves) per household, but only about one-fifth of the households had any at all. Large farms without coffee averaged nearly 2 units, significantly more than all other producer groups (averaging £ 0.25 animal units per household). Not surprisingly, large farms without coffee also devoted significantly more of their land to pasture (see the section on land use).

Few farmers reported hogs (9%) and none reported goats or sheep.[27] Most households had poultry, mainly chickens and turkeys. Some households reported raising substantial populations of chickens (up to 180), for both consumption and sale. Again, this seemed to be relatively more common for large farms without coffee.

In rural areas, livestock (especially cattle and hogs) are often regarded as a form of security and investment. In an emergency, livestock can be sold for cash, and extra income can be invested (saved) in the animals. Because of the investment characteristic, one would expect the group with the largest amount of cash income (the large farms with coffee) to have the most animals, but those surveyed in this study did not. Instead, the large farms without coffee had the most animals. This pattern suggests that livestock, just like larger areas of maize and oranges, were a potential alternative to coffee as a source of cash income. Nonetheless, the sale of animals (either livestock or poultry) was relatively uncommon,[28] and was limited largely to the strata that did not grow coffee.

All farm animals except pigs and poultry consumed fodder from a variety of sources. Grasses (from pastures, undergrowth of pine forests, and along roads and paths) were grazed directly or collected to feed to animals at the homestead. Spoiled maize grain was frequently given to the herd. The use of maize residue as fodder appeared to be relatively unimportant in the watershed, mainly because fodder demand was relatively low (overall livestock numbers were low) and alternative sources of supply relatively abundant. In addition, maize plots were generally far afield and were harvested piecemeal, making them less suitable for pasturing animals.

[26] Averaging 1.2 animal units per household, comprising 1.0 horse and 0.2 mule or donkey animal units.

[27] In 1994, INI initiated a soft credit program in Plan Agrario for the purchase of sheep. Seventy sheep were brought in as part of this program but more than 30 died soon after arrival, and the initiative was ended. Rodríguez (1995) discusses the program and points out the importance of carefully planned and tested introductions.

[28] Overall, only 13% of respondents stated that they had sold an animal in the last year, whereas for poultry this was only 6%. The animals were sold in nearby communities throughout the year. No data were collected on barter exchange type transactions.

Outside Contact

We have already discussed labor exchange and off-farm work, but in this section we will give further attention to relations between the farm household and its surroundings. We will also review market integration for maize and beans, along with some indicators of support services and technological change.

Maize and bean purchases and sales – Maize and beans were the major source of calories for the people of the Texizapan watershed. Everyone in the survey sample grew maize and 70% of producers grew some type of beans in association with maize. However, in most cases, neither maize nor beans appeared to be produced in quantities large enough to meet consumption needs (this was the case during the year preceding the survey).

Maize was the major energy source for the inhabitants of the Texizapan watershed. Although maize was the most important crop in terms of area, it was surprising to find that half of the households were net consumers of maize. Only one-quarter of the survey population *appeared* to be self sufficient, while the remaining quarter of the respondents were net producers of maize (selling more than they buy). The net amount sold annually by producers who had a surplus ranged from less than 100 kg to nearly 1.5 t, with an average of about 500 kg. Annual purchases by net consumers of maize spanned a similar range and averaged about 460 kg. The survey average for the net transaction was 116 kg maize purchased annually (including the net producers, net consumers, and self-sufficient farmers). Maize purchases were mainly concentrated in the months preceding the maize harvest (June-September).[29] Maize was either bought from other farmers or from Conasupo stores (in Ocotal Texizapan or Ocotal Chico).

A very rough estimation of the household energy balance[30] suggests that one-fifth of the households did not consume enough maize to meet their energy needs. The household energy balance also seemed to be positively related to the use of (spoiled) maize as animal feed, as mentioned earlier. Bean production (the major protein source) fell far short of needs, with three-quarters of producers buying beans at some point during the year – including nearly half of the households buying continuously throughout the year.[31] Only two producers (6%) sold beans, and both did so in September at harvest time.[32] The remainder (18%) of the producers surveyed *appeared* to be self-sufficient for beans, neither buying nor selling.[33]

Support services – Only 21% of the respondents were members of some type of local organization, most commonly the Organization of Coffee Producers (14%) and, to a lesser degree, the Solidarity Committee, which worked for local reforestation. Half the farmers surveyed had held a position in the community, ~~most~~ often (30%) some position within the ejido structure.

[29] The reported duration of purchases ranged from one to eight months, with the average falling around 3.75 months.

[30] Defined as the energetic value of maize produced and (net) maize purchased minus the estimated energy requirements on a household basis, assuming maize is the sole source of energy intake.

[31] On average, producers buy beans nearly nine months of the year, and most families reportedly purchase 2-4 kg of beans weekly, with an average of 3.4 kg.

[32] They sell an average of 80 kg of beans and do not purchase beans later in the year.

[33] The *apparent* self-sufficiency reflects either sufficient bean production or insufficient income to buy beans to meet consumption needs. This group that neither buys nor sells includes farmers with both the highest and lowest gross cash income of the survey sample, and thus both situations (sufficient production or insufficient income) may well be present.

In the five years prior to the study, only 31% of the farmers surveyed had received a visit from an extension agent. Extension visits seemed to be concentrated in Plan Agrario and Ocotal Texizapan, whereas in Arroyo Texizapan no one reported such a visit. There also seemed to be a distinct bias towards visiting the large farms, especially of coffee growers. Extension agents came from various agencies, including INI, Inmecafe, Sedesol, and the PSSM. A little over half the visits were related to coffee production; the others had to do with fertilizer, credit, and orange and maize production.

Procampo is a government program designed to help farmers make the transition from protected high domestic prices to world prices for certain critical crops such as maize and beans, as Mexico's markets open up to free trade.[34] In the 1994 wet season (*temporal*) maize cycle, farmers received Mx$ 350 for each hectare registered under Procampo, and they received Mx$ 330/ha for 1994 dry season maize (referred to as *tapachole*, this crop is planted in November-December to take advantage of winter rains and harvested from February through May). More than three-quarters of the producers surveyed participated in the Procampo program, although the program did not cover all the maize area. Only 63% of the wet season area and 19% of the dry season area was reportedly included in the program. It appears that no producer surveyed in Arroyo Texizapan received Procampo assistance, but 80-100% of the producers in other ejidos did. Producers who had not registered for the Procampo program by 1995, the year of the survey, were not eligible for the support payment, and it appears that information about registration and participation did not disseminate well to Arroyo Texizapan.

Some producers had chosen not to participate in Procampo because of the volume of documentation and other requirements of the program. For example, to register for the program, a producer had to have planted maize for a number of years, and producers were penalized for the presence of perennial intercrops (for details see Rodríguez 1995, SAGAR 1996).

About one-quarter of the households received formal credit for maize production, but there was a marked concentration of production credit among the large farms (all except one are ejidatarios) and in the ejido of Plan Agrario. In Plan Agrario, farmers received credit in cash (varying from Mx$ 300-400) from SEDESOL for one or two years (average 1.4 years). The other producers who received credit lived in Ocotal Texizapan and received credit in kind (300 kg of fertilizer) from INI for one to six years (average two years). Those who received credit said they got it for weeding and fertilizing, the two potentially most cash-intensive practices of maize cultivation. Not surprisingly, those who received credit tended to use herbicide and fertilizer more often.

Technological change – Most farmers in the area had experience in using external inputs; 64% had used fertilizer and 79% had used herbicides (Table 5). Both fertilizer and herbicide use were higher among farmers who grew coffee, the local cash crop. ($P \leq 0.07$ and $P \geq 0.02$ respectively). This related to the relatively lower opportunity cost of capital and higher costs of labor, in comparison with the non-

[34] The program was designed with the assumption that prices would fall in local currency as Mexico moved toward world prices. However, world prices have increased substantially, while Mexico has undergone a devaluation since beginning the liberalization process. As a result, the maize price in local currency had to be adjusted upwards, making Procampo somewhat superfluous, although producer payments continued.

coffee growers, leading to some substitution of capital for labor. In addition, it is noteworthy that only a relatively small percentage of the external inputs were actually employed on coffee (Table 5). In other words, coffee producers appeared to use their cash crop to finance the use of external inputs for their food crop.

In 1989, INI began an input promotion program among the ejidatarios which offered credit in kind, including fertilizer, herbicide, and insecticide. Perales (1992:45) concluded that the program, which was still active at the time of this survey, had increased farmers' external input use in the Sierra Santa Marta. However, in the study area, the program appeared to have influenced fertilizer use only. Two-fifths of fertilizer users in the sample initially obtained their product from government institutions, whereas no producer received herbicide through similar channels. In the same way, nearly three-fifths of the producers who had used fertilizer initially learned to do so from an extension agent. The remainder learned either from a neighbor, a family member, or by themselves. In contrast, none of the herbicide users initially learned how to use it from an extension agent. Most farmers learned by themselves (nearly one-half) or through their neighbors, family members, or while working off-farm.

The length of use for both products ranged from 1 to 16 years (average 4.2 years for both) and was positively correlated (R^2: 0.62; $P \leq 0.01$). Small farms without coffee generally seemed to have been using inputs for the shortest time, while the large farms seemed to have been using inputs for the longest time.

About 76% of all producers had their own backpack sprayer for applying herbicide. Sprayers were more common on large farms than small farms (86% and 64%, respectively). Farmers used different herbicides but mainly relied on paraquat. The frequent use of this relatively toxic chemical was worrysome, in view of the limited educational background of farmers, the limited extension services they received, and the generally limited precautionary measures they took. As a result, there seemed to be some real health risks/ costs for the herbicide user. One-third of the farmers who used herbicides reported feeling poorly afterwards. The most common malady was a headache followed by fever and dry throat, while others mentioned feelings of nausea, backaches, and chest pains.

Table 5. External input use, Texizapan watershed, Veracruz, Mexico, 1995.

			Farm type			
	Survey average	n[a]	Small, no coffee	Small, coffee	Large, no coffee	Large, coffee
Fertilizer						
% used fertilizer	64	33	50	80	43	77
% used fertilizer on maize	52	33	38	60	43	54
% used fertilizer on coffee	39	18	NA[b]	0	NA	54
Herbicide						
% used herbicide	79	33	75	100	43	92
% used herbicide on maize	76	33	75	100	14	92
% used herbicide on coffee	17	18	NA	0	NA	23

[a] n = number of cases. [b] NA = not applicable.

Several soil conservation technologies had been introduced in the Sierra Santa Marta over the four years prior to this study; chiefly the use of *Mucuna* spp. (velvetbean, referred to locally as *pica pica mansa*) and contoured hedgerows (*muros vivos*). Velvetbean is an aggressive, climbing legume that can be grown as a green manure, either as a sole crop or as an intercrop in maize. The use of velvetbean can generate various soil fertility and soil and water conservation benefits and can have a positive effect on maize production.[35] In the 1950s, farmers in the Sierra had already began experimenting with velvetbean. Spontaneous diffusion of the technology, however, was very slow. In 1991 only about 300 producers, spread over a number of villages, reportedly used it. In 1992, the PSSM initiated an extension network which, among other activities, promoted the use of velvetbean. Their extension efforts included presentations, videos, experimental plots, recruitment and training of local farmer extensionists, and distribution of free velvetbean seed. By 1993, over 2,250 farmers had been contacted in more than 45 communities in the Sierra, and 5 tons of seed had been distributed to the 1,164 producers who requested it (Buckles et al. 1994). Not surprisingly, initial adoption rates were much higher in communities that had a local promotor (92%) than in communities where farmers only attended a presentation and received seed (55%).

Velvetbean extension efforts in the Texizapan area appeared relatively successful, as more than 85% of the farmers surveyed knew of velvetbean. Of those who could explain its usefulness, most stated that it was for maize fertilization. Fifty-five percent of the total survey (or three-fifths of those who had heard of velvetbean) were actually using it – albeit on an apparently limited scale. Comments from those using it ranged from neutral ("I'm trying it," or "A 15 kg bag of seed is sufficient for reseeding") to positive ("It functions the same as fertilizer," "It helps the ears of maize," and "It eliminates the need to burn the field"). There were some negative comments as well ("It won't stop growing," "It facilitates the lodging of maize," and "It's vulnerable to the *kuikui*" [a bird]).

For contoured hedgerows, farmers had to establish rows of *Gliricidia sepium*, a leguminous tree commonly found in the area, along contours traced on the land, with the distance between contours depending on the slope of the land (steeper slopes had closer contour rows, whereas gentler slopes had them further apart). Contoured hedgerows form a barrier against run-off, thereby reducing soil erosion, and gradually lead to the formation of terraces. Labor costs for establishing the hedgerows are considerable and the erosion control benefits are not immediately apparent. Outside assistance (e.g., from the extension agents) is needed to establish the contour. Hedgerows also need to be pruned biannually (to 30-40 cm), so as not to shade the crop excessively. The PSSM has promoted the contoured hedgerow in the Sierra through its extension network. Fewer farmers were familiar with contoured hedgerows than with velvetbean; only 36% had heard of them, and only 13% of the sampled farmers were using them. The users were all large coffee producers in the ejidos with extension agents — mainly in Plan Agrario. No one in Arroyo Texizapan had heard of contoured hedgerows.

[35] According to Soule (1997), farmers listed the advantages of using mucuna in order of importance as: improving soil fertility, increasing moisture conservation, improving weed control, softening the soil, improving the dry season maize crop, and erosion control. Disadvantages included the increased presence of rats and snakes, increased labor needs, inability to intercrop beans, and increased fire risk caused by the presence of large amounts of dry matter.

The Maize Cropping System

To obtain detailed information about farmers' practices specific to the maize cropping system, the survey focused on each household's largest maize plot. The farm typology did not help explain the observed variability in input use or field-level output, and small sample size and variability in data severely limited our understanding of the numerous underlying factors. Here we simply present the sample data, highlighting noteworthy differences. We describe in turn the main, wet cropping season; the secondary, dry cropping season; and the economics of maize production. (For a detailed description of the crop production calendar, see Buckles and Erenstein 1996.)

General Characteristics

Most households cultivated one main field of maize, and fewer than one-third of the producers surveyed had multiple plots of maize. The bulk of the maize area was in the farmer's primary plot, which averaged 1.9 ha (sd: 0.9), while the survey average for total maize area was 2.2 ha per farmer. Secondary plots thus accounted for roughly 12% of the maize area.

Many farmers had changed their maize area over the five years preceeding our study. Only 31% of the sample had maintained their maize area more or less constant during that period, while about half the households (48%) increased theirs and the remaining 21% decreased their maize area. The most common reason for increasing the land planted to maize was related to increasing family size. Conversely, the most common reason for decreasing maize area was a decrease in family size. This finding again points to the subsistence orientation of maize production in the area. Interestingly, though, one-fourth of the producers who had increased their maize area said they did so because of the Procampo support they received, which was based on maize area.

The agroecological environment of the maize fields could generally be considered marginal for the crop, and fields were largely located on steep slopes with varied soils.[36] Fields generally had limited access to water and were distant from the homesteads, lying at an average 33 minutes walking distance from producers' homes (sd: 20), with roughly one-third of the sample under 20 minutes, one-third around 30 minutes, and one-third 45-90 minutes away. Stuart (1978:96) explained that producers generally preferred to have their fields at least a certain distance from the homestead to reduce the probability of livestock wandering into crop stands. More than 40% of those surveyed had fenced maize fields and fenced fields appeared to be more common (54%) for locations less than 30 minutes from the homestead, presumably to protect fields from wandering animals.[37] Fields ranged in slope from an estimated 0 to 110%, with the average falling around 50% (sd: 29). Only 27% of the farmers had black soils (considered relatively fertile) in their maize fields, while 40% said they had red soils (considered relatively infertile). The remainder of the maize fields comprised mixtures of the two and fell somewhere between the extremes for fertility.

Traditionally, beans and other crops such as bananas, pineapples, mangos, squash, and

[36] As noted earlier, farmers avoid soils considered unsuitable for maize. These soils are generally associated with the prevalent vegetation: for example, it is common to avoid the pine forest areas within the watershed. This coincides with findings reported by Stuart (1978:90).

[37] The difference is probably less than expected because of the proximity of other communities to the fields in question.

sweet potatoes were grown between maize rows or as dividers between fields (Perales 1992). In the early-to-mid-1990s, the quantity and number of intercrops seemed to have declined (Perales 1992; Buckles and Erenstein 1996). Nevertheless, many farmers continued intercropping, and 88% of producers reported harvesting some product other than maize from their maize fields. Beans were the most frequent intercrop, grown by 70% of households – mainly bush beans (*frijol bejuco*) and to a lesser extent climbing beans (*frijol de mata*).[38] Other products commonly harvested from the maize field included squash (*calabaza*), tomatoes, small onions, and volunteer greens (*chipile* and *quelite*). Occasionally bananas, sweet potatoes (*camote*), chayote, blackberries, and sugarcane were harvested.

Traditional slash and burn agricultural systems generally combine limited external input use with extended fallow to rebuild fertility and production potential. At least two studies (Perales 1992:88b; Buckles and Erenstein 1996:10) stated that fallow periods in the area had become too short. In the time of Stuart (1978:175), fallows were deemed mature when shrub and tree species reached 4-5 m or 20 cm in diameter. According to Perales (1992:88b), bushy fallows "are only a memory" now. The change to grassy fallows has implications both for soil fertility, as the slashed vegetation returns fewer nutrients to the field, and for weed build-up, as the grassy weeds are inadequately suppressed in the fallow phase (Buckles and Erenstein 1996). Buckles and Erenstein (1996:11) also noted that upland slopes of the Sierra had relatively longer fallow periods (up to ten years) than lowland areas (average about two years). In the survey area, which was situated in the transition zone between the upper and lower areas, most fields were in their first, second, or third year of cultivation, with 22-25% in each category. On average, the main maize field was used for 3.6 years, which approaches the reported "ideal length of cultivation" cited by producers (4.3 years). However, the years of cultivation for the ideal and actual periods of cultivation presented some variability, each ranging up to 15 years. The reported "ideal fallow time" was slightly shorter than the cultivated period, with an average of slightly less than four years.

Where limited external inputs are employed, the fallow:use ratio (years of rest to years of cultivation) could serve as an indicator of system sustainability. Fallow:use ratios for the survey covered a broad range, from 0.1 (2:17) all the way to 4 (8:2), averaging 1.1. One-quarter of those surveyed had ratios above 1 (i.e., their maize land spent more time in fallow than cultivation), 36% had ratios equal to one, and 38% had ratios less than one (i.e., more time in cultivation than fallow).[39] Many interrelated factors potentially affected the reported ratios, and no single factor stands out among them. Even so, the average ratios reported in this study approximate those estimated earlier by Stuart (1978) for the neighboring area.

The Wet Season Maize Crop

Field preparation – Between the middle of March and the beginning of June (average 13 April, sd: 26 d), farmers would begin to clear land in preparation for planting the wet season maize crop. Land clearing in the study area was a purely manual, labor-intensive operation. The cutlass *(machete)* was the main tool, occasionally supplemented by an axe. No one reported using herbicide prior to sowing.

[38] Bean yields were reportedly only 32.6 kg/ha.

[39] Includes 13% with ratios under 0.5 (i.e., more than twice as much time cultivated as fallowed).

Farmer estimates of the time required for field preparation averaged approximately 14 days per hectare (sd: 6), whether for clearing a previously cultivated field or for clearing secondary growth on fallowed fields.

All farmers burned their fields during land preparation (though in one case the fire was unintentional). Chief among the farmers' reasons for burning were rodent control (45%) and the need to clear the land of weeds and debris (39%). The remaining reasons included the control of *chahuistle* (tar spot disease caused by *Phyllachara maydis*), custom, and explanations related to the indigenous belief system. Although burning is a practice well adapted to clearing mature secondary vegetation, it is less appropriate for more intensive agricultural systems with short fallow periods (Buckles and Erenstein 1996).

Establishment – The timing of planting is generally more critical than the timing of land clearing, and it is thus not surprising that farmers' planting dates fell within a narrower window of time. While the clearing dates ranged over four months, planting dates ran from 12 May to 20 July (average 19 June, sd: 16 d), with three-quarters of the planting dates falling in June. Planting date appeared to be strongly related to field location on the upper or lower slopes of the watershed. Location affects the environmental conditions, like rainfall, wind and temperature, which in turn strongly influence the planting window. The average planting date for the upper slopes of the watershed was 11 June, whereas fields in the lower areas were two weeks later on average, around 25 June ($P \leq 0.01$).[40]

Planting was always manual and almost always done using a dibble stick. Only occasionally did farmers use other tools like the hoe or cutlass. The average seeding rate was 13 kg/ha (sd: 5, n: 30). This low seed rate was related to the wide spacing and resultant low plant densities (average of 12,000 hills and 44,000 seeds per ha, based on farmers' estimates).

Seed – Most maize varieties grown throughout the Texizapan watershed were unimproved local varieties.[41] More than four-fifths of farmers surveyed used their own seed selected from the previous harvest, whereas the remainder were evenly divided between farmers who procured their seed from other producers in the area and those who purchased seed.

Four categories of maize were apparent: white, yellow, black, and variegated (white-red).[42] Everyone planted white maize; 67% of the survey population planted black varieties; 27% planted yellow maize; and 9% planted variegated maize. White maize was by far the most important for meeting daily consumption needs and was mainly used to make tortillas. White maize thus accounted for the vast majority of maize area per household (over four-fifths, averaging 1.5 ha). Although black maize was planted by two-thirds of the producers surveyed, it represented only 15% of the household maize area. Most farmers

[40] This relationship is the opposite of that described by Stuart (1978:178), where planting constraints and soil types lead to earlier planting dates on the lower slopes, where soils are heavier and more moist.

[41] However, it seems that the distinction between "local" and "improved" was not clear-cut, as two producers also reported planting improved black maize. The problem was compounded by the language issue: the varieties generally have local names, and these are different for the two native languages spoken in the area.

[42] The categories used here simply refer to maize grain color, a distinction that does not come close to describing the rich variation in farmers' varieties (see Perales 1992; Rice et al. 1997).

planted a small area of black maize (average 0.3 ha) for special food preparations. Significantly more black maize was planted in the upper slopes of the watershed than in the lower areas (86% vs 53% of producers respectively; $P \leq 0.04$), mainly because of its greater prevalence in Plan Agrario. Like white maize, yellow maize was used for food and feed in similar ways. However, yellow maize represented only a very small share of household maize area (5%, or 0.08 ha). It was believed to be more resistant to insects (Rodríguez 1996) and better adapted to growing on slopes or in upland areas (Perales 1992; Rice et al. 1997). Yellow maize indeed tended to be relatively more common in Ocotal Grande and in Plan Agrario, which are located at higher elevations, than in other communities.

Different maize color combinations were grown concurrently in the fields of the Sierra Santa Marta. A white-black pattern was detailed by Perales (1994:74) and a white-black-yellow by Stuart (1978:370-83). In our study, we encountered both patterns (reported by 36% and 27% of respondents, respectively). Other farmers reported planting white maize exclusively (24%), and to a lesser degree (12%) other mixes. The white-black pattern was most common on large farms, whereas the white-only pattern seemed to predominate on small farms. Geographically, the white-black pattern tended to be concentrated in Plan Agrario, whereas the white-only pattern was preferred in Arroyo Texizapan. The white-black-yellow pattern was more evenly distributed across farm types and ejidos.

Weed control – Nearly all farmers weeded their maize crop two or three times (averaging 2.4 weedings). Farmers used both physical and chemical control methods, generally a cutlass (fluctuating around three-fifths of farmers per weeding). Chemical control consisted of herbicides applied using a backpack sprayer, reportedly used by one-third of the farmers for the first weeding and up to half of them for the second.[43] Forty percent of the sample farmers applied no herbicide to weeds in maize, 30% applied it once, and 30% applied it twice, for a survey average of 0.91 herbicide applications per maize cycle. In general, farmers who used herbicides weeded more often (2.6 times on average) than those who did not use herbicides (2.1, $P \leq 0.02$), a finding consistent with Perales (1992:45). The most commonly used herbicide was paraquat, occasionally supplemented by another herbicide such as glyphosate or 2,4-D. Four-fifths of farmers reported having access to water near their fields for mixing herbicides.

Labor needs averaged 15 days per hectare for the first weeding to 10 for the last weeding. However, there were large differences in labor requirements, depending on whether or not a herbicide was used (Table 6). For example, the herbicide treatment for the first weeding required only about 7 days per hectare, whereas manual weeding alone took about twice as long.

Table 6. Labor needs for weeding, Texizapan watershed, Veracruz, Mexico, 1995.

	Days to weed 1 ha	SD[a]	n[b]	Prob.
First weeding	14.60	10.90	33	
No herbicide	17.30	10.30	24	
Herbicide	7.26	9.41	9	0.017
Second weeding	10.00	8.50	31	
No herbicide	14.80	9.55	16	
Herbicide	4.93	1.90	15	0.001
Third weeding	9.66	10.10	13	
No herbicide	14.00	12.40	7	
Herbicide	4.64	2.08	6	0.099

[a] SD = standard deviation. [b] n = number of cases.

[43] Note that some producers use more than one method of weeding at the same time.

Fertilization – Only half of the sample farmers fertilized their maize,[44] resulting in an average of 0.6 fertilizer applications per cycle (sd: 0.7). Of those who did, one-fourth fertilized it twice and the rest only once, which is again consistent with Perales (1992:45). The first application occurred about six weeks after planting, and the second about two weeks later on average, at roughly two months. These averages are later than the dates recommended by INI, which were at 20-30 days after planting (Perales 1992:45), but they are consistent with Perales' observation that most farmers waited until the rains were securely established, about 40 days after planting, before applying fertilizer.

Forty-six percent of the farmers applied nitrogen, 33% phosphorus, and 27% potassium. Doses for users were also relatively limited, averaging only 37 kg N/ha (sd: 21), with even smaller quantities of P and K (20 kg P_2O_5/ha and 10 kg K_2O/ha). Formulations varied, but the most common products were urea and 18-12-6. Compound fertilizer was originally introduced for coffee and was applied mostly by coffee producers.

Pest incidence and control – Almost all producers reported some problem with insects or diseases, the most common problem being fall armyworm and the *mosca pinta* (Table 7). Half the farmers used insecticides; many of the remainder said they did not because of the costs involved. This is consistent with the fact that insecticide users had higher gross cash incomes (Mx$ 4,700) than nonusers (Mx$ 2000, $P \leq 0.05$). Insecticide use was also relatively more common on small farms (60% versus about 45% for larger farms). The most common insecticide was parathion followed by cypermetrina.

About half the farmers reported problems with vertebrate animals, in particular moles, badgers, raccoons, and squirrels. Though most farmers said they did little to combat these pests, a few used dogs or poison, and some even returned to their fields at nights with dogs

Table 7. Pest and disease incidence, Texizapan watershed, Veracruz, Mexico, 1995.

English name	Spanish name	Local name	Scientific name	Percentage of farmers affected by pest
Insects and diseases				**97**
Fall armyworm	*Cogollero*	*Ocuili*	*Spodoptera frugiperda*	70
?	*Mosca pinta*	*Pipixle*	*Aenolamia postica*	46
?	*Gusano medidor*	*Quipts suegui*	*Mecis latipes*	18
Tar spot disease	*Mancha de asfalto*	*Chahuistle*	*Phyllachara maydis*	9
Vertebrate animals				**54**
Mole*Tuza*	*Tugepich*	*Geomys mexicanus*		27
Badger*Tejón*	*Chiicue*	*Nasua narica*	27	
Raccoon	*Mapache*	*Ascan*	*Procyon lotor*	27
Squirrel	*Ardilla*	*Cunqui*	*Sciurus spp.*	18
Mouse*Ratón*		*Mus agrarius*	9	
Birds*Aves*			6	

[44] According to Rodríguez (1995:10), a considerable fraction did not use fertilizer because they believed the "ground will become accustomed" to it, so without the input, future yields would be relatively lower.

and torches to chase pests away. Rodríguez (1995:9) noted this practice in the study area and that farmers occasionally had to reseed their fields because of problems with vertebrate animals.

Harvesting – Most farmers harvested some maize ears in the milk stage (*elotes*), when husks are still green. The green ears were carried home, boiled and eaten, or used to produce fresh maize tamales. The ears were harvested in varying amounts, averaging around 70 kg of grain equivalent per hectare or 120 kg per household.[45] A few producers harvested larger amounts of green ears for sale within the community.

After the maize matured, all farmers bent the stalk just below the ear so the ear was pointing down towards the ground. Bending over the stalk reduces the height of the crop and thus its susceptibility to lodging as a result of strong winds later in the season. The practice also reduces the exposure of the grains on the cob to humidity and disease and allows farmers to leave unharvested maize in the field to dry from the end of September, when it reaches maturity, until March or April, when farmers finish harvesting. The sample farmers required slightly less than four days to bend stalks of a hectare of maize, on average.

As maize was predominantly grown to meet consumption needs, most farmers harvested piecemeal until March or April, when the harvest began in earnest (42% reportedly began their harvest in March). Dates for beginning harvest ranged from September through April, and the ending date again varied widely, ranging from December through the last day of April.

Harvesting was an entirely manual process. One-quarter of the producers left the husks on the cobs when harvesting. Most farmers used animals to transport their harvest from the field to the homestead (79%). The remainder used the *mecapal*, a head strap that enables a person to carry a large load. An average of seven days was needed to harvest and transport one hectare of maize in the survey area.[46]

Yields – Yields in the area were difficult to quantify through farmers' estimates.[47] Part of the difficulty arose from the subsistence orientation of the production systems. None or only a small fraction of the produce was marketed, and most was harvested piecemeal. Farmers generally reported their yields in numbers of *costales* (sacks of cobs, either with or without husks). Converting sacks to kilograms of maize grain was complicated and depended on whether or not the farmer removed the husks and on cob characteristics such as the size, relative grain weight, and shelling ratios. The situation was further complicated by the existence of two types of sacks. One, the *costalilla*, generally refers to a recycled sugar or fertilizer sack made of plastic fiber, which formerly held about 50 kg of either of those substances. The second measure is the *costal de ixtle* or maguey. This is a natural fiber sack distributed by Conasupo which holds roughly twice as much as a *costalilla*. Finally, farmers used many terms to describe

[45] These numbers are indicative only and assume that one bag of *elotes* yields the grain equivalent of one bag of dry cobs.

[46] Based on how much a person could harvest and carry home in one day. Answers varied considerably, and the overall average seems to be on the low side. This result is probably related to the piecemeal nature of the harvest and to some respondents not adequately accounting for travel time.

[47] A crop-cut survey could potentially have alleviated part of this problem but was not part of this initial descriptive survey.

their sacks (*costal, costal de ixtle, costal de maguey, costalilla,* and *saco*), and it was not necessarily obvious which type was implied by farmers' often varying terms. To circumvent some of these problems, enumerators asked farmers for their conversion ratios (i.e., how much shelled grain one of their bags of cobs yielded). Although the average (32 kg) approximates our estimate,[48] there is again wide variation (10-100 kg). Finally, some farmers reported yields directly in kilograms per hectare. All yields were eventually converted to kilograms of shelled grain per hectare to allow for comparison. However, in view of the factors we have just described, these reported yields are of indicative value only.

What is clear is that reported yields were extremely low, averaging 840 kg/ha for the 1994-95 cycle (sd 365, n 33). Yields in the previous two cycles were even lower, averaging around 650 kg/ha (sd: 450). The high variability of yields and small sample size make it difficult to separate the major factors influencing yields. However, yields appeared to be better at lower elevations (930 kg/ha) than at higher ones (720 kg/ha; $P \leq 0.08$), possibly because agroecological conditions are more favorable at the lower elevations.

According to Stuart (1978:275-8), farmers agreed about what constitutes good and bad yields, but he also noted the difficulty of converting farmers' values to metric units. Stuart studied a similar region near Texizapan but at a lower elevation, and therefore the yields he reported can be roughly compared to those reported in this survey. At the conversion rates used for this study, "good" yields in the area studied by Stuart (for 1978, with no mentioned external input use) were 850-1,000 kg/ha for wet season maize. "Adequate yields" were around 725 kg/ha, and "poor" yields were 500-650 kg/ha. A comparison of the findings of both studies generates two major observations. First, regardless of computational difficulties, yields fell within a similar range. Second, maize yields in the region seemed to be stagnant. This was not entirely surprising, in view of farmers' limited use of external inputs (fertilizer and improved varieties).

Farmers were asked about the expected yields from a new field just brought into cultivation and an old ("tired") field, to obtain another indicator of potential yield variability. The responses generated an extremely wide array of yields, but the ratio of yield from a new field to that of an old field was relatively consistent. New fields were expected to yield more than twice (2.4 on average) as much maize as old fields.

The Dry Season Maize Crop

In addition to the main wet season maize crop, most farmers (79%) planted dry season maize as a relay crop. Rainfall during the second season was limited, so the crop depended largely on residual soil moisture. According to the farmers, this was a risky planting season with many potential problems (drought, winds, pests, etc.) that could reduce maize yields to little or nothing.[49] Reported yields averaged only 170 kg/ha of maize grain for farmers who planted a dry season crop (sd 244, n 24), half of whom harvested nothing at all. Understandably, farmers chose to plant fewer hectares of maize in the dry season than in the wet season (1.1 ha, sd 0.9 n 24), averaging roughly half of the wet season area. Stuart (1978:169) pointed out that

[48] A *costal* of cobs is equal to 37 kg of shelled grain and a *costalilla* is equal to 17 kg shelled grain. A *saco* is equivalent to a *costal*. A *carga* is two *costales*.

[49] Thereby limiting the potential yield benefits of greater radiation.

less time was invested in field preparation and weeding during this season, and Perales (1992:47) observed that the low yields and high risk meant that little, if any, fertilizer was used. According to Stuart (1978:166), farmers viewed the dry season cycle as only supplementary to the wet season maize cycle, and it could not be depended upon to do more than "help out."

Although the incidence of dry season maize was reportedly similar in the upper and lower elevations of the watershed, yields at the upper elevations averaged only 33 kg/ha, whereas those in the lower areas averaged 260 kg/ha ($P \leq 0.03$). This difference was related mainly to the fact that 89% of farmers who planted maize at the higher elevations harvested nothing at all. Most farmers acknowledged this, saying that maize just did not grow on the upper slopes. However, they were apparently still willing to run the risk. This seems to contradict the widely held view that resource-poor farmers are averse to risk, but it may have been directly related to Procampo, which provided income support payments on an area basis for the dry season as well as the wet season. Procampo coverage in the dry season was less complete and common, but those who did receive this assistance for the dry season generally also sowed the largest areas of dry season maize. Unfortunately the survey data do not allow us to explore whether there was an interaction between the support program and widespread dry season planting.

Storage Practices

All farmers initially stored maize in the field by bending the stalks, and then harvested the ears piecemeal. Once the final harvest had been brought in, the family needed to store it in some other way, select seed for the next cycle, and attempt to keep insects at bay. Around 60% of sampled farmers reported shelling their maize prior to storage and generally stored the maize in sacks. The remainder largely stored their maize in an *estiba* — a platform raised 0.5-1 m off of the ground onto which the maize, generally unhusked, is stacked. Maize was also stored in the *tapanco*, the space above the kitchen and below the thatched roof, where the smoke helped protect it from pests. There seemed to be a lot of variation among households in caring for their maize, as well as variation within the same household across years.

In some households, maize to be used as seed was selected immediately upon arrival at the homestead; in others seed was selected and separated from grain for consumption every day as food was prepared.[50] Many households selected seed when maize arrived from the field and then continued to select seed throughout the year during food preparation. Maize selected for seed was often hung from a tree or the rafters of the house to help keep it safe from rodents.

Insecticide (mostly lindano and parathion) was applied to stored maize — both food and seed, shelled grain and husked cobs — in more than 70% of the households. The health implications of applying insecticide to food maize are unclear, because food maize is generally washed as part of the preparation process.

The Economics of Maize Production

Labor use – Growing maize in the Texizapan watershed is a labor-intensive activity. Farmers reported needing an average of nearly 70 days

[50] This survey distinguished between storage practices for food and seed maize, but differences were less than expected, and in most cases the storage practices were similar. This may be related to the fact that the maize seed selection is an iterative, continuous process. Rice et al. (1997) further describe the complexity of maize selection and storage of future seed.

labor to produce one hectare of maize (Table 8). The estimates reported by Stuart (1978) are very similar to the Texizapan survey results, with the exception of the time spent bending stalks and harvesting.

To simplify labor estimation, in the present survey farmers' estimates of the labor required for various activities were solicited by asking how much one person could accomplish in one day. That information was then converted into labor needs per hectare of maize.[51] Unfortunately, this method of questioning, possibly combined with language problems, may have led to a slight over-estimation of the amount one person can accomplish, as some farmers may have stated an ideal rather than an actual value. This may, in part, explain why the survey averages for labor needs appear to be somewhat lower than other estimates for similar areas.

Notwithstanding this bias, on average the labor estimates seem reasonable. Family members provided most of the labor for maize production, especially the male adults. Women and children participated primarily in weeding but also played a substantial role in bending and harvesting (Table 9). They participated less frequently in planting and land preparation. On the other hand, an average of about 22% of the total work was done by nonfamily labor. The local labor exchange accounted for 15% of total average work (11 days per hectare, SD: 11, n: 30) and paid laborers did 6% of all work (5 days per hectare, SD: 10, n: 31). As with the

Table 8. Labor estimates for agricultural activities from three studies in the Sierra de Santa Marta, Veracruz, Mexico.

Activitiy	Texizapan survey, 1995 Survey average	SD[a]	n[b]	Stuart (1978) (estimate)	Pare, Aguero, and Blanco (1994) (estimate)
Clearing	13.50	5.13	33	12-16	22[c]
Planting	5.12	2.36	32	6	4
Total weeding	27.90	19.70	33	25-30	32
First weeding	14.60	10.90	33	NA	NA
Second weeding	9.39	8.58	33	NA	NA
Third weeding	3.81	7.84	33	NA	NA
Bending stalks	3.94	1.56	33	8-10	16
Harvesting and carrying	7.02	5.60	32	10-12	20
Subtotal (to facilitate comparison across sources)	57.40	21.60	31	61-74	94
Insecticide application[d]	0.97	NA	NA	NA	NA
Fertilizer application	2.91	NA	NA	NA	NA
Shelling	8.38	3.65	33	NA	NA
Total 69.60	21.60	33	NA	NA	

[a] SD = standard deviation. [b] n = number of cases.
[c] Assumes clearing of *acahual* from a long fallow period, not from previous field, as in other estimates.
[d] The survey did not address labor needs for fertilization and insecticide application. Average labor needs reflect the respective frequency of application multiplied by standard labor needs (assuming 6 days per ha for fertilizer and 2 days per ha for insecticide application). Data on labor needs for shelling were collected but varied widely. The data are based on a manual shelling rate of 100 kg per day.

[51] The alternative of asking how much time was actually spent on each activity would require clarifying on a case by case basis the number and type of people involved in the work, duration of their participation, and so on.

participation of women and children, labor exchange was also used most often for weeding and harvesting and to a lesser degree for planting and field preparation. Day laborers, when hired, were also used predominantly for weeding and harvesting. The use of women, children, and nonfamily labor therefore seemed to be concentrated around maize weeding and harvesting, which are among the most labor-consuming activities.

Valuation of resources – Because farmers usually purchase **external inputs** in the market, such inputs have a visible cost. Relatively less visible, though, are the transportation costs to the farmer of bringing the product from the market to a remote homestead. Farmers surveyed generally had to purchase agrochemicals outside the watershed in nearby towns (Soteapan, Mecayapan or Tatahuicapan) — a couple of hours walking distance from their communities. For bulky products such as fertilizer, transport costs may therefore constitute more than 20% of the estimated on-farm price of the input (Table 10). Internal inputs (notably seed for local maize varieties and transport animals) are valued at their opportunity cost.

Table 9. Percentage of households using various sources of labor, Texizapan watershed, Veracruz, Mexico, 1995.

	Family labor		Nonfamily labor	
Activity	Female (n=30[a])	Child (n=22)	Labor exchange	Day laborers
Clearing	7	18	27	3
Planting	10	23	27	6
Weeding	63	55	55	21
Doubling	27	27	6	3
Harvesting and carrying	27	41	39	18

[a] n = the number of households for which data were taken.

Assigning value to **outputs** generally presents no problem, when most of the outputs are marketed. In subsistence systems, however, by definition most produce is not marketed. In fact, only one-quarter of the survey households were net sellers of maize, whereas half were net buyers. The opportunity cost of maize was therefore assumed to be the on-farm purchase price of maize. This on-farm price was higher than the on-farm produce price for more commercial farmers on two accounts. For one, being an on-farm *purchase* price, transport cost from the market to the farm was *added* to the market price, instead of being subtracted in the case of sales.[52] Secondly, by its very nature the local market differed from the maize market prevalent in more commercial areas, resulting in substantially higher market prices. For instance, farmers reported local sale and purchase prices for maize that averaged M$ 0.70-0.75 per kg for the year preceding the survey. This was substantially higher than the official M$ 600 per ton upon commercialization of the produce from the main 1994 season through Conasupo.[53] Similar circumstances applied to beans.

The remoteness of the watershed thus had a profound influence on the on-farm value of inputs and outputs. Notwithstanding, the estimation and attribution of average transport costs remains somewhat arbitrary. Visits to the nearby towns probably had multiple purposes,

[52] Although the transport costs themselves are variable. On the one hand, transport costs are relatively low because of the proximity of the local market (maize is generally bought from neighboring farmers or the local Conasupo outlets). On the other, transport costs are relatively high due to the piecemeal nature of the purchases and unmechanised modes of transport.

[53] Though nominal prices started to increase after the 1994 temporal season, due to the economic crisis that affected Mexico in late 1994. The official price for the subsequent second season maize increased to M$ 715 per ton.

only one of which was purchasing inputs. In addition, the watershed's very remoteness could translate into significant differences in travel times, depending on the community from which one departs. Table 10 presents detailed on-farm prices of the more common inputs and outputs. The opportunity cost of crop residues is assumed to be negligible, in view of the abundant sources of forage and the limited demand.

Table 10. Field prices for agricultural inputs, Texizapan watershed, Veracruz, Mexico, 1995.

Input and unit	On-farm cost	Specifications[a]
Labor		
Human labor (Mx$/person/day)	13	Without food. For maize day laborers, average rate Mx$ 11/ day plus food (range 10-15, 2, n: 8). Food valued at Mx$ 2/day (similar to Erenstein and Cadena1997). For coffee day laborers, average rate Mx$ 15/day (range 10-20). For coffee harvest also payment per task, with an average Mx$ 18/bag *(costal)*[b] harvested (range 10-20), roughly equivalent to a day's work.
Rental, pack animals (Mx$/animal/day)	14	Survey average (4, n: 10, range 10-20).
Land rental (Mx$/ha)	0-150	Only one case reported paying cash land rent (150).
Physical inputs		
Local maize (kg)	1.7	Assumed to be double the purchase price of food maize to account for the price premium of seed over food. (Note, however, that seed is generally exchanged in kind between farmers).
Urea (46-0-0) (50 kg)	44	Commercial price[c] plus transport costs (estimated at Mx$ 10/bag)[d]
Triple superphosphate (0-46-0) (50 kg)	48	Same as above.
Potassium chloride (0-0-60) (50 kg)	45	Same as above.
Herbicide		
Gramoxone (L; *a.i.* paraquat)	27	Average commercial price given by farmer (24.1 4.51, n: 19) plus transport cost (estimated at M$ 3.4/litre)[d]
Faena (L; *a.i.* glyphosate)	38	Average commercial price given by farmer (2 cases, same value) plus transport (same as Gramoxone).
Insecticide		
Foley (L; *a.i.* parathion)	31	Commercial price[c] plus transport costs (same as Gramoxone, above).
Insecticide for storage pests		
Graneril (kg; *a.i.* lindano)	9	Same as above.
Products		
Maize (sale) (Mx$/kg)	0.70	Average sale price within the watershed (0.18, n: 8).
Maize (purchase) (Mx$/kg)	0.85	Average purchase price within the watershed (0.75 0.17, n: 19) plus local transport (estimated at M$0.1/kg).[e] Purchase price average high Mx$ 0.79/kg (0.17, n: 18), average low Mx$ 0.66/kg (0.22, n:13).
Beans (sale) (Mx$/kg)	2.15	Average sale price within the watershed (0.21, n: 2).
Beans (purchase) (Mx$/kg)	3.08	Average purchase price within the watershed (2.59 0.29, n: 25) plus local transport (estimated at M$0.5/kg).[e] Purchase price average high Mx$ 2.71/kg (0.45, n: 25), average low Mx$ 2.47/kg (0.31, n:16).
Livestock (Mx$/head)		One horse sold for Mx$ 600, and three cattle for Mx$ 550-875 per head.

[a] To estimate transport costs, arbitrary assumptions were made regarding average travel times and modes (see below); but these nonetheless reflect local conditions, constraints and opportunity costs.

[b] A *costal* is a bag made of plastic or natural fiber (*ixtle*) and filled with produce. It is used as a local measure. A *costal* of coffee weighs 50-60 kg when filled with freshly picked coffee.

[c] Based on a June 1993 price (FIRA, San Andrés Tuxtla) plus inflation (Banco de México).

[d] For fertilizer assumes 1 person and 2 horses/mules @ 2 bags/horse or mule for a day trip to nearby Soteapan or Tatahuicapan. For pesticides assumes 1 person and 1 horse/mule @ 8 bottles/horse or mule for a similar trip.

[e] For maize assumes 1.5 hrs for 1 person and 1 horse/mule to buy and collect 50 kg within the watershed. For beans assumes 1.5 hrs for 1 person to buy and collect 5 kg.

With respect to **labor**, farmers supplement their family labor with labor exchange and paid laborers. While labor exchange is paid in kind, wage laborers are paid an average of Mx$ 11 per day plus meals, amounting to an estimated Mx$ 13 per day. For this study, we assumed that the wage rate for day labor adequately reflected the opportunity costs of labor and therefore all labor (both family and nonfamily) for maize production was valued at this cost.

Valuation of **land** resources for the Texizapan watershed is problematic. In the current extensive land-use system, land is generally not the most limiting factor, and as a result the local land rental market is not very well developed. In fact, only one farmer reported renting land (at Mx$ 150 per ha annually), although more than one-third of the households have no access to land of their own. Because of the subsistence orientation of maize production, land was frequently loaned to such households relatively free of charge. The real opportunity cost of land in the area was probably somewhere between the extreme values of Mx$ 0 and Mx$ 150. To circumvent the land valuation issue, the budgets do not deduct the cost of land. The various indicators of return therefore include the return to land.

The cost of **capital** was generally reflected through the market interest rate. However, in remote rural settings interest rates were highly variable and depended heavily on the credit source. Commercial credit was rarely available to the subsistence-oriented households in the study area. Use of official subsidized credit (0% nominal interest) for maize was reported by about one-quarter of the producers. Other producers relied either on their own cash sources (for example, from coffee production or off-farm work) or on informal sources (for example, family members or shopkeepers). Balente (pers. comm.) reported that farmers in Arroyo Texizapan who did not grow coffee frequently obtained short-term credit to purchase maize inputs from coffee-growing farmers in nearby Ocotal Grande, at rates starting at 5-10% per month. For longer-term credit, farmers could travel further afield to neighboring Soteapan. Although no precise data were collected to measure the real cost of capital in the study area, we assumed that a monthly rate of 5% adequately reflected the *average* opportunity cost of capital (though the actual rate could vary from 0 to 10% or more).

Crop budget – Table 11 presents a crop budget for *wet season* maize (1994 cycle). A few observations about the budget components are in order:

- Income estimates include maize yield, intercrop yield, and Procampo support payments. Yields of maize and beans, the major intercrop, are relatively straightforward, although reported bean yields were very low. Yields of the other intercrops are more difficult to quantify. For simplification, the budgets assume the monetary value of all other intercrops to equal the value of the bean intercrop. The budgets include the Procampo support payment, taking into account the incomplete coverage in terms of area.[54]

[54] As noted earlier, this producer subsidy was paid based on a number of prerequisites, including the requirement that the field registered in the program be planted to maize (or another program commodity) in the cycles prior to *temporal* 1994. An additional prerequisite was that the field continued to be used for agricultural purposes. In view of the subsistence orientation of agriculture and limited alternative opportunities in the study area, agricultural use of the respective fields in the watershed was largely synonymous with maize cultivation. As such, Procampo was considered as a benefit directly attributable to maize cultivation.

Table 11. Crop budgets for wet season maize, Texizapan watershed, Veracruz, Mexico, 1994.

	Price by unit (Mx$)	Units/ha	Mx$/ha[a]
Income			
Maize (kg)	0.85	840	715
Beans (kg)	3.08	23	71
Other intercrop	NA[b]	NA	71
PROCAMPO (ha)	350	63	221
Total gross benefit	NA	NA	1,078
Variable costs			
Physical inputs			
Maize seed (kg)	1.7	13.0	22
Fertilizer			
Urea (50 kg)	44	0.7	32
Super phosphate (50 kg)	48	0.3	14
Potassium chloride (50 kg)	45	0.1	4
Herbicide			
Gramoxone (L)	27	3.6	99
Insecticide			
Foley (L)	31	0.3	8
Interest on cash (6 mo) (%/mo)	5	214	64
Animal transport, harvest (animal)	14	2.3	32
Total, physical inputs	NA	NA	274
Labor			
Land preparation (labor days)	13	13.5	176
Planting (labor days)	13	5.1	67
Weed control (labor days)	13	27.9	363
Fertilization (labor days)	13	2.9	38
Insecticide application (labor days)	13	1.0	13
Doubling (labor days)	13	3.9	51
Harvesting (labor days)	13	7.0	91
Shelling (labor days)	13	8.4	109
Total labor (labor days)	NA	69.7	907
Total variable costs	NA	NA	1,181
Fixed costs			
Capital (lump sum)	25	NA	25
Total fixed costs	NA	NA	25
Returns			
Value added (Mx$/ha) [A - B1]			804
Net benefit (Mx$/ha) [A - B - C]			(128)
Costs per kg maize (Mx$/kg)			1.44
Productivity of labor (kg maize/labor day)			12.0
Return to labor (Mx$/labor day)			11.2
Cash flow (Mx$/ha)			(16)

[a] Multiplications may not correspond due to rounding. [b] NA = not available or not applicable.

- For physical and labor inputs, we used average rates of application, including zero rates for nonusers. Physical inputs are reported in terms of the most common product. Seed rates of the intercrop are assumed to be negligible, in view of the limited area actually planted and considering that many intercrops were actually volunteers. Physical inputs also include the use of animals to transport the harvest where this was done.[55]
- Interest on cash is calculated over only external inputs and contracted wage laborers. An interest-carrying period of six months was the assumed average. However, this period could vary, depending on the availability of cash within the household (e.g., the timing of the coffee harvest, the maize harvest, and the Procampo payment).
- The maize cropping system relied predominantly on manual labor supplemented with some basic tools such as the cutlass, the hoe, and the backpack sprayer. A lump sum of Mx$ 50 per farm (or Mx$ 25 per hectare of maize) was assumed to reflect adequately the cost of these capital goods (operation and maintenance, depreciation and interest).

Income or gross benefit was relatively low, amounting to about Mx$ 1,100/ha for the 1994 wet season maize cycle. This relatively low income was primarily related to the low yields. The intercrop accounted for about one-eighth of the estimated income, and Procampo may have accounted for as much as one-fifth.

Costs were predominantly variable, amounting to Mx$ 1,180/ha. In view of the limited use of external inputs, it is not surprising that labor costs amounted to over three-quarters of all variable costs. Physical inputs totaled around Mx$ 275/ha, with herbicides and interest being the major cost components.

The budgets include a number of return indicators. The **value added** represents the gross benefit minus the external inputs — in other words, the return to invested labor, land, and capital. In view of the limited external input use, the value added amounts to 75% of the gross benefits. The **net benefit** represents the gross benefit minus all costs incurred (including nonmonetary costs, except land - in other words, the gain that is left to the farmer). The net benefit shows that the average farm incurred a loss of Mx$ 130 per ha. However, this does not mean that these farms incurred a financial loss, only that the remuneration of the factors of production was less than their assumed opportunity costs.

The limited gains from maize cultivation also become apparent when one considers costs per kilogram of maize,[56] which are substantially higher than the on-farm maize price. **Labor productivity** averages 12 kg of maize per day, whereas the **return to labor day** is substantially less than the assumed opportunity costs of labor. The estimated **cash flow**[57] for maize suggests that the average farmers' cash outlays were not recovered through cash income, further tightening the existent cash constraints.

These indicators suggest that, economically speaking, farmers would have been better off buying their maize in the market while working off the farm as day laborers (under the prevalent opportunity costs and other budgetary assumptions). Notwithstanding, maize

[55] Assuming two animals make four trips a day, each carrying two bags (at 37 kg of grain equivalent per bag). The four daily trips are based on the average field distance of 33 minutes on foot each way.
[56] This indicator sums all costs (variable and fixed, with the exception of land) and divides this by the maize yield. It assumes there is no interaction between the maize and the intercrop.
[57] This indicator adds the cash income generated by Procampo and limited maize sales and deducts cash outlays including interest for external inputs and wage laborers.

production was expected to continue in the area. First and foremost, these resource-poor farmers produced maize to cover most of their consumption needs and, with it, reduce the risk of not being able to meet these subsistence needs. Depending entirely on markets for the provision of both income and food is a risk these farmers are generally not willing to take. In addition, they generally have limited alternative income opportunities anyway, either on- or off-farm. Furthermore, especially for non-coffee producing farmers, cash is in eternal short supply, thereby constraining food purchases, as well as productive outlays for that matter.[58]

Summary and Conclusions

At the time of our survey, rainfed agriculture was the central component of the farming systems of the Texizapan watershed in the Sierra de Santa Marta, southern Veracruz. Agricultural land use was relatively extensive and based mainly on maize and coffee. Non-agricultural land uses, such as unimproved pasture and various types of forest, occupied a significantly larger area. Some of the forest types, however, were found on land that was apparently unsuited to agriculture.

In terms of area, maize was the main crop and was grown by all households, predominantly to meet consumption needs. Coffee was the main cash crop but was limited by agroecological factors to the higher slopes (>500 masl). The livestock herd comprised mostly horses, mules and donkeys, and generally served as transport for agricultural production and other purposes. Other types of livestock were relatively uncommon. The average family contained 5.7 persons. The family provided most of the agricultural labor, but their contribution was frequently supplemented by labor exchange (especially for maize production) and day labor (especially for coffee production).

Based on farm size and economic scale, the study distinguished four farm types: small farms with and without coffee and large farms with and without coffee. All types faced several constraints, although certain constraints were more specific to a particular farm type. For example, small farms (on average <3 ha) appeared to be relatively limited by lack of access to land, whereas large farms (average ±20ha) appeared to be relatively labor constrained. Although all farms appeared to have severe liquidity/cash constraints, this constraint was less problematic for coffee producers, who generally marketed a crop annually. One-third of the sample supplemented their income through off-farm work, this being more common among the small farms without coffee. Producers on large farms without coffee tried to supplement their income mainly through other productive farm activities (e.g., maize, livestock, and orange production for the regional market).

The maize cropping system could be characterized as relatively land extensive and labor intensive, requiring on average 70 labor days per hectare. All practices were entirely manual (i.e., no mechanization whatsoever), partly due to the steep slopes. External input use was limited and emphasized herbicides. The frequent use of toxic herbicides such as paraquat represented potential health risks/ costs to the user. Half the sample reported using fertilizers, but at generally low levels.

[58] The budget also highlights the importance of Procampo for the incomes of these resource-poor households, especially cash income. Although this support payment was conceived to alleviate the maize price decline foreseen in relation to NAFTA, the majority of households in the watershed are either self-sufficient or net buyers of maize. Procampo therefore became a direct source of new, additional income for these households instead of alleviating income foregone.

Use of improved maize varieties was uncommon, and farmers grew different local materials of different grain colors such as black and yellow, although white materials accounted for the most maize area.

All farmers used burning as a land preparation practice prior to maize planting. About half the farmers reported they were experimenting with green manure crops (velvetbean). The maize yields in the main season (wet season) were low, averaging less than 1 t/ha. Maize was generally intercropped to different degrees with beans and other crops, although intercrop yields also appeared to be low (e.g., < 50 kg/ha beans). Dry season maize cultivation was more widespread than previously thought (79%), although the crop yielded less than 200 kg/ha for this risky season in 1995. Economic returns to maize cultivation were low as a result of low yields, the high labor input, and the limited external input use. The cash flow from maize cultivation was very fragile and largely dependent on the Procampo support payment. However, regardless of its limited economic attractiveness, maize cultivation was expected to continue in the study area, in view of households' consumption needs and limited alternative income opportunities.

Although all households produced maize, half the sample reported being net buyers of maize. The remaining half of the sample was divided between households that were *apparently* self-sufficient (either they could not or did not need to buy maize) and those that marketed a surplus. The need to buy beans – the major protein source – was even more widespread. In view of the limited number of other food sources available locally and constraints on disposable income, the nutritional status of the households warrants closer attention.

In conclusion, the farming systems in the study area can be characterized as peasant households (Ellis 1988:12) whose livelihoods are based on access to land, which utilize mainly family labor in farm production, and which engage only partially in imperfect markets. The challenge remains of how these peasant households can develop into more productive family farms. An essential component of any development strategy with this objective is to raise the productivity of the maize production system on a sustainable basis, so that consumption and other needs can be more adequately met. Productivity-enhancing and resource-conserving practices will have to be disseminated more widely if this objective is to be achieved. Promising measures that require low levels of external inputs include the use of green manures, the conservation of crop residues as mulch (i.e., the elimination of burning during land preparation), and higher plant densities. In addition, some changes in external input use (both in rate and efficiency) may be required, such as the use of locally adapted improved varieties and chemical fertilizers.[59]

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