The Environmental & Social Impacts of Economic Liberalization on Corn Production in Mexico

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The views in this paper are those of the author and do not necessarily reflect those of Oxfam GB or of WWF.

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Preface

Governments around the world have embraced market liberalization as a means of enhancing efficiency and achieving economic growth. But it is broadly acknowledged that liberalization by itself cannot guarantee favorable outcomes for sustainable development. Many important social and environmental goods are undervalued by commercial markets, and so require the protection and support of public policies – policies that themselves have too often been found in tension with efforts to make markets as "free" as possible. These tensions – and the failure of governments to adequately resolve them – have led to widening popular mistrust of "globalization" and free trade. These same tensions have also produced a growing body of literature dedicated to understanding the social and environmental dimensions of market liberalization. This study by Dr. Alejandro Nadal was commissioned as a contribution to that literature.

Dr. Nadal examines Mexico's effort to liberalize and "modernize" its agricultural sector, and in particular its domestic production of corn. His approach is highly critical, and his ultimate conclusion is both simple and stark: liberalization has failed to achieve the environmental and social improvements it promised. In place of anticipated reduced pressures on marginal lands and gains in human welfare, Dr. Nadal argues, liberalization has pushed subsistence corn producers increasingly away from environmentally sound production practices and deeper into poverty. At the same time, he finds, the "opening" of the Mexican corn sector is threatening to reduce the extraordinary genetic diversity of Mexican corn stocks, with potentially serious implications not only for Mexican farmers, but also for the future availability of diverse and adaptive Mexican varieties that could help feed a hungry developing world.

The roots of the problem, Dr. Nadal contends, lie in a combination of both bad planning and incomplete implementation by the Mexican government of its policies for transforming Mexican agriculture. He finds that the errors in planning stemmed in part from unrealistic and oversimplified assumptions about how poor Mexican corn producers would react to the effects (principally price effects) of liberalization. More deeply, Dr. Nadal argues, the traditional approach to trade liberalization – with its focus on market-based "efficiency" – in this case seriously undervalued the social and environmental benefits offered by diversified, small-scale, non-intensive agricultural practices.

Dr. Nadal notes that the original plans for "modernizing" the Mexican corn economy did recognize the need for a long transition period and for on-going government interventions to smooth the adjustment process. He criticizes the fact that this transition period was sharply truncated, and was accompanied by a failure to maintain effective adjustment support for corn producers. Dr. Nadal concludes that poor planning and unbalanced implementation, in the absence of essential complementary policies, resulted in overly-rapid liberalization with negative social and environmental consequences.

The arguments made by Dr. Nadal – and doubtless his version of some of the facts – are certain to provoke debate. In the hope of preventing any misunderstandings, WWF and Oxfam wish to state unequivocally what we think this paper is *not*: it is not an effort to prove that NAFTA is the principal cause of environmental degradation or poverty in rural Mexico. Dr. Nadal does not pretend that the free trade agreement itself is the cause of the problems he identifies. On the contrary, Dr. Nadal states explicitly and repeatedly that NAFTA was part of a broad "policy mix" that included monetary, financial, and domestic regulatory elements. Moreover, both the "modernization" of Mexican agriculture and the opening of the Mexican economy are policies that date back nearly a decade before NAFTA, and were well advanced by the time NAFTA was negotiated. Nevertheless, NAFTA is an integral and significant part

of these processes, and it is entirely correct to discuss the issues raised by Dr. Nadal in the context of analyzing NAFTA's environmental and social dimensions.

WWF and Oxfam are pleased to have supported this paper and its dissemination. Dr. Nadal's arguments are compelling, and fit sufficiently with the obvious realities in Mexico to deserve the most serious consideration. Furthermore, the issues highlighted in the paper present a clear and credible case for studying and respecting the complex linkages between sustainability, poverty reduction and market liberalization. The stakes are simply too high to move ahead with liberalization without taking full account of the human and environmental impacts on the ground, or of the need for private markets to function in the context of strong public policies. If Dr. Nadal's paper engenders debate, in our view it is precisely the sort of debate that would have been highly relevant and productive at the time NAFTA was being negotiated. It is equally needed today.

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Executive Summary

The North American Free Trade Agreement (NAFTA) between Mexico, the United States and Canada came into effect on 1 January 1994. This study compares the anticipated impacts of liberalizing the Mexican corn sector, which produces the country's key staple food crop and provides an important source of livelihoods, under NAFTA with the actual socio-economic and environmental outcomes. In so doing, it provides an important example of the social and environmental problems resulting from a rapid and poorly-planned adjustment to a more liberal agricultural trade regime in the absence of adequate transitional state support.

Conclusions and policy recommendations

Poverty levels in Mexico have increased in the past five years and the situation of rural farmers, especially corn producers, is desperate, partly as a result of the NAFTA-induced changes in trade and other government policies. These changes have resulted in higher levels of migration from rural areas and increased pressure on land, aquifers and forests. Some of the most alarming (and unexpected) impacts are the expansion in surface area of corn cultivation and the fall in average yields. Together, these have generated intense pressure for encroachment on Mexico's biosphere reserves and other protected areas. In the long run, unless these negative trends are reversed by appropriate policy interventions, the socio-economic and environmental crisis in rural Mexico will deepen.

The main findings of the study can be summarized as follows:

- Liberalization of the corn sector under NAFTA has failed to generate the expected economic, environmental and social benefits. Current liberalization patterns and inadequate state support threaten the ability of Mexican farmers to continue to grown corn and the ability of consumers to afford it.

- In spite of a sharp drop in corn prices and the increase in imports, Mexico's production has remained stable. In fact, the cultivated surface devoted to corn has expanded, while yields have dropped. The increased overall consumption of maize (domestic production plus imports) is
explained by increased use as cattle feed and in industrial processing.

- The study shows that there has been little incentive and opportunity for farmers to reallocate productive resources to other crops. In addition, due to market imperfections and segmentation, the expected benefits in terms of lower consumer prices for maize products have failed to materialize, and tortilla prices have actually risen.

- While modernization or crop substitution may be an option for a small group of competitive producers, a number of less profitable growers are being forced to migrate (to urban areas or to other countries). One of the main findings of the study is that migration and the weakening of social institutions are contributing to genetic erosion as traditional knowledge on corn seeds is lost.

- The restructuring of the corn sector following NAFTA is also contributing to accelerating soil erosion trends both through specialization and monoculture, coupled with increased use of fertilizers (as is observed in the case of the more competitive producers), and because of a more intensive use of soils, including through the extension of the agricultural frontier to marginal lands, by traditional producers.

On the basis of these findings, the study proposes a set of policy recommendations that cover not only the agricultural sector, but also changes required in macroeconomic and social policy. Three critical policy areas are considered:

- Macroeconomic and social sector policies to support Mexican agriculture in general and corn production in particular (including public investment in health, housing, education and communications, and a return to the original fifteen-year transition period for corn prices under NAFTA);

- Sustainable intensification of agricultural production through the promotion of two crop cycles per year and sustainable measures to increase crop yields (e.g. erosion measures, controlled use of external inputs, soil conservation practices);

- Targeted subsidies to strengthen the capacity of producers to develop and conserve their genetic resources (using both direct support measures and technical assistance). *In situ* or dynamic conservation is considered to be a top-level priority, depending critically on the welfare of subsistence corn producers.

Background

Since its earliest cultivation in Mexico some 5,000 years ago, *Zea mays* – 'corn' (US English), 'maize' (UK English), 'el maíz' (Spanish) – has become one of the three most important staple food crops in the world. Yet nowhere is corn more deeply entwined with the social and economic fabric of a nation, or more genetically diverse than in its country of origin. Forty-one racial complexes and thousands of corn varieties are recognized in Mexico, forming a rich reservoir of genes for coping with drought and other adverse environmental conditions. Mexican corn producers already rely heavily on these adaptations for their survival, but the repository of genetic diversity can also play a crucial role in meeting the challenge of world food demand in the twenty-first century.

Chapter VII of the North American Free Trade Agreement (NAFTA) covered the agricultural sectors of Canada, Mexico and the United States of America. For Mexico, this meant opening-up its corn sector to imports, in exchange for guaranteed access to the Canadian and US markets for horticultural products and other labor-intensive crops where Mexico was thought to enjoy competitive advantages due to its labor surplus and lower costs.

From the Mexican viewpoint, corn was by far the most important crop included in NAFTA, accounting for approximately 60% of land under cultivation and a similar proportion of agricultural output by value, at the time of the final treaty negotiations. In terms of employment generation, corn is the single most important commodity in the economy providing the main source of livelihood for over three million producers, who account for 8 per cent of Mexico's population and 40 per cent of people working in the agricultural sector. Corn producers have a direct and significant impact on Mexico's natural resource base, especially in terms of soil conservation, aquifer use and chemical inputs. It is clear, therefore, that the inclusion of corn in NAFTA implied fundamental restructuring of the agricultural sector in Mexico, with wide-ranging social, economic and environmental consequences.

Characteristics of the Mexican corn sector

NAFTA negotiators viewed the Mexican corn sector as inefficient in comparison with yields derived from the US Corn Belt. However, their narrow economic concept of efficiency failed to take account of the following two important facts.

First, there are deep structural differences between corn producers in Mexico and those in the United States, which make it difficult to compare corn production in the two countries. Enormous disparities exist in labor/output coefficients; US corn is produced at roughly 40 per cent of the cost of production in Mexico; and average yields vary from 1.8 tons per hectare in Mexico to 8 tons per hectare in the United States. However, the difference in productivity may be significantly less when considering the 'external' social and environmental costs of capital intensive agricultural practices in the US. Furthermore, there is a great heterogeneity in Mexico's corn sector and poor producers with low yields coexist with more competitive farmers producing yields comparable to those found in the US.

Second, it is estimated that 60 per cent of Mexican producers (1.8 million) use locally adapted corn varieties, covering 80 per cent of the total area under corn cultivation. These producers are effectively custodians of genetic diversity, with careful selection of the varieties best suited to local growing conditions being the most important tool in their struggle to survive and remain productive. However, NAFTA negotiators failed to recognize the important role played by this part of Mexico’s corn sector in maintaining the country's genetic diversity, seeing these (inefficient) producers merely as a drain on the economy. As a result, it was considered desirable for this group of producers to move from corn production to cultivation of other crops, or to non-agricultural sectors of the economy.

Liberalization of the corn market under NAFTA

Because of the strategic importance of corn production in Mexico, NAFTA originally established a long transition period for the sector, allowing fifteen years for the final alignment of domestic corn prices with international (principally US) prices. At the beginning of the transition period, the existing tariff and import permit system was transformed into a tariff-rate quota (TRQ) regime that would gradually be phased out. During the fifteen year transition period, the tariff-free quota (initially set at 2.5 million tons per year) was to expand at a constant rate of 3% per annum, while the applicable *ad valorem* tariff for imports exceeding the quota would be reduced from 206% in 1994 to zero by 2008.

Mexican corn producers received assurances that adjustment-assistance policies would be implemented during the fifteen-year transition period, ranging from direct income support mechanisms to credit, infrastructure investments, and agricultural research and development. The price support mechanisms that had existed for the last forty years were to be replaced gradually by these non-trade distorting measures.

A key finding of this study is that the planned fifteen-year transition period was actually compressed to roughly thirty months. Between January 1994 and August 1996 domestic corn prices fell by 48%, thereby converging with the international market some 12 years earlier than provided for under NAFTA, and forcing Mexican corn producers into a rapid adjustment. This was because the Mexican government did not implement the tariff rate quota as planned, but instead exempted all corn imports from tariff payments after 1994, on the grounds of a need to lower prices and reduce inflationary pressures.

This abrupt and premature termination of the adjustment process took place against a background of declining state support for agriculture. The policy instruments supposed to assist transition rapidly lost most of their effectiveness. As a result of inflation, PROCAMPO, the mechanism for direct income support, lost 40% of its value in real terms. In addition, credit provision declined to extremely low levels and public investment in infrastructure was severely curtailed. Finally, the price regulation agency, CONASUPO, which was to have been gradually phased out, was completely dismantled in late 1998.

Projected and actual impacts of NAFTA on the Mexican corn sector

During the NAFTA negotiations, there was no in-depth analysis of how NAFTA was likely to affect the Mexican corn sector despite the strategic importance of the sector for Mexico's agricultural labor force and entire economy. Some rough estimates and general models were developed, but they were fundamentally flawed by lack of precision and rigor, unsound assumptions and a theoretical bias favoring trade liberalization. Not surprisingly, the predictions made by these models, which were developed more as a *post hoc* rationalization exercise than as a serious effort to examine implications of a major policy decision, turned out to be erroneous. The decision to liberalize the corn sector under NAFTA was based more on ideology than careful analysis of the facts.

The models predicted that Mexican corn output would decrease in response to a fall in domestic prices under NAFTA. It was asserted that this would release labor, land and capital for reallocation to more productive activities, utilizing Mexico's comparative advantage of abundant low-cost labor. Environmental benefits were also predicted since it was assumed that marginal land that is vulnerable to erosion would be left fallow.

Between 1994 and 1998, imports of cheap corn did lead to price reductions, and at a much faster rate than anticipated. However, the predicted drop in domestic corn output did not take place, with production remaining at historically high levels (about 18 million tons per year). At the same time the area under corn cultivation actually increased, implying a drop in average yield per hectare and suggesting that more marginal land was being cultivated under increasingly stressful conditions.

The fundamental flaw in the official pre-NAFTA studies was the assumption that only one variable, market price, would determine changes in the behavior of Mexican corn producers. However, producers' decisions are made in the light of many other factors, such as market prices for alternative crops, wage costs, and interest rates. In order to understand the impact of NAFTA, the behavior of corn producers has to be analyzed in the context of the wider economy, an approach that was taken in this study.

Environmental and social impacts of NAFTA-led liberalisation

Mexico's corn sector is characterized by a wide diversity of producers reflecting diverse environmental, social and economic circumstances. These factors are also closely interrelated with the genetic variation in corn from one area to another. The impact of liberalization under NAFTA on different groups of corn producers depends crucially on their ability to adjust to the resulting changes in price and associated government policies. The study identifies three broad categories of producers – 'competitive', 'intermediate' and 'subsistence' – and describes how each category of producer has responded to the need to undergo a rapid adjustment to the NAFTA-induced price changes, with a particular focus on the social and environmental impacts.

(1) Competitive producers enjoy profit margins that enable them to withstand the pressure of price reductions and face the challenge of competition from NAFTA-related corn imports. They have access to good soils, irrigation (or dependable high rainfall), input-intensive technologies, and well-established marketing channels. Most own larger-than-average land plots and have the flexibility to shift to other basic grains, horticultural crops or non-traditional commercial produce.

As corn prices dropped, so did most of the prices for possible substitute crops. Except for beans, cotton and soybean, other crops such as barley, rice, sorghum and wheat, maintained lower prices than corn, so that corn remained relatively more profitable. This was the reason

behind the decision of competitive producers to continue corn production (a decision reinforced by CONASUPO – the former state grain agency – concentrating its reduced purchasing power in regions where competitive producers were dominant).

It is also now clear that, in contrast to many pre-NAFTA predictions, labor-intensive horticultural crops cannot provide the 'economic space' for reallocating labor and land from the corn sector. For most horticultural crops, technological improvements have achieved significant growth in output without any need for additional labor or land. Furthermore, Mexico has probably already maximized its penetration of the North American market, in the face of strong competition from California, Florida and Central/South America.

Competitive corn producers use water, fertilizers, pesticides and mechanized traction. However, current levels of use of these inputs may prove to be unsustainable in the long run. In the case of water, for example, abstraction from many Mexican aquifers is already exceeding replenishment rates, and salinization and accumulation of chemical residues are widespread. On the other hand, new technologies in water management and irrigation, as well as in fertilizer application, may reduce these risks.

Transgenic corn seeds are already on the market in Mexico and are probably being used in the fields of the more productive farmers in the north west. The possible environmental impacts of this development are still being debated, but there are reasons to believe that use of genetically modified seeds may pose serious threats to some wild relatives of corn which are important gene repositories for domesticated varieties. Populations of these wild relatives are already declining at alarming rates and their vulnerability cannot be ignored. Exchange of genetic material with transgenic plants will almost certainly affect population dynamics.

(2) Intermediate producers had moderate profit margins before NAFTA entered into force. They normally operate under less favorable rain-fed conditions than competitive producers, although soil quality (in terms of depth and drainage) may be adequate. They may or may not have the ability to shift to other crops, and can only withstand the pressure of foreign competition through exceptional efforts.

For the time being, intermediate producers have remained strong market participants and continue to engage in corn production. The relative price structure of agricultural products affected them in more or less the same way as described for competitive producers. However, in comparison to competitive producers, they have encountered more difficulties because of their narrow profit margins and are now operating under more stressful conditions. Fieldwork undertaken for the present study shows that intermediate producers may have to choose between abandoning production or maintaining output under increasingly stressful conditions. Because of a lack of viable opportunities in other sectors of the economy, however, abandoning corn production has not been an attractive strategy to date. Many producers have maintained production only out of desperation, basically to satisfy household needs and perhaps to sell a modest surplus.

The economic pressure on intermediate producers means that they have been forced to cut direct monetary costs, notably through a reduction in hired labor. This in turn leads to fewer employment opportunities for, and strong migration pressures on poorer subsistence producers struggling to find off-farm sources of income. At the same time, cutting the work force may have detrimental effects on corn yields because key labor-intensive operations have to be scaled back. There is also likely to be a reduction in capacity to maintain soil conservation structures and practices (e.g. use of terracing, hedging, groundcover crops, mulching, minimum tillage, ridge planting and alley cropping). Whilst such measures are of great importance in combating land degradation, they involve considerable costs, attract no official support and consequently remain outside the scope of most intermediate producers. In some cases, field maintenance and soil conservation work has traditionally been carried out

through community involvement, but migration and poverty are eroding the structure of communities.

It is too early to be certain how intermediate producers will respond to the pressures of falling prices and rising costs. They may remain in the corn sector, effectively becoming subsistence producers, or they may abandon the corn sector and migrate in order to find alternative sources of income. Evidence suggests nonetheless that a number of mid-sized growers have been forced out of the corn market.

(3) Subsistence producers constitute 40 per cent of all Mexican corn producers and operate under difficult conditions of inferior soil, sloping terrain, irregular rainfall, and small landholdings. Production is for family consumption only and there is no surplus to sell, meaning that basic household costs have to be met through off-farm employment. Poor soil quality means that there is usually no possibility of converting to other crops.

Counter-intuitively, the response of subsistence farmers to NAFTA-induced price reductions has been to maintain and even expand the area of corn cultivation. Strong inflationary pressures mean that rural wages have fallen considerably since 1994, whilst employment generation has lagged behind mediocre growth in GDP. Corn production has therefore remained a crucial element in the survival strategies of poorer farmers. Quite simply, it is cheaper to grow corn for household consumption than to buy corn products at the local market. This is because market imperfections and the monopolistic behavior of cartels that control the tortilla industry have prevented the 50 per cent cut in corn prices being passed onto consumers of corn products.

Much of the literature justifying the inclusion of corn in NAFTA explicitly adopted the assumption that subsistence producers would not be affected by price reductions because they do not sell any of their produce. This assumption failed to recognize the importance of the wider economic context, within which subsistence producers must obtain sufficient income to cover basic household needs. This income has to be derived from off-farm activities or through petty corn sales between harvests. Deriving income from petty corn sales is problematic as subsistence farmers are often forced to sell in a buyers' market, immediately after harvest when supply is greatest and prices are low. Conversely, when purchasing corn to restore family provisions, they often face a sellers’ market as prices tend to be higher in the long periods between harvests. Thus, their net income from petty corn sales is often negative, but this practice is necessary to meet short-term needs for cash.

The stressful conditions under which subsistence growers operate are having critical effects on the social and environmental fabric of Mexico, with migration being one of the most important issues. Recent research shows that the probability of migration in areas where corn production is carried out in small plots, with local varieties, and where poverty is pervasive, is higher than in other areas. Social institutions that play a key role in resource management tend to deteriorate under the combined pressure of poverty and migration. For example, migration negatively affects the ability of communities to take important collective action that is frequently required at times of planting or harvest. This often translates into adverse environmental impacts, including deforestation, soil erosion and lower capacity to manage genetic resources (for instance, signs of carelessness in seed selection are already appearing in several key regions). The study argues that the process of genetic erosion mediated through the disappearance of the institutional and social base is one of the major threats to Mexico's corn growers and their capacity to improve their livelihoods.

In the latter respect, the inclusion of corn in NAFTA is also a clear example of how trade liberalization planned with a short-term view can have long-term negative impacts. Global demand for corn is projected to rise rapidly in coming decades with the bulk of new demand arising in tropical countries. Exploiting the potential of Mexico’s genetic resources may play

a decisive role in satisfying this demand. The present study provides ample justification for continuing to support Mexican corn producers in order to ensure the development and *in situ* conservation of local varieties.

Introduction

a) Overview of the Mexican corn sector and its inclusion in NAFTA

Nowhere in the world is corn so intimately related to the social and cultural fabric of a country as in Mexico. It is now established that corn is a domesticated form of the wild Mexican grass 'teosinte' (*Zea mays parviglumis* or *Z. m. mexicana*). Archaeological evidence places the time of corn domestication between 5,000 and 10,000 BC.[i] Domestication took place in four centres, two of which are located in the central Mexican highlands (McClintock, 1977; Lothrop, 1994). Mexico is not only the centre of corn's origin; it is also the centre of its genetic variability (Wilkes and Goodman, 1995; Hernández Xolocotzi, 1987). Domestication and distribution of races and varieties took place throughout Mexico in a complex process interwoven with historical events.

Belonging to the grass family (*Gramineae*), corn is endowed with a formidable capacity to adapt to a wide range of temperatures, altitudes and rainfall regimes. For example, average growing season temperatures can exceed 26° C or be as low as 12.5^{o} C. Consequently, corn is cultivated in latitudes varying from the equator to more than 50 degrees north or south and from sea level to 4,000 m altitude. The 'ears', sheathed in leaves, are themselves examples of the wide genetic variability of corn plants, varying from less than 7 cm to more than 45 cm in length. The kernels are arranged in rows along the corn cob, with the number of rows varying from eight to more than 36. The kernels also vary widely in shape, composition (starch and sugar content), and hardness of the pericarp (the skin covering each grain to protect it from humidity and pests, and which allows corn to be stored prior to consumption).

Corn is grown in fully irrigated land, as well as semi-arid conditions, with the growth cycle varying from 3 to 12 months. Height variations are also considerable, with dwarf varieties not exceeding 65 cm, while other groups exceed 3 m or even 5 m. On average, however, the height of corn plants is approximately 2.5 to 3 m, with the alternating leaves which grow from the plant's solid stem changing from deep to light green. Finally, corn is well adapted to both acid and alkaline soils, to different soil structures and textures (ranging from sandy to clay-rich). The capacity of corn to adapt to the multitude of environmental conditions goes hand-in-hand with its genetic variability.

This means that genetic – environment interactions are more intense in the case of corn than for other basic grains (wheat, rice, barley or sorghum). The diversity of Mexico's environment and ecological niches has favoured diversification and 41 racial complexes, and thousands of varieties, are now recognized (Ortega Paczka, 1997).

The genetic variability of corn is probably the most important instrument at the command of Mexico's corn growers. But their production methods have often been branded by policy-makers as 'inefficient', when production costs in Mexico are compared with international (mainly US) costs. It is also claimed that subsidies required to maintain this production represent a significant share of public expenditures that could be better employed elsewhere. This comparison essentially relies on the difference between average yields: approximately 7.5 tons per hectare per year (t/ha/yr) in the US versus 2.0 t/ha/yr in Mexico. However, this does not take into consideration the fact that Mexican corn is grown in extremely different conditions from those in the US.

Corn varieties used in the United States are modern, technology-intensive hybrids, some of which have been genetically manipulated. In some modern, irrigated Mexican farms, yields are comparable with the US figures. But in rain-fed areas, yields are approximately 1.7 t/ha.

Rain-fed land accounts for more than 80% of the total area of corn cultivation in Mexico and is frequently difficult to cultivate (e.g. due to steep slopes, poor soil or adverse climate).

For economically poor producers, facing the added challenge of a difficult growing environment, the genetic variability of corn is crucial for reducing the risk of total crop failure. Every year, these producers select the seeds to be used for the next harvest, thus acting as curators of genetic resources that will be of strategic importance for global corn production in the 21st century (when the greatest demand will be in tropical countries).

The inclusion of corn in the North American Free Trade Agreement (NAFTA) was a fundamental decision for Mexico. Corn accounts for approximately 60% of cultivated land, and roughly the same percentage of total agricultural production in terms of monetary value. Although the share of total GDP generated by agriculture has dropped from 15% in 1960 to less than 7% in 1998, the sector still accounts for more than 22% of the total labour force, mostly in corn production. Corn is also the main component of Mexicans' staple diet.[ii]

Trade liberalization in the Mexican corn sector was hailed by government officials as the key to NAFTA. By agreeing to take this crucial decision, Mexico opened its major market for corn products to exports from the United States, with a view to restructuring its agricultural sector towards more labour-intensive but profitable crops. In return, it was maintained that the United States and Canada would open their markets for horticultural crops, where Mexico was considered to enjoy a comparative advantage due to the availability of abundant cheap labour (see Chapter 1, Assumption 4, page 19).[iii]

On one hand, the NAFTA negotiations were held without adequate representation of corn producers who were excluded from the process leading to final agreement. On the other hand, industrialists who use corn to manufacture flour, packaged foods, and feed for cattle and poultry, were actively involved. This inevitably led to a perception of bias.

The negotiations were further influenced by the notion that Mexico's comparative advantages were to be found in labour-intensive activities such as horticultural production. It was argued that the existing agricultural system was not only sapping the country's fiscal reserves through subsidies to small-scale corn producers, but also preventing realization of the country's comparative advantage. For the Mexican government, the rationale for NAFTA was to reallocate these producers to cultivation of more labour-intensive crops or employment in other economic sectors. The present research shows, however, that the comparative advantages were superficially assessed and turned out to be unreal. In fact, Mexico's access to the North American market for horticultural crops has already reached its upper limit, and further expansion is unlikely.

For a third consecutive year, the agricultural sector in Mexico experienced negative growth rates in 1998. Inflation has also regained strength in 1998, and was especially intense for basic products such as tortillas, milk, beans, poultry and eggs. The prices of key agricultural inputs have all increased significantly, and so have corn imports, peaking in 1996 at an all-time high of 5.9 million tons. Prices began falling in the second half of the 1980s, but the trend accelerated after NAFTA entered into force. Public subsidies for the corn production sector have continued to drop, and the timetable for full liberalization has been dramatically shortened.

b) Objectives and structure of the present research paper

This study examines the social and environmental impacts of economic liberalization in the corn sector from two perspectives.

First, trade and economic liberalization in the corn sector is examined in the wider context of macroeconomic policy. Without this more general approach, analysis of the impact of trade liberalization would be incomplete, possibly resulting in erroneous conclusions, especially in terms of future policy development. Many studies in the trade and environment literature focus on trade liberalization as an isolated mechanism somehow disconnected from other elements of economic policy. These studies fail to grasp the full impact of the forces unleashed by implementing an economic model of which trade liberalization is but one component. Trade liberalization in the corn sector is part of a policy mix which, in Mexico, included elements such as fiscal balance, anti-inflationary monetary policies, exchange rate management, deregulation of the financial/banking sector, large-scale privatization, and deregulation of markets for agricultural inputs (e.g. fertilizers, pesticides, seeds). Failure to recognize the combined effect of these policies leads to serious misunderstanding of the process of economic restructuring underlying trade liberalization.

Secondly, the social and environmental effects of trade liberalization are analysed together. This is in contrast to many other studies, which artificially separate them The starting point for the present analysis is that social and environmental issues are part of a complex matrix of interdependencies at the household and community levels. The capacity of an individual household to manage corn production has an impact on the natural resources at that family's disposal. This is reflected cumulatively at the community level in terms of ability to influence the surrounding landscape and to maintain sustainable production.

This study is divided into six chapters. The first chapter examines the role and position of NAFTA in Mexico's overall economic strategy, covering the relations between trade liberalization and macroeconomic policies, including interest rate variations and exchange rate policy. The chapter also critically reviews the strategic objectives pursued through inclusion of Mexico's corn sector in NAFTA, and the assumptions regarding their viability.

The second chapter examines the five-year record of NAFTA implementation, focusing not only on NAFTA itself, but also on the accompanying instruments applied in the transition towards full implementation. Key issues include the truncated transition period (from that originally foreseen) and the incorrect prediction that lower corn prices would lead to reductions in total corn production and surface area under corn cultivation.

The third chapter focuses on the structure of the corn sector in Mexico. The analysis is based on data describing technology profiles, social characteristics of producers, resource endowment and profitability levels. This analysis sets the stage for a more detailed study of the impact of trade liberalization at regional and household levels, and helps explain how different categories of corn growers are reacting to the changing conditions brought about by NAFTA.

Chapter four examines fieldwork carried out at the household level in seven different regions. The survey examines how households have redefined their production strategies in response to trade liberalization, and assesses the social and environmental consequences. Three categories of producers are defined in terms of level of profit from corn production, and resource endowment (which may or may not enable them to increase competitiveness or seek alternatives). Although the analysis was carried out at sub-regional level, data are frequently aggregated to provide a regional overview.

The fifth chapter concentrates on three environmental and social issues of prime importance for the future of Mexico's corn sector: migration, soil erosion and genetic diversity. Consideration is given to how migration, triggered by the income and price effects arising from trade liberalization, contributes to soil erosion and influences soil conservation practices. Maintenance of genetic diversity – a cornerstone of traditional corn production strategies – is

also at risk as a result of the extraordinary economic pressure threatening the future of small corn producers.

The final chapter presents policy recommendations aimed at fostering sustainable development and environmental stewardship in Mexico's agricultural sector.

1. Trade liberalization in the corn sector under NAFTA

This chapter examines the role and position of trade liberalization in the corn sector in relation to the broader Mexican economic context.

1.1 Trade liberalization and corn: the complete economic model

The Mexican economy began a process of structural adjustment more than twelve years ago. An important part of this process is related to trade liberalization. This is not surprising as the 1982 economic crisis and its aftermath were seen by many as the terminal phase of a system based on import substitution and protectionist barriers. This model was held responsible for causing inflation, external and domestic imbalances, welfare reductions, and interrupting the process of economic growth. A firm conviction emerged in official circles that a new economic model was needed in Mexico.

The new economic model which emerged in 1986 went beyond deregulation of international trade flows: it also included a set of monetary and fiscal policies in addition to those targeting exchange and interest rates. Deregulating the financial sector was also essential. In fact, transforming the Mexican economy into an open economy was seen as a venture that relied on both macroeconomic policies and institutional reform such as large-scale privatization and deregulation. Not all of these measures were introduced at the same time or with the same degree of coverage.

The strategic policy objectives of the new open economy model that began to emerge in 1986 were:

- internal equilibrium of key macroeconomic variables (price stability and balance in public finances);
- balance of external accounts (trade and current accounts);
- improvements in welfare;
- sustained growth at the highest historical rates (at least 6% per annum).

In this new model, monetary policy played a critical role in the opening of the economy and was a key instrument for attaining price stability. It was also going to be accompanied by the deregulation of the financial sector. The main instrument for the adjustment of external imbalances emanating from trade deficits was to be through relative prices (i.e. exchange rate adjustments). In order to avoid distortions in interest rates, public deficits would have to be maintained at a very low level. In fact, balanced budgets appeared to be a desirable policy objective and stringent fiscal discipline was imposed.

In this context, opening the economy became a cornerstone of the new policy package: it was an instrument that could be used for several objectives at the same time. Trade liberalization would help fight inflation due to economic pressure brought about by cheaper imports. It would also help achieve economic restructuring through the reallocation of productive resources in accordance with the economy's comparative advantages. In some cases, such as the corn sector, opening the economy would also ease pressure on public finances as subsidies would be reduced.

Healthy and balanced budget policies implied stringent fiscal discipline and the diminution of subsidies and transfer payments. The latter ran against two of the critical objectives of the

new model: on one hand, their weight in the Federal budget hampered the government's ability to attain healthy fiscal policies. On the other hand they distorted relative prices and prevented the emergence of Mexico's true comparative advantages.

The central idea behind the new economic model was that markets allocate resources more efficiently than any other mechanism. As in the pre-Keynesian days, the supporters of this model held that any costs during the adjustment process would be absorbed by a growing economy. Social dislocation would lead only to frictional unemployment during the transition period. Social safety nets for those that would lose during the adjustment process would focus on the needy.

Evidence shows that four strategic objectives pursued during the period 1986-1994 were never attained: (1) inflation was not curtailed on a sustainable basis; (2) public finance became more distorted and was over-dependent on oil revenues; (3) the deficit in Mexico's external accounts became unsustainable; (4) indicators of social welfare worsened as Mexico's population became more impoverished. GDP growth rates for the period showed a mediocre performance, with an average 1.8% for the period 1986-1994. This growth rate corresponds in reality to a semi-stagnant economy. As a result, the dramatic drop in GDP during the 1982-1988 period could not be corrected. In fact, continuous marginal drops in per capita GDP between 1994-1999 further aggravated the already serious situation that had been inherited from the eighties.

The contradictions inherent to this model led to the crisis of December 1994. This was presented as a financial and exchange rate crisis, but proved that there were structural problems involved in the implementation of the new economic model.[iv]

A good example of how the new economic model has failed to perform adequately is related to the struggle against inflation. Although a significant reduction in inflation rates was attained during 1989-1994, this relied on an overvalued exchange rate, and a rapid and non-selective opening of the economy which forced domestic prices down because of international competition. The containment of real wages (minimum wage expansion was systematically indexed on expected inflation rates that were always below actual inflation rates) was a further important factor. This combination of policy instruments led to temporary price stabilization, but to an increasing deficit in the trade balance and a contraction of the domestic market, putting at a disadvantage small and medium-size businesses producing for the national market. As the external imbalance intensified, it became clear that exchange rate adjustment could not be postponed indefinitely. However, this would be in contradiction to exchange rate stability, which was needed to attract foreign investment in order to finance the external current account deficit.

By 1994, the incompatibility of different policy instruments led to a critical situation on both external and domestic fronts. Eventually, the current account deficit appeared to be unsustainable, capital flows were reversed, and the December 1994 crisis was triggered. In the aftermath of this crisis and the ensuing stabilization programme, inflation reached 52 percent and interest rates experienced extraordinary hikes (which in turn led to the bankruptcy of the banking system). GDP dropped by more than 6% taking Mexico into its most severe recession since the 1930's.[v]

This brief analysis shows that trade liberalization occupies a key position in the new economic model, but that it is not the only policy objective. Figure 1.1 shows that it is part of an overall strategy made up of different macroeconomic policy objectives and instruments. The objectives of 'free trade' are usually presented in terms of welfare and efficiency gains, as price distortions disappear and comparative advantages gain the upper hand. However, as is now clear in the case of the Mexican corn sector, these objectives are subordinated to other, more powerful factors: the elimination of subsidies has a greater weight in the complete

model as it is related to the strategic goals of less state intervention in the economy, no deficit, and less pressure on capital markets and on interest rates.[vi] Figure 1.1 also makes an explicit reference to the incentives that deregulation of the financial sphere created for speculative investments.

Trade liberalization in the corn sector occupies the centre of the diagram, but the arrows symbolize the fact that the model's original objectives have not been attained, and that there were other negative results. Some of these negative results have interacted (as shown by the blue arrows between the overvalued exchange rate and the trade deficit), which is why the transition period, originally conceived for fifteen years, has been truncated. This also explains why calendars and resources allocated to the sector during the adjustment process have been drastically reduced. Finally, it shows that other powerful economic forces come into play and influence production decisions and resource management capabilities of corn producers.

1.2 Corn in NAFTA: strategic objectives and underlying assumptions

NAFTA is a critical part of a strategy directed towards a major restructuring of Mexican agriculture. It is therefore important to understand the basic assumptions and strategic objectives of agricultural trade liberalization under NAFTA.

According to various studies and official documents, the structure of agricultural trade that would emerge from NAFTA was linked to crop liberalization in Mexico and horticultural reform in the United States. In other words the United States would increase its exports of grain, oil seed, and meat products that are land and capital intensive. It would also increase exports of certain fruits that are better produced in northern latitudes (Hufbauer and Schott 1993:47; de Janvry 1996:6).

Mexico would increase its exports of products where it was considered to enjoy significant comparative advantages. These products are labour intensive vegetables, fruits and nuts, as well as coffee and tropical fruits. In the process, rural population would be drastically reduced (Tellez 1992) and a major reallocation of labour, land and capital towards more profitable employment would take place. NAFTA is thus part of a multi-faceted effort to bring about a restructuring of Mexico's agriculture on a truly large scale.

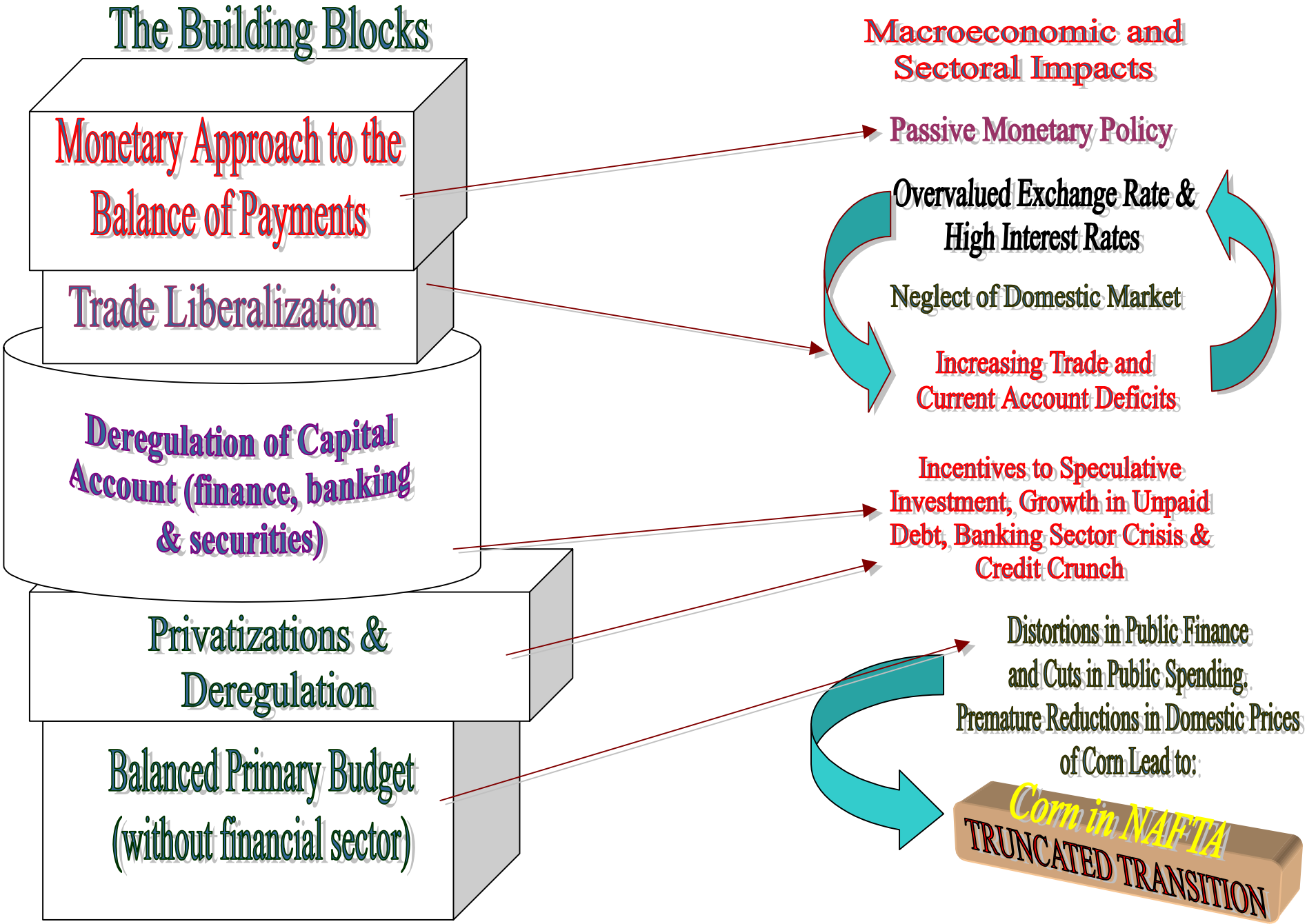
It is important to note that the corn varieties produced in the United States and in Mexico are not strictly the same commodity. The US is the largest producer of yellow corn, normally used as animal feed. On the other hand, Mexico is one of the largest producers of white corn varieties that have a finer texture and higher flour content, making them more suitable for direct human consumption. White corn prices are, on average, 25% above the prices for yellow corn. This additional price differential should be borne in mind when analysing NAFTA's corn regime.

Key strategic objectives pursued through the inclusion of corn in NAFTA were the following:

- NAFTA provided an ideal opportunity to pursue policy objectives focusing on efficiency gains at both consumer and producer levels;
- The bias towards more labour-intensive activities would generate more employment opportunities and access to comparative advantages;
- Cheaper imports would help reduce inflationary pressures;
- The trend to align domestic and international prices would further reduce the need for subsidies, relieving pressure on fiscal policies;
- The reallocation of productive resources towards more labour-intensive crops, as well as other non-traditional and commercial crops (sugar cane) and land use patterns (forestry and livestock), would also relieve pressure on marginal lands.

The feasibility of these objectives rested upon a set of fundamental assumptions (listed below) about the structure of Mexico's agricultural sector. These assumptions are related to the performance of the Mexican economy, mobility in the agricultural sector, natural resource endowment, and the size of international markets for agricultural products. They also depend upon the incentive effects of relative prices in the agriculture sector and in the wider economy. Relative price changes influence producers' decisions and strategies, the duration of the transition period, and the capacity of public expenditure to allocate adequate resources for producers to adjust during the transition period.

It is important to note that this set of assumptions led policy-makers to anticipate that the negative social and environmental impacts of trade liberalization under NAFTA would be minimal. If the assumptions proved to be correct, unemployment, poverty and large-scale migration would be avoided. Conversely, if the assumptions were groundless, the feasibility studies carried out would be of little value.


The Building Blocks
Monetary Approach to the Balance of Payments
Trade Liberalization
Deregulation of Capital Account (finance, banking & securities)
Privatizations & Deregulation
Balanced Primary Budget (without financial sector)
Macroeconomic and Sectoral Impacts
Passive Monetary Policy
Overvalued Exchange Rate & High Interest Rates
Neglect of Domestic Market
Increasing Trade and Current Account Deficits
Incentives to Speculative Investment, Growth in Unpaid Debt, Banking Sector Crisis & Credit Crunch
Distortions in Public Finance and Cuts in Public Spending.
Premature Reductions in Domestic Prices of Corn Lead to:
Corn in NAFTA
TRUNCATED TRANSITION

Box 1.1

The Levy-van Wijnbergen Studies

By far the most detailed calculations on resource reallocation following trade liberalization are found in Levy and van Winjbergen (1992). In another study (Levy and van Winjbergen 1995), the authors elaborate on the need to carry out a gradual transition using a general equilibrium model.

Levy and van Wijnbergen first estimate the total rural labour force. Using econometric estimates of aggregate supply elasticities for maize under irrigated and rain-fed regimes, and assuming a 50% NAFTA-induced price reduction, they calculate the land and labour released from maize cultivation. These calculations are based on average yields and land to labour ratio by types of crops.

Levy and van Wijnbergen then calculate average labour requirements on non-maize irrigated land and estimate the increase in non-maize employment. They assume 30% of the released land under irrigation would be reallocated for other grain crops, 30% for fruit and vegetables, and 30% for cotton, tobacco and other crops.[vii] Half of the released rain-fed land would be devoted to pasture, with the remaining half equally divided between other grains and other crops (but not fruits and vegetables).[viii] Under these conditions, non-maize production on rain-fed land would require 29.6 million worker-days and there would be a net release of 26.13 million worker-days which translate into 145,000 workers. This is a small number relative to total rural labour force (approximately 6 million workers).

Two central problems affect the estimates in the 1992 study. First, the data is unreliable: the numbers are outdated, from different sources and various years. Second, the analysis is based on a partial equilibrium approach, assuming corn prices are the only independent variable conditioning all output decisions by corn producers. This largely explains why key predictions in the Levy-van Wijnbergen model did not materialize.

These assumptions were explicitly included in the most important studies used to justify the inclusion of corn in NAFTA (Levy and van Winjbergen 1992 & 1995, see Box 1.1 below; de Janvry, Gordillo and Sadoulet 1997; de Janvry *et al.* 1995a and 1995b), as well as in official rhetoric concerning the trade agreement (see Téllez 1992).

Assumption 1: Frictionless resource reallocation through lower corn prices

NAFTA was considered an ideal opportunity to focus on efficiency gains at both the consumer and producer levels. To attain these efficiency gains, resource reallocation would be induced by price signals. At the producer level, NAFTA would provide freer entrance into the United States market for agricultural products in which Mexico enjoyed a comparative advantage of labour availability, facilitating the transition away from subsistence maize production.

The process through which productive resources (land, labour and capital) would be reallocated to more competitive crops is seen as ‘frictionless’, i.e. producers read market signals correctly and re-orient their activities to more profitable activities where they enjoy competitive advantages.

The simplistic assumption of frictionless adjustment is only one part of the problem. Corn producers do not take decisions regarding quantity of corn to be produced solely on the basis of the price of corn. Their supply function includes many other elements, especially the cost of their labour force, as well as the relative prices of other crops. The Levy and Wijnbergen 1992 study is based on a partial equilibrium approach “mostly because of the forbidding data requirements for a full-fledged general equilibrium model” (Ibid.:482).[ix]

All of the studies used to assess the impact of NAFTA on corn production fail to acknowledge cross price elasticities. Hence, they cannot explain why, in the case of Mexico, the fall in corn prices

coexists with the stability in overall corn output, not to mention the expansion of production in several states (see Table 3.5, Chapter 3).

Assumption 2: Investment in public works to ensure smooth adjustment period.

It was assumed that an adequate flow of public resources would facilitate a smooth transition to greater efficiency in Mexican agriculture, especially in the corn sector. Levy and van Wijnbergen (1995) emphasize the need for an adequate level of public investment to be injected gradually during the transition period. This would help transform rain-fed land into irrigated land and was seen as a means of countering the negative wealth effects brought about by reduced prices. It was recognized that the assets of maize producers operating on rain-fed land would decline in value due to the fall in price of their outputs. In order to compensate this loss, public investment to transform the land to irrigation would be needed.

The general equilibrium model in the Levy-van Wijnbergen study (1995) went as far as to quantify the amount of public investments required. For the first five years of the transition period (with a gradual elimination of tariffs and subsidies), the study established that $16 billion (constant 1989) pesos would be required. This amount of investment would allow for irrigation of approximately 8% of the total land resource and improve the productivity of corn producers' assets.

However, the gradual approach recommended by Levy-van Wijnbergen in their study was not followed. The transition period established under NAFTA was accelerated and the 1995 economic crisis made it impossible to allocate fiscal resources in the amounts required. Thus, public investment in irrigation infrastructure has remained stagnant, while technical assistance and research and development in the agricultural sector are at an all time low. Official credit at subsidized rates has almost disappeared and the crop insurance system has ceased operating except in the most profitable cases.

Assumption 3: Neutral technical change

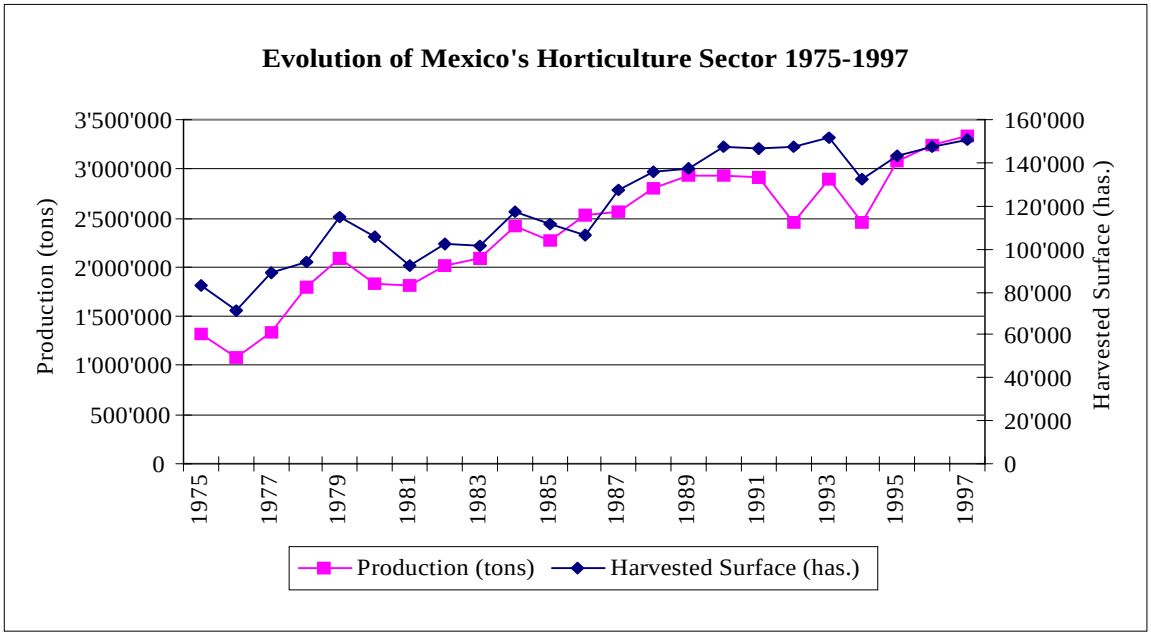
All of the studies on NAFTA's impact on agriculture assumed a static model in which technical change does not involve factor substitution. Even in terms of conventional (neoclassical) economic theory, this seems unacceptable.[x] Available data confirm that mechanized production has been increasing for crops identified as more labour intensive (e.g. horticultural products). The assumption of neutral technical progress is unrealistic and should not have been a reference for policy making in this sector.[xi]

There are other reasons why the horticultural sector may tend to absorb less labour in the future. The use of better fertilizers, pesticides, and varieties giving greater yields, suggest that there may be important productivity gains without significant employment expansion. Figure 1.2 shows that in a period of more than twenty years, production of Mexico's eight most important horticulture crops maintained an upward trend, going from 1.2 million tons in 1975, to 3.2 million tons in 1997. During the same period, cultivated surface area rose from 82,000 hectares to 151,000 ha for those same crops. Whilst total output increased at an average yearly rate of 8%, cultivated surface increased by a rate of only 4% per year.

Output increases have been more related to technical progress (such as greater quality inputs and better management practices) than to expansion in the area of cultivation. Horticultural employment increases as harvesting and packaging take place at greater scales. However, as scale increases, so do possibilities for capital-intensive technical progress in the form of greater mechanization. As a consequence, the employment generation effect is reduced.

There is a similar situation in the fruit sector. Figure1.3 shows that since 1975, total output increased from 1.6 million tons to 8 million tons in 1997. The average yearly growth rate was 11% during this period. Meanwhile, the area under cultivation rose from 160,000 to 600,000 hectares, representing an average annual growth rate of 7.5%, significantly below the growth in output.

Figure 1.2



Source: Author's calculations with data from Centro de Estadística Agropecuaria (SAGAR).

Yields have increased significantly, going from 10 t/ha to 13 t/ha for the entire period, but much of this increment comes from greater productivity in the last decade. The curve showing area under cultivation also appears to level off during the period immediately after NAFTA came into existence.

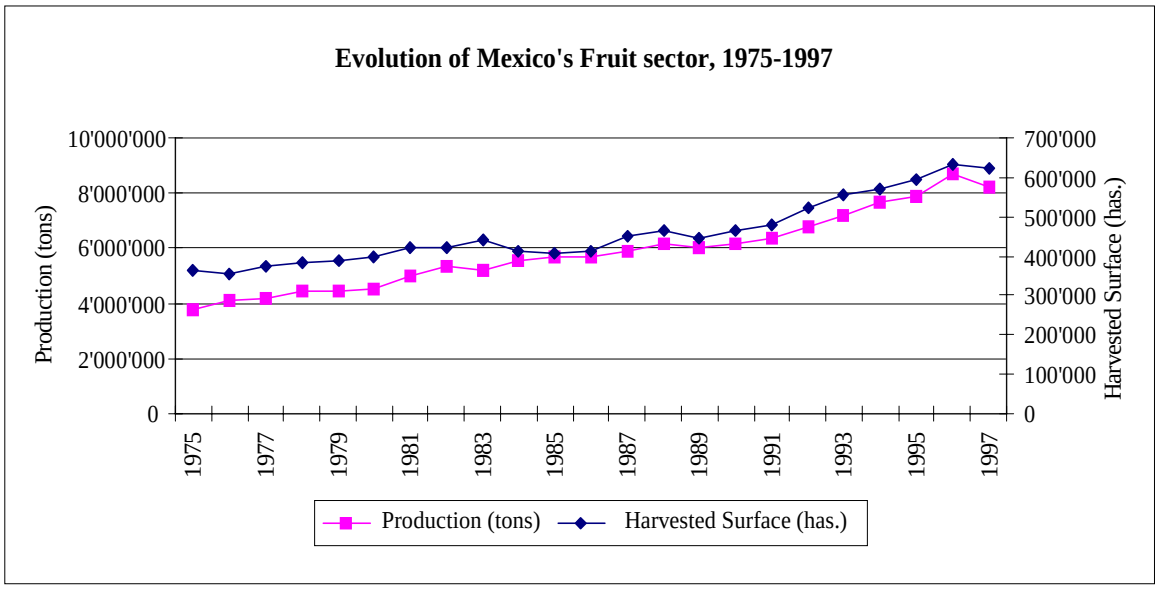
Even though horticulture and fruit production are more labour-intensive than corn and other basic grains, more efficient use of inputs has led to greater productivity and higher yields. It is therefore not realistic to rely on horticulture and fruit growing to generate enough new employment for absorbing the labour force that theoretically would be displaced from corn production as a result of trade liberalization. A similar pattern can be identified in the production of flowers for the export market (see Lara Flores 1999).

Recent research (Málaga and Williams 1999) shows that wage differentials and tariff reductions will not be the main factors explaining expansion of shares in the US market. The authors use an econometric model to identify the factors that may explain the expansion of Mexico's exports to the United States. The main result is that without significant improvements in productivity as a result of technological change, Mexico's exports will not make significant inroads in the US market. The expansion of cultivated area alone will, therefore, not be the critical variable in the development of export-oriented crops.

In the case of tomato production in north-west Mexico, recent research shows that greater reliance on chemical inputs (fertilizers and pesticides) and genetically modified seeds has been accompanied by a fall in the cost of labour as a proportion of overall costs. Harvesting time has been cut by more than 60% (Grammont, H. 1999:14).

Finally, Mexico's comparative advantage cannot be explained simply by labour intensity in the harvesting of horticulture and fruits, as posited by many analysts during the NAFTA debate. Although the cost differential between Mexican and US producers is significant, with Mexican harvesting wages up to three times lower than those in the US, this advantage is attenuated if cost differentials in processing, packaging and transportation are factored in (see Gomez Cruz and Schwentesius Rindermann 1993).

Figure 1.3



Source: Author's calculations with data from Centro de Estadística Agropecuaria (SAGAR).

Assumption 4: Unlimited expansion possibilities for Mexico's share of the North American horticulture market

There are three additional elements related to Mexico's share in the US market of horticultural products. One is that Mexico already accounts for more than 60% of total horticultural imports to the US, although this represents less than 2% of that market. The Mexican share is limited by external competition (Europe, Central American countries) and by the fact that domestic producers are able to supply the market for much of the year. In summer, Mexican exports fall with sales to the US market restricted to a few niche crops. Competition is driven less by labour costs than by seasonal factors.

Finally, producers in California, Texas and Florida are introducing various forms of technical progress that will enable them to expand their capacity to supply the US market even in winter. For example, the use of bio-engineered tomatoes allows producers to conserve frozen produce, to be matured for the winter market.

It seems therefore that doubling the area of horticultural cultivation in Mexico remains an elusive goal.

Assumption 5: Automatic crop substitution and reallocation

An important point to consider is the overall effect of NAFTA-related trade liberalization on crop substitution in the wider agricultural sector. This is important because changes in land-use patterns depend critically on the way in which NAFTA affects other crops. Maize was not the only basic grain to be the object of trade liberalization. Trade in sorghum, for example, a key substitute crop, was also deregulated and this led to significant price reductions, thus reducing possibilities for conversion to this crop.

In the case of sugarcane, the promise of expansion in production and access to the giant North American sugar market was considered a key benefit for Mexico under NAFTA. However, attainment of this objective was blocked by the designation of high fructose from corn syrup (HFCS) as a 'sweetener' under NAFTA definitions. This change was introduced after the agreement had been ratified by Mexico and constituted a key concession to ensure ratification by the US Congress. Once HFCS was included in NAFTA as a sweetener, Mexico became a country with a technical sugar deficit. Because access to the US sugar market continued to be limited to countries with a sugar surplus, Mexico lost the chance to gain a better position in the North American market and sugarcane is not an option for maize producers.

As far as other non-traditional export crops (such as coffee, cocoa, palm tree products, flowers) are concerned, it remains to be seen if they offer the potential for reabsorbing the land and labour theoretically to be released from maize production. Although it can be argued that Mexico can expand its exports of such crops, a more detailed analysis is required. The example of sugar cane demonstrates that reallocation of resources is determined not only by technical requirements (soil characteristics, water availability, etc.), but also institutional ones.

Assumption 6: Subsistence producers are not affected by lower prices

The assumption is that subsistence producers are not affected by NAFTA-induced lower corn prices because they do not generate marketable surpluses. This view ignores the fact that subsistence households are part of a market economy where monetary flows are required. Alternative sources of income are important. Besides, the vast majority of these producers sell small amounts of their production throughout the year in order to meet short- term liquidity needs. They then have to replace their original stocks in order to ensure family subsistence.

In this context, it is important to observe that real wages have maintained a decreasing trend for several years. As Levy and Wijnbergen conclude, rural wages would be forced down as a result of the declining trend in corn prices. Thus, subsistence workers will find themselves under additional pressure in seeking sufficient off-farm income.

Assumption 7: Lower tortilla prices

It was assumed that cheaper corn imports would lead to lower final consumer prices. Tortillas would sell at a lower price and consumer welfare would increase. The increase in consumer welfare would take place at all levels of rural and urban populations. It would also have the effect of relieving costly programmes to subsidize consumers, a key problem in public finance. It was argued that providing price support systems for poor and inefficient maize producers artificially raised the price of the final product.

This assumption does not take into consideration that tortilla, as well as many corn-related markets (flour, dough), are segmented and very imperfect markets. This is the case in Mexico where, in spite of liberalization, an increase in cheap corn imports and a resulting fall in the domestic price of corn, the price of tortillas has actually risen (see Chapter 2, section 2.8).

Assumption 8: Adequate performance of the Mexican economy and employment generation.

A final critical assumption of NAFTA is that displaced labourers will be able to find adequate employment opportunities, either in the rural sector or in the urban markets. In all computable general equilibrium (CGE) models used to estimate the effects of NAFTA, the assumption of full employment was introduced. This overlooks: (a) the existing deficit in jobs, (b) serious rural unemployment, and (c) the evolution of real wages in both rural and urban sectors.

It was argued that the social dislocation following trade liberalization in the corn sector would be mitigated through the action of the same market forces. In the first place, the number of workers released would be comparatively small (the total labour force for 1989 was 6 million workers). The fall in the rural wage rate would generate employment in maize and vegetable production until excess labour was eliminated, thus resulting in rural market equilibrium. A significant proportion of the released labour would be reabsorbed through direct interventions such as investment in public works for irrigation (in fact, such investment did not occur – see Assumption 2). Final equilibrium would be restored through migration.

1.3 Summary and conclusions

1. Trade liberalization in the agricultural sector – especially in relation to corn – has been a critical component of an overall strategy of economic reform. The Mexican strategy was based on several premises regarding macroeconomic policies, basically marked by the belief that less state intervention is better for the country. In addition, as the process of economic reform advanced,

trade liberalization was seen as a key instrument in attaining fiscal objectives for a balanced budget. This was very clear in the agricultural sector, where price support measures were considered too burdensome for the new strategy. Cheaper imports would thus help reduce fiscal expenditure.

2. However, adequate public investments are required for adjustment to the new challenge posed by foreign competition. In the critical conditions encountered by the Mexican economy in 1995, these investments were abandoned, with reduction of fiscal spending remaining the key objective.

3. The new economic strategy also relied on a passive approach to monetary policy, abandoning the use of money supply as an instrument to assist the economy during the downturns. Financial deregulation of the banking, securities and money markets was also implemented, opening new possibilities to speculative investments. These policies were accompanied by major privatization schemes and further curtailment of state intervention in the economy.

4. The Mexican government failed to carry out a serious, comprehensive and in-depth analysis of the implications of including basic grains in NAFTA. The studies used to support decision-making were inadequate and could not provide an accurate estimation of how events would develop.

5. Furthermore, the studies undertaken were based on a number of assumptions that did not reflect economic reality. For example, the central assumption was that Mexico's comparative advantages in international trade would be effectively developed as price distortions caused by protectionist policies disappeared. The combined efficiency and welfare gains would more than offset costs incurred during the transition period. Thus, producers affected by declining prices would be able to modernize their production activities, or diversify into alternative crops, and become more competitive. The substitution effect implicit in the change in relative prices would be associated with a process of technical change (input and output mix) which would generate efficiency gains. However, as outline in the next chapter, this scenario did not materialize.

2. Implementing the NAFTA corn regime: a story of broken promises

This chapter compares and contrasts the projected and actual impacts of NAFTA on the Mexican corn sector.

2.1 Performance of main policy instruments

NAFTA provided for conversion of the existing corn tariff system into an import quota system to be phased in over fifteen years.[xii] During the first year, Mexico's tariff-free import quota was set at 2.5 million metric tons of corn. This quota was to expand at a compound rate of 3% *per annum* starting in 1995, leading to a tariff-free import quota of 3.6 million tons by year 14 of the agreement, in 2008. The objective was to bring domestic prices into line with international corn prices by gradually phasing out tariffs on imports.

As previously noted (see Chapter 1, p.14), yellow corn and white corn, were treated as one and the same commodity during NAFTA negotiations, even though significant price differentials exist between the two (i.e. white corn is usually traded at 25% above yellow corn prices in international markets).

A similar regime was established for most basic grains.[xiii] For example, NAFTA immediately transformed the import license system for kidney beans into a tariff-rate quota, with the initial quota expanding at a compound rate of 3% per annum. Over-quota imports were subject to an *ad valorem* tariff to be phased out over fifteen years, with a reduction of 30% by the end of the sixth year (bringing the initial tariff down from 133.4% to 93.9%).[xiv]

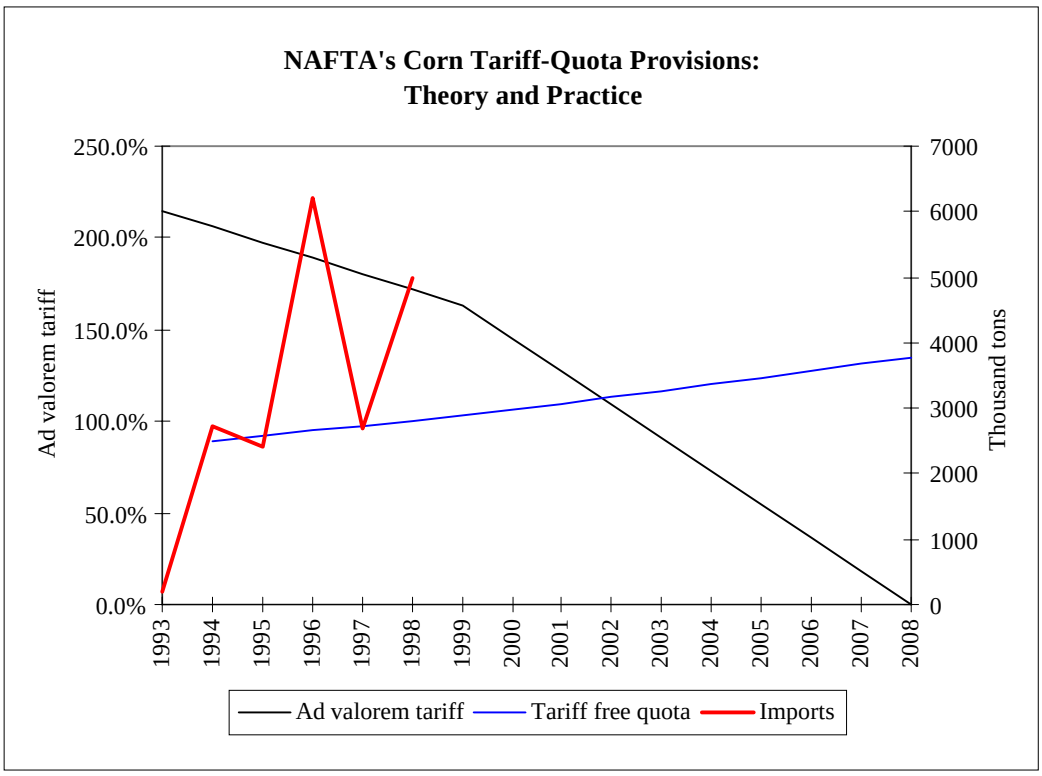
Since NAFTA implementation began, annual corn imports into Mexico have always exceeded the tariff-free quota (see Figure 2.1). The peak year was 1996, with 5.9 million tons of corn imported. Taking into account actual and authorized imports as of September 1998, corn imports for that year were likely to exceed 5 million tons.

The quota system set out under NAFTA was not implemented as planned, and all corn imports into Mexico since 1994 have been exempt from tariff payments. This means that corn producers have not received the level of transitionary protection intended to provide a breathing space for them to adjust to a more open trade regime.

Public officials have justified this policy as a means of controlling prices and therefore reducing inflationary pressures. In 1993, as deregulation of the corn sector began, CONASUPO (the state agency responsible for grain production, marketing and distribution) ceased to be the sole importer of basic grains. As a result of these factors, perverse incentives acted in favour of private importers, some of whom (in the industrialized tortilla market) also received significant direct subsidies. By failing to implement the tariff-quota system, the Mexican government effectively dismantled whatever was left of the structure put in place for the 15-year transition period for corn, thereby placing tremendous and unexpected pressure on Mexico's corn producers.

The cost of the fiscal revenues foregone as a result of the government's failure to implement the tariff quota system can be estimated at more than two billion dollars. Table 2.1 can be compared with the sums allocated to PROCAMPO and *Alianza para el campo* (see pages 24-25) for the year 1996: $800 and $250 million dollars respectively.

Figure 2.1



Source: NAFTA, Schedule of Mexico, Annex 302.2, tariff item 0713.33.02

In addition to reiterating their inflation concerns, fiscal policy-makers justified not implementing the tariff-rate quota system as planned by claiming that higher tortilla prices would lead to renewed pressure to increase subsidies in order to keep tortilla prices stable. In this way, it was argued, revenues from tariffs imposed on imported corn would be cancelled out by losses incurred through higher subsidies. This point is further examined on pages 34-35 At this stage, it is important to note that tortilla prices and subsidies to the industrial flour producers both increased significantly during the first five years of NAFTA implementation.

Table 2.1

Foregone Fiscal Revenues from Corn Imports

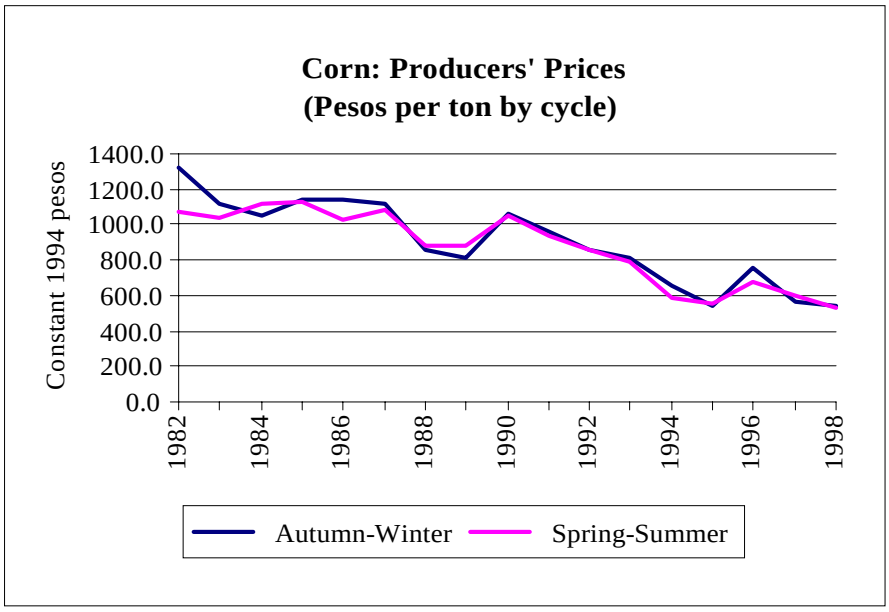
Year	Tariff-free quota (1,000 tons)	Total imports (1,000 tons)	Volume over quota (1,000 tons)	Price per ton USD	NAFTA *ad valorem* tariff*	Foregone Fiscal Revenues (USD)
1994	2,500	2,717	217	150	206%	**$67,053,000**
1995	2,575	2,400	-	160	197%	-
1996	2,652	5,900	3,248	220	189%	**$1,350,518,400**
1997	2,731	3,071	340	180	180%	**$110,160,000**
1998	2,813	5,028	2,215	170	172%	**$647,845,241**
Total Corn-related Foregone Revenues, 1994-1998						**$2,175,576,641**

*See NAFTA, Annex 302.2 in Schedule of Mexico, tariff item 0713.33.02.
Unit prices are CBOT prices plus transportation to Mexican ports (Gulf of Mexico) or border.
Corn imports for 1998 (5,028,613 tons) are final estimates by SAGAR.

In summary, the Mexican government failed to live up to its commitments to Mexico's corn producers. Failure to implement the agreed tariff-rate quota system eliminated all protection for the corn sector and prematurely truncated the planned 15-year transition period.

At the same time, corn prices (for both annual production cycles) have fallen since 1982, with a continuous downward trend since 1990. The rate of decline even accelerated in 1993, in anticipation of NAFTA ratification. Although an adjustment was introduced in 1995, when inflation rose to 52%, the trend soon resumed (see Figure 2.2). As a consequence, the livelihoods of millions of corn growers and their families were imperilled.

Figure 2.2



Source: Author's calculations with data on corn prices provided by Asociacíon nacional de empresas comercializadoras de productores del campo, NAEC.

2.2 Agricultural policies linked with trade liberalization

Two basic policy instruments were set up to assist producers during the anticipated transition period: (i) PROCAMPO (a direct income subsidy), and (ii) *Alianza para el campo* (a programme designed to increase productivity and competitiveness). It was claimed that these measures would ensure a smooth transition to open competition with agricultural producers in the rest of the world (especially the United States and Canada). These two sets of instruments would also accompany the phasing out of CONASUPO, the state body responsible for support policies, marketing and distribution of basic grains.

2.2.1 PROCAMPO

PROCAMPO, the income support mechanism established in 1994, was conceived as a 'deficiency payment' (i.e. compensation for loss of income expected as a result of lower corn prices after trade liberalization) and designed to bridge any gap between the guaranteed 'floor' price (i.e. the level at which state intervention is triggered) and the government's target price. This is justified on the grounds that income support instruments must be separated from production and technology-related decisions. As a result, public intervention becomes less market distorting and farmers more responsive to market forces. PROCAMPO is thus considered to be neutral in terms of producers' decisions regarding allocation of productive resources.

PROCAMPO was to remain at a constant level during its first five years of implementation before being phased out over a 10-year period. Direct payments to individual producers were initially set at

approximately US$ 100 per hectare. Today, they are worth less than US$ 62 per hectare. The original purchasing power of PROCAMPO payments has not been maintained in real terms.

The original rationale for PROCAMPO payments has been seriously distorted by curtailment of credit for agricultural producers and deregulation of industries producing agricultural inputs. Input prices have increased significantly in recent years, except in certain regions where there has been enough competition between suppliers to result in stable (or even decreasing) prices.

Due to the scarcity of credit, producers have had to rely on PROCAMPO payments for purchasing inputs, especially fertilizers, pesticides and seeds. Fieldwork for the present study shows that this is by no means an uncommon practice. For example, producers in Venustiano Carranza district and Chiapas mentioned that PROCAMPO payments had been given directly to suppliers of fertilizers and seeds. In Ajuchitlán (Guerrero) producers used PROCAMPO funds to pay suppliers of hybrids.

In many other instances, producers complained about delays in PROCAMPO payments inhibiting production planning notably in Atoyac (Guerrero), Ario (Michoacán), Nopalucan and Mazapiltepec (Puebla).[xv]

In relation to the 1999 federal budget, government officials stated that PROCAMPO would remain constant in real terms, with payments increasing from $8,521 million pesos in 1998 to $9,623 million pesos for 1999 – in line with the government's inflation target of 13%. However, it is anticipated that this level of expenditure will not be reached in practice due to budget cuts, exchange rate adjustments, increments in prices and tariffs of goods and services, and increases in interest rates. These factors are likely to favour inflationary trends, meaning that the general inflation rate could reach 17%-20% during 1999. It is clear that, in real terms, PROCAMPO will continue to lose value.

To summarize, PROCAMPO has not only lost its capacity to compensate producers for the price reductions and hence loss of income, it is no longer separated from output and technology decisions.

2.2.2 Alianza para el campo

This mechanism provides subsidies on a 'matching funds' basis, supplementing payments for advanced irrigation systems, high yield crop varieties, mechanized equipment, etc. It is geared towards increasing productivity and competitiveness, although the budget is not very big. The programme started in 1996 with a total of $1.88 billion pesos and has suffered severe cuts.

Total funding allocated through PROCAMPO and *Alianza para el campo* (see Table 2.2; figures are for the entire agricultural sector, not just corn producers) has stagnated in real terms since 1994, the first year of NAFTA implementation. The number of producers receiving support through PROCAMPO fell 14% between 1994 and 1998, whilst the *Alianza* budget decreased by 23% in real terms during the programme's first three years of operation. Furthermore, *Alianza* funds were allocated primarily to producers with the highest degree of flexibility to move to more intensive production, rather than those in greatest need.

In constant 1994 pesos, total appropriations for agricultural development in the Federal budget have dropped from $20.5 billion pesos in 1995 to $14.1 in 1996 and $13.5 in 1997. The data given in Table 2.2 correspond only to two components of those total appropriations, Procampo and Alianza para el campo.

Table 2.2

Adjustment Policy Instruments

(i) Expenditure on Adjustment Policy Instruments *(millions of constant 1994 pesos)*

	1994	**1995**	**1996**	**1997**	***1998**
PROCAMPO	4,704	4,260	3,624	3,439	3,463
Alianza			1,880	1,332	1,465
Total	**4,704**	**2,875**	**5,504**	**4,771**	**4,928**

(ii) Beneficiaries of Adjustment Policy Instruments (millions of producers)

	1994	**1995**	**1996**	**1997**	***1998**
PROCAMPO	3.29	2.95	2.91	2.87	2.85
Alianza			2.52	3.45	3.99

Source: SAGAR and 4º Informe de Gobierno, 1998.

*The fiscal adjustments carried out throughout 1998 had an impact on budget appropriations for the present year. Although it is not yet possible to establish the final amount, a reasonable estimate is $12 billion pesos in real terms (constant 1994 pesos).

2.3 Other relevant policies

CONASUPO, the state firm which was responsible for implementing the price support mechanism in the past, has drastically reduced its operations and will soon cease to exist. In 1998, it continued to purchase corn and beans, but at a much-reduced level (see Table 2.3). It should also be noted that CONASUPO has abandoned areas where corn producers are poorer or less productive and has concentrated its operations in states with high productivity (e.g. Sinaloa in 1996-1997).

Table 2.3

Phasing out of CONASUPO's Price Support Mechanism

	1994	**1995**	**1996**	**1997**	**1998**
Total Purchases (million tons)					
Corn	8.1	3.7	1.5	3.4	2.2
Beans	0.3	0.2	0.1	0.08	0 .1
Share of total production (%)					
Corn	44	20	8	19	12
Beans	24	18	8	8	10

Source: Compañía nacional de subsistencias populares (CONASUPO), Informe de labores 1999.

An important variable is the price level at which CONASUPO's reduced operations are taking place. Basically, indifference prices are used to establish the price floor for its market operations in the regions where it is still operating.

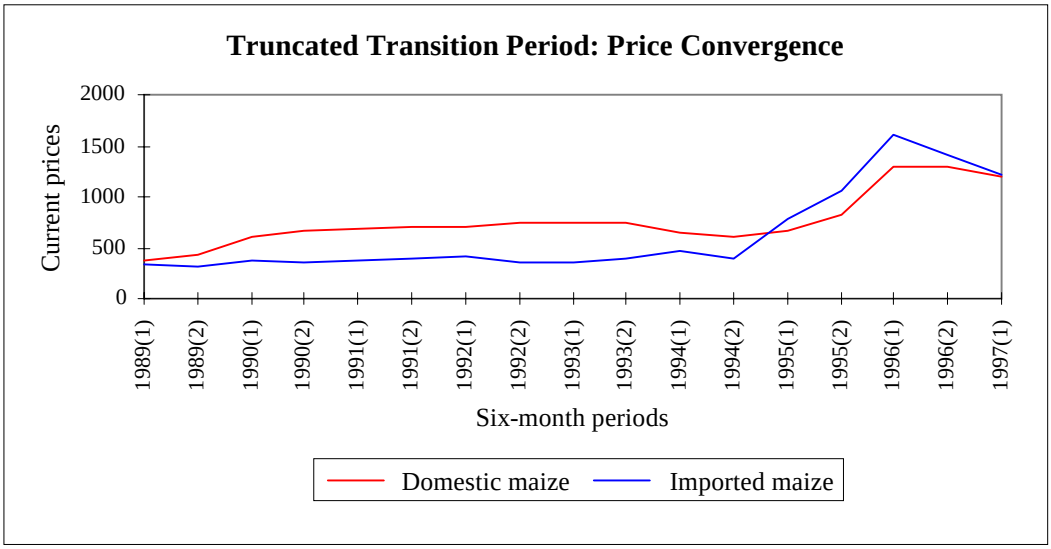
Even though CONASUPO was being phased out, it remained an important element in the minds of producers. As it was effectively difficult to wipe out a fifty-year old policy instrument in just a few months, a mechanism resembling price support was put in place for corn and beans during the period 1993-1998. The notion that CONASUPO maintained a policy of 'guaranteed prices' was an important element in rural Mexico and may have persuaded producers that corn was less risky, in spite of the

significant drop in the prices and scale of CONASUPO operations. For producers interviewed in Jalisco (Cuquío and Ixtlahuacán), CONASUPO's activities remained crucial for maintaining already diminished margins of profitability in 1993-1995. In the region of Puebla (Mazapiltepec, Soltepec and Nopalucan) CONASUPO's presence was important for corn growers as it provided a sense of price stability: it was seen as a 'last resort' guarantor by local producers. Nowadays, after two years of CONASUPO withdrawal, producers complain about lower corn prices and increasing uncertainty.[xvi]

2.4 The truncated transition period

In the case of corn, the convergence of domestic and international prices is the most significant indicator that the transition period is over, a full twelve years before its planned completion (see Figure 2.3).

Figure 2.3



Source: Author's calculations with data on domestic prices and international prices provided by ANEC.

Between 1990 and 1994, the exchange rate overvaluation played a key role in controlling inflation and maintained a certain degree of protection for domestic corn producers. The red line in Figure 2.3 shows relative stability of domestic prices although prices were going down in real terms. In 1994, domestic prices started to fall but were adjusted under the 1995 stabilization programme. Import prices increased significantly and were higher than domestic ones following a 'macro devaluation' of the exchange rate. This lasted 24 months and by the end of 1997, domestic and international prices were roughly at the same level.

In summary, less than 30 months after NAFTA came into effect, the transition period for Mexico's corn sector was truncated. This happened in the context of inflationary pressures, high interest rates, falling real income, and contractional monetary and fiscal policies that have virtually eliminated support policies for the sector.

2.5 Five years into NAFTA: the gap between predictions and reality

The agricultural sector's performance over the past five years has been a record of stagnation, negative growth rates, and mediocre trade balance performance (see Table 2.4). Agricultural GDP has been stagnant since 1992, dropped in the wake of the 1995 economic crisis, and in spite of government efforts, remains below 1994 levels. This trend has coincided with growing poverty for Mexico's rural population.

Table 2.4

Performance of Mexico's Agricultural Sector since 1994

	1994	1995	1996	1997	1998
Sectoral GDP*	78.1	70.6	79.6	77.2	69.9
Growth Rate (%)		0.86	3.5	1.43	-5.2
Sector Trade Balance**	(0.73)	1.3	(1.0)	(0.3)	0.1
Sector + Agrofood Balance	(2.8)	1.1	(1.4)	(0.7)	---

*Billions constant 1994 pesos, deflated with Banco de México's consumer price index.
**Billions of US dollars.

Source: Centro de estadística agropecuaria, Secretaría de agricultura y ganadería (SAGAR) and 4º Informe de Gobierno, 1998.

In the previous chapter, it was noted that implementing NAFTA was central to the Mexican government's strategy for agricultural reform. Owing to lack of any real recovery in the economy, the capacity of the agricultural sector to adapt to trade liberalization has been severely impaired, especially since investments and support programmes for the sector are being cut.

The truncation of the transition period is of course associated with a dramatic drop in corn prices. Before NAFTA was ratified, government officials postulated that prices would drop as a result of cheaper imports, producers would react by substituting crops or engaging in activities that would lead to a change in land use patterns. A significant reduction in corn output would follow. The first two steps in this line of reasoning have materialized. However, corn production has remained stable (as can be seen in Table 2.5), except for 1998 when corn output was affected by a severe drought.

Table 2.5

Corn Production in Mexico, 1988-1998

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Corn	10.5	10.9	14.6	14.2	16.9	18.1	18.2	18.3	18.0	18.0	16.4
I (%)	26.6	24.9	22.6	30.0	31.9	42.5	47.0	34.2	31.7	37.8	35.3
R (%)	73.4	75.1	77.4	70.0	68.1	57.5	53.0	65.8	68.3	62.2	64.7
Surface	8.0	7.5	7.9	7.7	8.0	8.2	9.1	9.0	8.6	9.0	8.4

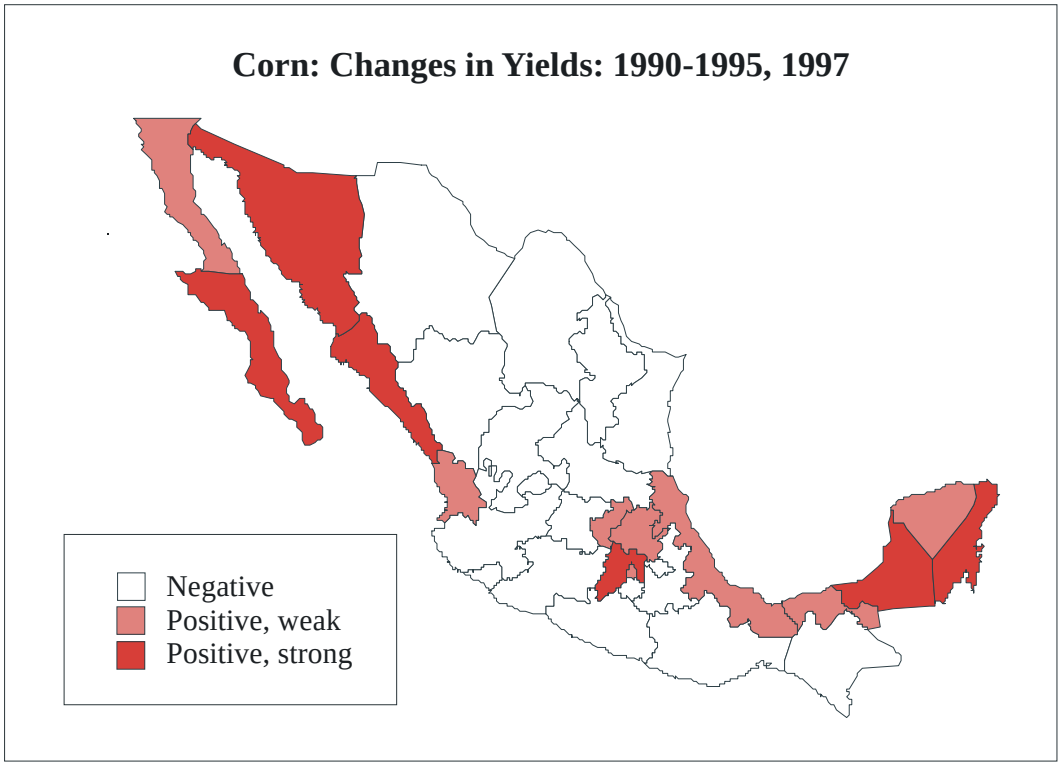
I: Irrigation; R: Rain fed. Percentages refer to share of total production.
Surface: million hectares of corn cultivation. Corn: million tons

Source: Centro de estadística agropecuaria (SAGAR).

The stability of corn production stems from a variety of factors and it is important to examine these in detail. For example, state-by-state data show that both modern and traditional production sectors contribute to sustained corn output levels in Mexico, although their motivation may be quite different.

Map 2.1 and Table 2.6 show the changes between average yields for the period 1990-1995 compared with 1997. Yields have been calculated according to area cultivated, rather than area harvested. This may have the effect of underestimating yields because the area cultivated is normally greater than that harvested. On the other hand, production costs depend more on the area cultivated. Map 2.1 shows that only fourteen states have 1997 yields above the 1990-1995 average. All the other states show a negative change.

Map 2.1



Note: the map is constructed from data in column five of Table 2.6. It shows that during the period in question, yields have dropped in more than half of the states.

Source: Author's calculations based on Anuario Estadístico del Sector Agrícola (SAGAR) over several years.

Of the 14 states showing positive changes, only six show significant increments. Furthermore, only three of the 14 (México, Sinaloa, Veracruz) are amongst the ten top states in overall corn production.

Of the 18 states showing drops in yields, 14 also show increases in cultivated area, suggesting increasing degradation of land. A fall in area harvested also indicates that crops may have been damaged more frequently as poor-quality land was subjected to cultivation without adequate infrastructure and technical resources. These data contradict the positive environmental effects that trade liberalization and related policies in the corn sector were supposed to bring about. It was often argued that growers would be liberated from the requirement to plant certain crops and would respond to market forces in a more efficient manner (SARH 1994).

Table 2.6

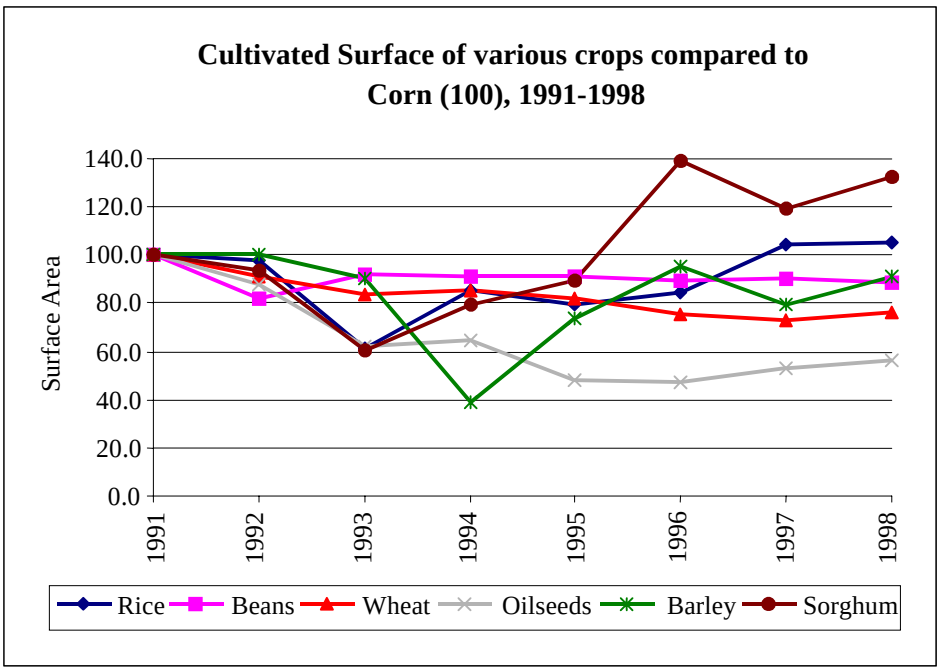
Trends in Post-NAFTA Corn Production

(Changes in Cultivated, Harvested Surface, Production and Yields, 1990-1997)

	Cultivated area (ha)	Harvested area (ha)	Production (tons)	Yield (tons/ha)
NATIONAL TOTAL	727497.7	-131880.7	1330367.3	-0.01
JALISCO	38878.2	-34136.8	-208214.3	-0.45
MEXICO	-8156.3	3918.5	476741.5	0.80
SINALOA	161671.2	163068.8	1187407.8	0.82
CHIAPAS	176856.5	73009.3	143888.8	-0.18
PUEBLA	17187.8	-82811.2	-168240.0	-0.31
MICHOACAN	38442.2	-20181.7	68794.5	-0.02
GUERRERO	27183.7	-72880.5	-26542.5	-0.16
VERACRUZ	81550.2	81377.0	294520.2	0.26
TAMAULIPAS	-153767.0	-177634.0	-592364.8	-1.10
GUANAJUATO	-42450.0	-135544.5	-288984.2	-0.53
CHIHUAHUA	38117.8	26089.8	55752.3	-0.06
OAXACA	81278.7	34302.0	78775.8	-0.01
HIDALGO	-5904.7	-28919.3	43491.5	0.18
SONORA	28434.3	29131.5	264298.3	1.23
TLAXCALA	-6124.7	-18727.7	-84001.2	-0.50
ZACATECAS	574.0	-63390.0	-59997.8	-0.18
DURANGO	21603.7	-46528.0	-32854.5	-0.26
NAYARIT	8947.3	11724.3	39206.5	0.18
SAN LUIS POTOSI	59316.2	-2381.3	-57837.7	-0.37
QUERETARO	16321.0	-7983.5	33334.5	0.11
YUCATAN	11943.5	19244.0	28552.2	0.12
MORELOS	6433.2	3732.8	2769.2	-0.20
NUEVO LEON	25277.5	17543.5	-28424.2	-0.48
TABASCO	35929.2	37881.8	66579.0	0.20
CAMPECHE	50279.8	56789.5	104160.3	0.40
COAHUILA	658.5	-4507.2	-31353.2	-0.57
COLIMA	3195.0	2317.5	-5941.2	-0.37
AGUASCALIENTES	-2374.7	-33407.7	-6986.0	-0.07
BAJA CALIF. SUR	3156.7	2916.2	19304.0	0.30
BAJA CALIFORNIA	-5720.2	-5118.5	-13806.0	0.21
QUINTANA ROO	20294.0	40557.7	30247.5	0.29
DISTRITO FEDERAL	-1534.8	-1333.2	-1909.2	0.12

Source: Author's calculations based on Anuario Estadístico del Sector Agrícola (SAGAR) over several years.

Figure 2.4

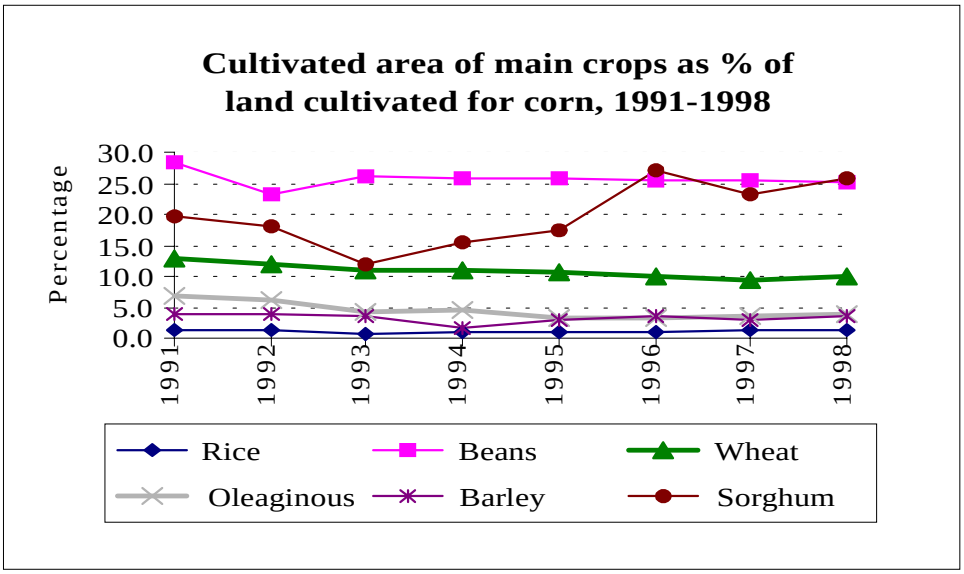


Source: Author's calculations based on Anuario Estadístico del Sector Agrícola (SAGAR) over several years.

Data for Mexico's main crops (1991-1998) show that the area of land cultivated for beans and sorghum increased in comparison with the area allocated to corn. The area of other crops (rice, wheat, oilseed and barley) remained below that for corn, although barley showed a strong increase between 1994 and 1998.

Figure 2.5 shows the area under cultivation for each of Mexico's main crops *as a percentage* of cultivated land devoted to corn. Only sorghum shows an important increase, rising from 12% in 1993 to 26% in 1998. Barley remains constant, at a level of 3%.

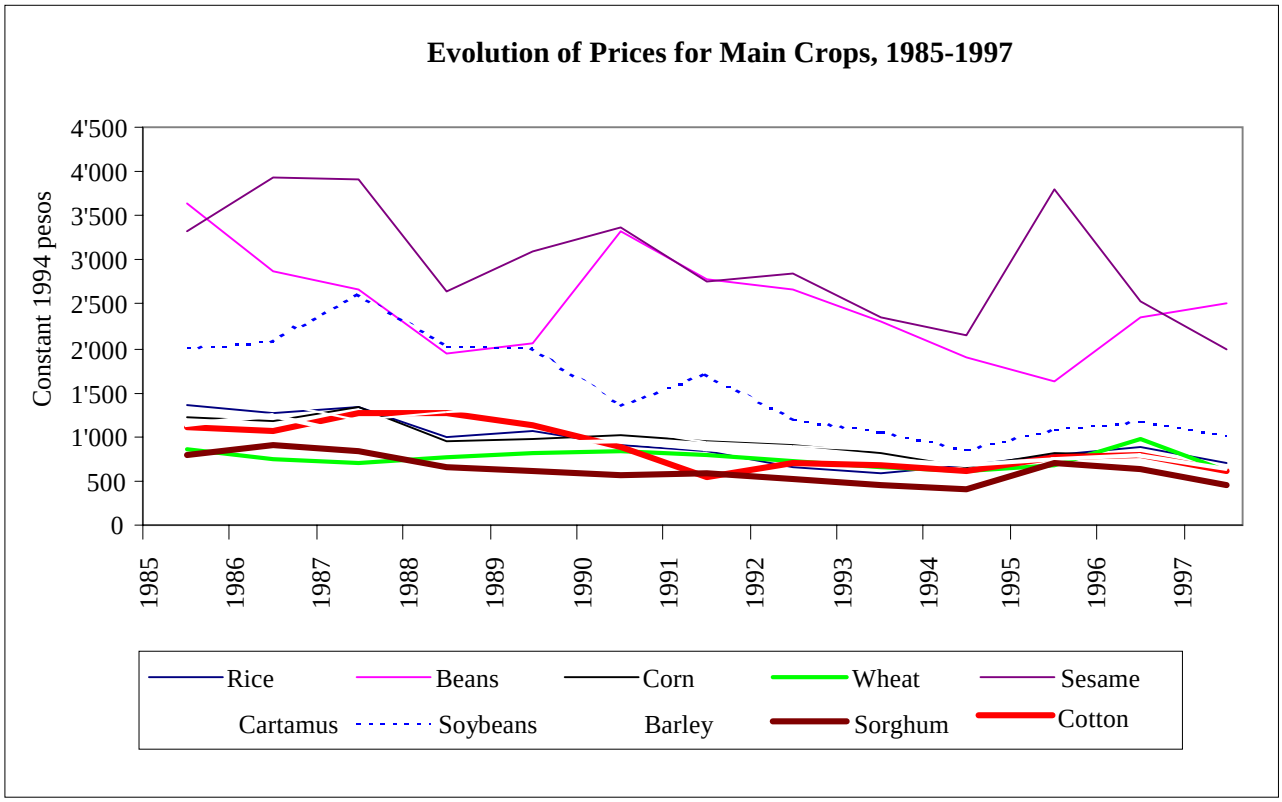
Figure 2.5



Source: Author's calculations based on Anuario Estadístico del Sector Agrícola (SAGAR) over several years.

This distribution of land between different crops is consistent with the relative price structure in the agricultural sector (see Figures 2.6 and 2.7). It is clear that none of the crops has experienced significant growth in real terms during the period 1989-1995.

Figure 2.6



Source: Author's calculations based on Anuario Estadístico del Sector Agrícola (SAGAR) over several years.

Four crops (sesame, beans, cotton and soybean) show strong price variations, but significant overall drops. Only sesame subsequently recovering to 1985 levels. The remaining crops (barley, carthamus, corn, sorghum, and wheat) show a smooth downward trend for the entire period. Inflation during this period was relatively high (especially 1985-1989 and 1995), so that trading conditions deteriorated for the agricultural sector as a whole.

Only three commodities have a higher price than corn: beans, cotton and soybean. Most crops, including barley, rice, sorghum and wheat, have lower prices, thereby restricting economic scope for crop substitution.

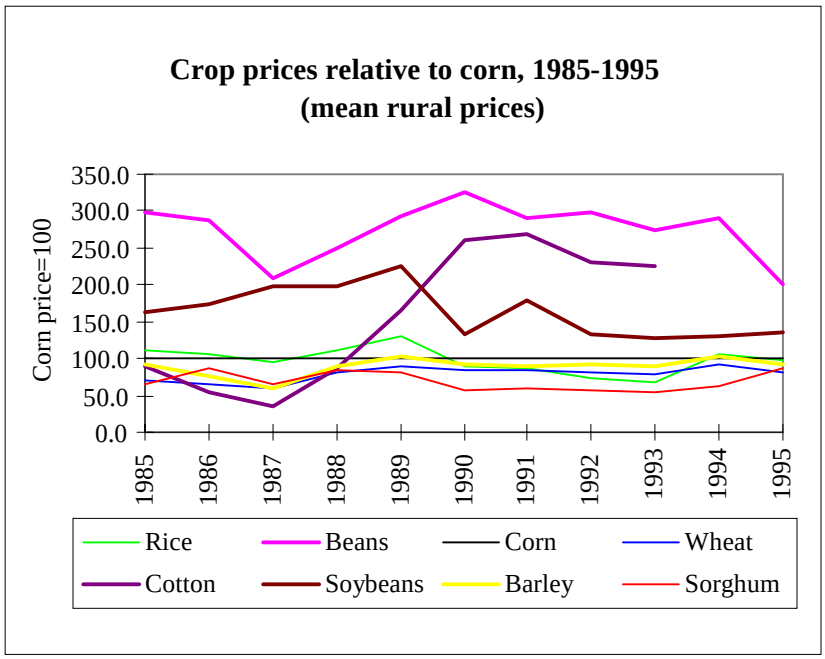
States such as Sinaloa, which have irrigated land that in theory should be allocated to the most profitable crops, have in fact made their most important contribution to Mexican corn production during the past three years, with corn becoming the most important crop in irrigated land. This is what Appendinni (1996) has calls 'regressive crop restructuring'.

However, corn production has not only increased in the modern sector. It has also expanded in the traditional sector. Producers in states such as Guerrero and Oaxaca have increased their level of production during the last four years, particularly in the mainly rain-fed spring-summer cycle.

In terms of volume, corn production in the states of Guerrero and Oaxaca increased at considerable rates (9% and 14% *per annum* respectively) between 1990 and 1995. In these states, the vast majority of producers are small-scale, poor farmers, who use traditional technologies. These producers operate on sloping land, often on poor quality soil, and have increased their production in spite of the fact that corn prices have fallen, in order to maintain income levels..

Analysis of corn production in Oaxaca indicates that only 25% of production growth is related to increased yields, while 65% was due to expansion of land under cultivation. Corn producers were increasing output under conditions of severe economic stress which led to additional pressure on lesser quality land. This is what a corn grower from Guerrero described during our field study as "the return to agriculture".[xvii] Other regions of Mexico show a similar pattern, as reported by WWF's study of the Calakmul area in Quintana Roo (Stedman-Edwards 1997:77): "Frontier expansion is driven not by profits that can be extracted in terms of timber, other forest products, or agriculture, but rather by the large population that is excluded from other economic opportunities."

Figure 2.7



Source: Author's calculations based on Anuario Estadístico del Sector Agrícola (SAGAR) over several years.

The distortions in the corn sector are thus twofold. On one hand, modern farmers, with access to irrigated land, hybrid crop varieties and mechanization, expanded production with the aim of reaping extra profitability from the structure of relative prices in agricultural products. On the other hand, poor producers also expanded production, albeit at a slower rate, and under very difficult conditions. This increase is explained by the fact that traditional producers have been severely affected by the general evolution of the economy during the past ten years, and their main survival strategy has been to use the resources available to them, especially their land.

It is difficult to see horticulture as a viable alternative to agriculture. In the first place, the horticultural sector has many entry restrictions for Mexican producers (Gómez and Schwentesius 1993; Thrupp 1995; de Janvry 1995).[xviii] Many corn growers that have the underlying potential of switching to horticulture may simply not be able to surmount these barriers.

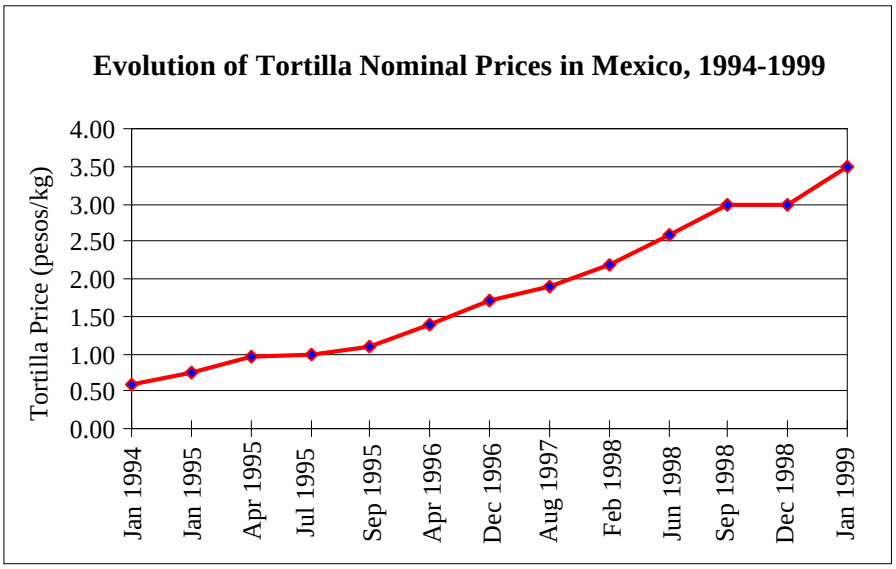
Secondly, horticultural products currently cover no more than 350,000 hectares, whilst the area of corn is around 8.8 million hectares. Even if a major effort to increase horticultural production generated cultivation of a further 300,000 hectares, the North American regional market will probably not be in a position to absorb a doubling of production.

Thirdly, the capacity of Mexican producers to displace US producers from the North American market has probably reached its limits, as indicated by the recent evolution of horticultural exports from Mexico to the United States (see also Chapter 1, Assumption 4).[xix] In addition, these products are as vulnerable as any other basic commodity to price fluctuations and market saturation (de Janvry 1996).

2.6 What happened to the price of tortillas?

During NAFTA negotiations, the assumption that lower corn prices would translate into lower tortilla prices, was seen as the linchpin of the entire package. Lower tortilla prices would have multiple benefits, including lower inflation and greater consumer welfare.

Figure 2.8



Sources: For 1994-1995, ANEC; for 1996, Rudiño, L., in *El Financiero* (9 September 1998); Other dates, Diario Oficial, 18 September and 31 December 1998.

However, the price of tortilla increased by more than 483% between entry into force of NAFTA in January 1994 and January 1999, with an average annual price increase of more than 35%. During the first six months of 1999, tortilla prices increased by more than 55% (see Figure 2.8 and Table 2.7).

These figures largely underestimate the impact of the tortilla price increase, since the data in Table 2.7 cover one of the zones for which the Trade Ministry maintained price controls, namely Mexico City, its metropolitan area and other close by municipalities. In the rest of the country, the price increments are significantly higher.

Further increases are likely because the price of tortillas was liberated at the end of 1998, marking the end of more than five decades of subsidies to consumers. Although there has recently been greater vigilance by regulatory bodies, and a commitment by the largest association of department stores to maintain the price at $3 pesos per kilogram for a three-month period, it is expected that the price will have reached $4.80 by the end of 1999. This will further aggravate the situation of poor consumers, including corn producers.

2.7 Subsidies to industrial corn flour producers

As the tariff-rate quota was abandoned *de facto*, and as tortilla prices increased, the Mexican government significantly increased its subsidies to the manufacturers of industrial corn flour, especially the two largest companies (GIMSA and MINSA) which account for 70% and 27% of the market, respectively.

This policy of targeting selected manufacturers is in sharp contrast with the previous policies of generalized subsidies which were shared between 3,000 producers of hominized corn dough and tortillas from this dough.[xx] This bias in the allocation of subsidies began under the previous administration when the quota assigned by CONASUPO to multiple producers was frozen at 2.5 million tons. Hence the real value of subsidies to small producers started to lose ground, while the subsidy for industrialized corn flour production increased dramatically. The subsidy allocated to GIMSA and MINSA, grew from $2 billion pesos in 1994 to $5 billion pesos in 1998. So-called

‘intrinsic costs’ used to calculate the amount of subsidy, were overestimated, as was the overall volume of output.

In the case of MASECA (GIMSA’s largest subsidiary) the 1996 subsidy ($341 million dollars or $2,679 million pesos at the 1996 exchange rate) was equivalent to 47% of gross sales, allowing the corporation to engage in a process of expanding both its national and international operations.

In summary, industrial producers of corn flour gained a double advantage. First, they were allowed to import corn directly without paying the tariff rate quota established under NAFTA.[xxi] Second, they received considerable direct payments from the Mexican government in the form of subsidies to keep tortilla prices stable.

Table 2.7

Evolution of Tortilla Real Prices, 1994-1999

	Price Pesos/kg	General Date	Annual Inflation Rate
January 1994	.60		
January 1995	.75	1994	9
April 1995	.95		
July 1995	1.00		
September 1995	1.10	1995	52
April 1996	1.40		
December 1996	1.70	1996	27.7
August 1997	1.90	1997	15.7
February 1998	2.20		
June 1998	2.60		
September 1998	3.00		
December 1998	3.00	1998	18.6
1 January 1999	4.00 - 4.80		
15 January 1999	3.50	Jan. 1999	2.5
June 1999	4.50	Jan.-June 1999	18.2

Sources: For 1994-1995, ANEC; for 1996, Rudiño, L., in *El Financiero* (9 September 1998); data for January-June 1999, from Banco de México. Other dates, Diario Oficial, 18 September and 31 December 1998.

2.8 Why did tortilla prices increase as corn prices were going down?

There are several explanations. First, whilst the two largest industrial producers of corn flour and tortillas benefited from lower prices for corn – their basic ingredient – they were not under pressure to lower prices of their final products. The market is not competitive and the producers therefore have considerable power to set profit-maximizing prices. Secondly, the largest tortilla corporation (MASECA) has embarked on several large-scale international projects designed to expand its scope of activities. The financial requirements for these new projects are significant, being met either through the group’s own assets, or through credits in the international market. However, greater profitability from tortilla sales in the Mexican market is another important source of revenue. Thirdly, manufacturers buying and using industrial corn flour to produce tortillas have simply transferred increased costs to the final consumer. This was made possible when tortilla prices were liberalized in 1996-1997. Finally, in rural areas, tortilla markets operate in a very imperfect manner, with market segmentation playing a crucial role. Corn imports do not reach rural tortilla producers directly.

2.9 Summary and Conclusion

The main policy instruments of NAFTA's corn regime have failed to generate the expected benefits (see Table 2.8). The long transition period originally established for Mexico's corn sector has been abruptly and prematurely terminated against a context of almost complete withdrawal of state support for agriculture in general. This is not simply because corn imports exceeded the tariff-free quota since this possibility was clearly taken into account by NAFTA. Neither is it because the tariff corresponding to excess imports was not applied, although this led to significant loss of revenue. The foreshortened transition period is primarily due to the early convergence of international and domestic prices.

The corn sector has shown great resilience, as corn output remains stable, although there has been an increase in area under cultivation and a reduction in yields. This is partly explained by the fact that, although corn prices have been cut by 45%, relative prices for other agricultural products have also dropped and, with only two exceptions, at an even faster rate. As a result there has been little economic incentive for farmers to reallocate productive resources to other crops.

During the same period, the accumulated economy-wide inflation rate was 173%. This means that in real terms (deflating the price of tortilla against what happens in the rest of the economy), the price of tortilla increased by 279%.

Table 2.8

A Scorecard for NAFTA's Corn Regime: what has actually been accomplished?

Original Plans and Objectives	Actual Effects
Cheaper imports to induce price reductions	Corn imports caused significant (45%) price reductions
Tariff-free quota to expand 3% while over- tariff quota gradually phased out	Corn imports exceed tariff free quota and the corresponding tariff is not applied.
Fifteen-year transition period for alignment of domestic prices with international prices.	Transition period truncated; domestic prices aligned with international prices in thirty months.
Resource reallocation: domestic corn output to be reduced and land and labour released for non-maize agricultural activities (e.g. horticultural sector).	Corn output stable at highest historical levels of 1994 (18 million tons). Area of corn cultivation expands, yields drop.
GDP in agricultural sector recovers significant growth rates.	Agricultural GDP stagnates during NAFTA's first five years
Trade balance for agricultural sector to generate a significant trade surplus as comparative advantages develop their trade potential.	Accumulated deficit in agricultural trade balance between 1992 and 1999 is $2.6 billion.
Adequate adjustment policies through direct income support policies and other policy instruments assist producers during transition period.	Main income support instrument PROCAMPO diminished by 50% in real terms and other support mechanisms are reduced; other public investments fail to materialize as fiscal policy becomes more restrictive.
Tortilla prices would be reduced as cheaper imports were used in the domestic industries.	Tortilla prices increase by 179%.
Subsidies to be reduced, both to growers and to industries using corn as main input.	Subsidies for industrial corn flour producers continue.

3. Profile of the emerging corn sector

This chapter examines the structure of the Mexican corn sector, including some of the key determinants of changes in producers' strategies as a result of new economic circumstances following entry into force of NAFTA.[xxii] *There are three principal sections: (i) analysis of profitability levels of different categories of producers; (ii) analysis of variation in technological, social and agro-ecological characteristics; (iii) analysis of geographical distribution of production patterns.*

3.1 The differing categories of producers in the Mexican corn sector

According to the 1991 census, there were just over 3 million corn-producing units in Mexico. Considering that the average rural family size in Mexico is six, the number of people depending directly on corn production for all (or a major part of) their livelihood is more than 18 million persons. This figure rises substantially if people depending indirectly on corn production (e.g. via transport, storage and trade) are taken into account.

No accurate information is available about the structure of the corn sector before and after the price reductions brought about by NAFTA. However, data from a 1991 (pre-NAFTA) survey help to show how profitability was affected in terms of the productivity and competitiveness of corn producers (see Table 3.1).

Categories III and IV in the first half of the table comprise 23% of all producers. The average yields (2.8-3.2 t/ha.) suggest that there is potential to increase competitiveness. These producers account for 50% of total production and are net sellers in the market. The average size of their plots is 4.7 ha for rain-fed land and 2.4 ha for irrigated land.

An intermediate group is formed by 50% of producers, who operate in 48% of the land under rain-fed conditions and using improved varieties or fertilizers. These producers have smaller plots. Their average yields (1.5 t/ha) could be improved if adequate infrastructure, access to credit and technical assistance were available. Most of these producers are probably selling part of their production in the local market.

The remaining 27% of producers operate on 21% of the land but produce only 10% of total output. These units are mostly producing for household consumption.[xxiii]

The second half of Table 3.1 shows how producers are distributed according to profitability levels. Two groups of producers show profits, while the other two operate with net losses.

The highest profitability group has the capacity to switch production to more profitable crops. The second group of producers has the potential to modernize corn production and compete with imports. The third and fourth categories of producers are engaged in production for household consumption, but have different resources and may thus opt for differing strategies.

In the case of 'profitable producers' (20% of total units, 28% of irrigated surface, and 50% of total corn production in Mexico) it was argued that corn price reductions under NAFTA would lead to conversion to more profitable horticulture crops. Some producers in this group are highly competitive, with yields comparable to those of their international rivals. Whilst CONASUPO maintained artificially high prices, profitable producers failed to reallocate productive resources to other crops. Even as CONASUPO passes into the history books, those producers who are sufficiently competitive are likely to stay with corn. In short, it was incorrect to assume that NAFTA would automatically trigger a switch to other crops.

Table 3.1

Profitability of Corn Producers in Mexico (1991)

Percentage distribution by Technology

	I Rain-fed Land races no fertilizer	II Rain-fed imp. vars/ fertilizer	III Rain-fed imp. vars/ fertilizer	IV Irrigation	Total
% of Producers	27.0	49.9	9.3	13.7	2,441,662
% Surface	21.1	48.8	17.2	12.9	6,163,350
% Production	9.5	40.9	26.5	23.0	11,174,408
Avg. size (ha)	2.0	2.5	4.7	2.4	2.5
Avg.yield (t/ha)	0.8	1.5	2.8	3.2	1.8
Production by unit (t)	**1.6**	**3.8**	**13.0**	**7.7**	**4.6**

Note: 'imp. vars' = use of improved varieties

Distribution by Profitability

	I Losses higher 50% costs	II Losses under 50% costs	III Profits under 33% costs	IV Profits above 33% costs	Total
% of Producers	27.8	36.4	16.4	19.4	2,441,662
% Surface	24.0	32.1	15.7	28.3	6,163,350
% Production	6.2	23.3	18.7	51.8	11,174,410
Avg. size (ha)	2.2	2.2	2.4	3.7	2.5
Avg.yield (t/ha.)	5	1.3	2.2	3.3	1.8
Production by unit (t)	**1.0**	**2.9**	**5.2**	**12.2**	**4.6**

Source: *Encuesta nacional sobre rentabilidad y productividad, maíz*, 1991, SARH. (Reproduced in FIDA 1993: 189, Table 8.2)

The profitability of 'intermediate producers' has been reduced post-NAFTA and this group is probably experiencing difficult operating conditions because input prices have increased, credit has been curtailed and infrastructure investments have stagnated. Between 1994 and 1997, the continued presence of CONASUPO and a perception amongst producers that they would receive a 'guaranteed price' from this body (even though actual price support was very limited) may have encouraged the continued cultivation of corn. With the disappearance of CONASUPO, intermediate producers may begin to leave the corn sector. This will have negative effects on employment opportunities for subsistence producers who need income from off-farm work to meet basic household bills.

The third and fourth categories of producers operate with losses and usually produce for household consumption. They may opt for different adaptive strategies: some may remain in the corn producing sector or change production (in favour of livestock production, for example). It is difficult to estimate the extent to which these changes may occur. Most of these producers do sell corn in the local markets, and the price reductions have probably been harsh for them.

The fourth category is formed by producers with no capacity to convert to other crops or alternative land uses. These subsistence producers operate in marginal lands on sloping terrain, with shallow soils and low yields.

They are likely to remain in the corn sector purely to meet their own subsistence needs and in order to avoid the high transaction costs of purchases at market prices. They are amongst the most vulnerable economic agents in the Mexican economy, as confirmed in a recent survey of social indicators (Instituto Nacional de Nutricion, 1997). They live below the poverty line and in conditions of technological stagnation or even regression (see de Janvry 1995; Gordillo *et al.* 1995; García Barrios *et al*., 1991). Technological regression manifests itself in the reduction of assets such as animals (see Gordillo *et al.* 1995) and is intensified by migration due to the loss of expertise in resource management.[xxiv]

Given the reduction in prices, it is most likely that less profitable or subsistence farmers are now producing mainly for household consumption and that production levels have increased to make up for the lower prices. This partly explains why corn output has expanded during the past four years despite a 40% drop in prices.

In spite of the fact that poorer producers use their corn output primarily for household consumption, they also live and operate in a monetary economy. They have to buy many other foodstuffs, medicines, tools, etc. and rely on other sources of income, such as waged labour, or other off-farm activities. Although 'farm gate' corn prices have fallen, consumer prices for corn products, such as hominized dough, or tortillas, have risen, thereby increasing pressure on poorer producers when they come to buy these essential items. Immediate cash needs may be satisfied through petty corn sales at the local market. Normally, however, poor producers have to sell at very low prices to local middlemen, but encounter very high prices when buying to replace the amount sold.[xxv]

The ability of corn producers to purchase corn to replace quantities sold depends on employment opportunities in the local or regional labour market and the evolution of rural and urban wages. Many subsistence producers migrate to the United States in search of jobs and better incomes. Employment creation is sluggish in Mexico and real wages have continued to fall over the past eight years, with decreasing corn prices representing a downward pressure on real rural wages. Proponents of NAFTA consider this impact on real wages as an advantage because of potentially positive effects on investment, growth and employment generation (see Chapter 1, Box 1.1 on the Levy and Wijnbergen model). However, investment and job creation are lagging behind.

It is difficult to predict how many corn producers will remain in the corn sector in the face of worsening economic conditions. Conventional economic analysis has attempted to address this in terms of supply price elasticities in a partial equilibrium context. It is evident that such a framework does not adequately explain the pattern observed (see Chapter 1, Assumption 1), which suggests that competitive growers will continue to reap profits, while subsistence growers may be *forced* to remain in corn production.[xxvi]Intermediate producers, who have marginal profit levels are the most likely to exit the corn sector.

Environmental effects will depend on the technical changes introduced by profitable producers, and the degree of technological deterioration experienced by intermediate and subsistence producers.

3.2 Technological and agro-ecological differentiation

Corn is a plant endowed with extraordinary adaptive capabilities, that can be grown in a very wide range of climatic and soil conditions with different chemical properties. Producers are widely distributed in Mexico and operate under very different social, economic, technical and environmental conditions.

Corn represents around 60% of total volume of Mexican agricultural production in volume, and covers 62% of the total area under cultivation. In monetary terms, corn production continues to account for more than two thirds of the gross value of Mexico's agricultural production; well above beans and wheat (12% and 11% respectively), and followed by rice, sorghum and soybeans. Other crops, including horticulture, account for only 6% of total gross value of agricultural production.

Table 3.2

Main Features of Corn Production in Mexico
(divided according to agricultural cycle)

		Spring-Summer		
Producers	**Units**	**Area (a)**	**Production (b)**	**Yields (b)/(a)**
1-5 hectares	1,682,977	2,516,756	2,467,775	0.98
> 5 hectares	996,836	4,851,774	5,841,738	1.13
Total	**2,679,813**	**7,368,530**	**8,309,514**	**1.05 (avg.)**

		Autumn-Winter		
Producers	**Units**	**Area (a)**	**Production (b)**	**Yields (b)/(a)**
1-5 hectares	224,822	289,917	309,428	1.07
> 5 hectares	246,764	943,411	1,609,319	1.71
Total	**471,586**	**1,233,329**	**1,918,748**	**1.39 (avg.)**

		Total Spring-Summer + Autumn-Winter		
Producers	**Units**	**Surface (a)**	**Production (b)**	**Yields (b)/(a)**
1-5 hectares	1,907,799	2,806,673	2,777,203	98
> 5 hectares	1,243,600	5,795,185	7,451,057	1.28
Total	**3,151,399**	**8,601,859**	**10,228,262**	1.18

Notes: (a) Hectares; (b) Tons

Source: Author's calculations from National Agricultural and Livestock Census, 1991.

There are two clearly-defined production cycles: spring-summer, characterized by rain-fed production, and autumn-winter, mostly under irrigation. In the latter cycle, the use of technologies such as mechanized traction, fertilizers and pesticides is more common. The number of production units operating in the spring-summer cycle is 2.6 million (85% of all production units), with 471,586 (15% of total units) in the autumn-winter cycle. Usually, more than 80% of annual corn output is derived from the spring-summer cycle. However, this situation changed significantly in 1994, when approximately 45% of total output (18.2 million tons) came from irrigated land and only 55% from rain-fed systems.

Corn producers operate under various legal regimes. More than 72% of units are organized as *ejidos* under Article 27 of the Constitution.[xxvii] These *ejidos* are responsible for 62% of total corn production and are mostly small plots with diverse technological and agro-ecological conditions. According to the 1991 census, almost 60% of production units operating under the *ejido* system were less than 5 hectares.

Yields for corn production have remained low during the past two decades. According to the 1991 census, average national yields were 1.05 tons/ha for the spring-summer cycle and 1.39 tons/ha for the autumn-winter cycle. This difference in yields between cycles reveals the greater productivity of irrigated systems, but also that yields from private plots are 16% and 26% higher than for *ejidos* units under rain-fed and irrigated regimes respectively.

It is important to note three important factors to explain yield differentials between corn producers. First, privately-owned plots may have better access to credit and technology than *ejidos*. Corruption and macroeconomic policies that reduce the flow of resources to the rural development banks restrict access to credit for *ejidos*. Secondly, larger units offer better opportunities for the introduction of more capital-intensive technologies (especially mechanized traction) which are scale-dependent.

Table 3.3

Main Features of Production Units Where Corn is the Main Crop

Property regime and size	Total production units	*Spring-Summer Cycle* Units	*Spring-Summer Cycle* Production (a)	*Autumn-Winter Cycle* Units	*Autumn-Winter Cycle* Production (a)
Total	3,151,399	2,679,813	8,309,514	471,586	1,918,748
< 5 ha	1,907,799	1,682,977	2,467,775	224,822	309,428
> 5 ha	1,243,600	996,836	5,841,738	246,764	1,609,319
Private	746,854	655,428	2,733,145	91,426	603,581
< 5 ha	486,125	433,172	512,486	52,953	59,712
> 5 ha	260,729	222,256	2,220,658	38,473	543,869
Ejidos	2,286,698	1,916,498	5,097,272	370,200	1,245,671
< 5 ha	1,359,022	1,190,897	1,854,469	168,125	244,740
> 5 ha	927,676	725,601	3,242,802	202,075	1,000,931
Mixed	117,847	107,887	479,096	9,960	69,494
< 5 ha	62,652	58,908	100,819	3,744	4,976
> 5 ha	55,195	48,979	378,277	6,216	64,518

Notes: For an explanation on the *ejido* property regime, see endnote xxviii. 'Mixed' = publicly-owned land rented to private entities. (a) Unit: tons

Source: Author's calculations from National Agricultural and Livestock Census, 1991.

A third element is that, in many instances, the intrinsic fertility of soils may be higher in land which has been consolidated into a single plot. Historically, land allocated to *ejidatarios* may have been of lower quality (this was often how agrarian reform operated).

In so far as the evolution of yields is concerned, an important national survey covering *ejidos* showed that yields tended to drop in this sector between 1990-1994.[xxviii] This was attributed to unfavourable climate conditions adversely affecting production in 1994. However, this is not altogether clear as yields decreased for both rain-fed and irrigated systems. From this, it may be argued that the gradual deterioration of technological capabilities and shortage of credit have negatively affected all categories of *ejido* producers.[xxix]

3.3 Regional distribution of corn production

The following analysis shows the distribution of yields by state and highlights the concentration of small production lots, rain-fed cultivation, subsistence producers, poverty and nutritional indicators. The links between social and environmental factors are outlined (e.g. poverty/migration and soil quality, upland cultivation).

Mexican corn producers operate under widely varying social and environmental conditions: an intricate matrix of social and physical conditions serves as the framework for corn production in each locality. The components of this framework are best described as agro-ecological units.[xxx] The following description provides an overview of agro-ecological units involved in corn production in Mexico. Although the data come from the VII Agricultural Census carried out in 1990, the basic structure has not changed and our comments remain valid.

Table 3.4

Corn Yields by Ownership Rights and Plot Size (tons/hectare)

	Spring-Summer	*Autumn-Winter*
Mexico	1.13	1.56
< 5 ha	0.98	1.07
> 5 ha	1.20	1.71
Private	1.24	1.82
< 5 ha	1.01	1.09
> 5 ha	1.	1.97
Ejido	1.07	1.44
< 5 ha	0.97	1.06
> 5 ha	1.13	1.58
Mixed	1.	1.91
< 5 ha	0.97	1.09
> 5 ha	1.27	2.02

Source: Author's calculations based on National Agricultural and Livestock Census, 1991.

Corn producers are distributed throughout the country, but 80% of total production is concentrated in ten states. The top six states (Sinaloa, México, Jalisco, Chiapas, Veracruz, Michoacán) account for 60% of overall output. The concentration of output in the top ten states has been maintained in recent years but a few changes deserve careful consideration (see Chapter 2, Map 2.1, and Map 3.1). The states of Jalisco, Michoacan, México and Chiapas remain amongst the top producers, although the relative importance of Sinaloa and Veracruz grew within the group.

In fact, Sinaloa was the biggest producer in 1994 and 1997. This state is characterized by high levels of irrigation and mechanized agriculture and has reverted to corn production in post-NAFTA years despite having the potential to switch to alternative crops.

For some elements of the analysis, it is appropriate to divide Mexico into a northern and a southern part, although this should not lead to oversimplification. It is true that many technological indicators (e.g. unit size, irrigation, mechanization, chemical inputs, use of hybrids) reach higher levels in western and northwestern states. Because census data only offer a coarse degree of resolution, the maps fail to capture regional differences. In the states of Chiapas and Guerrero, for example, there are areas where input intensity is comparable to more competitive levels. Likewise, in the northwestern states of Sinaloa and Sonora, there are regions where subsistence production prevails under very difficult conditions. However, with this caveat in mind, census data do offer a reliable approximation of some key regional features and disparities.

The group of states with the highest concentration of production units lies in the central and southern regions of Mexico (e.g. Chiapas, Guerrero, Hidalgo, Oaxaca, Veracruz). In these states, producers operate on small plots of land, where rain-fed production predominates, yields are low and where there is a strong incidence of poverty.

The highest number of production units operating under rain fed conditions is also concentrated in these states (see Map 3.2). This is not surprising since rainfall is concentrated in this southern half of Mexico. At the same time, it suggests that this land is more exposed to erosive processes than land in the northern half of the territory.

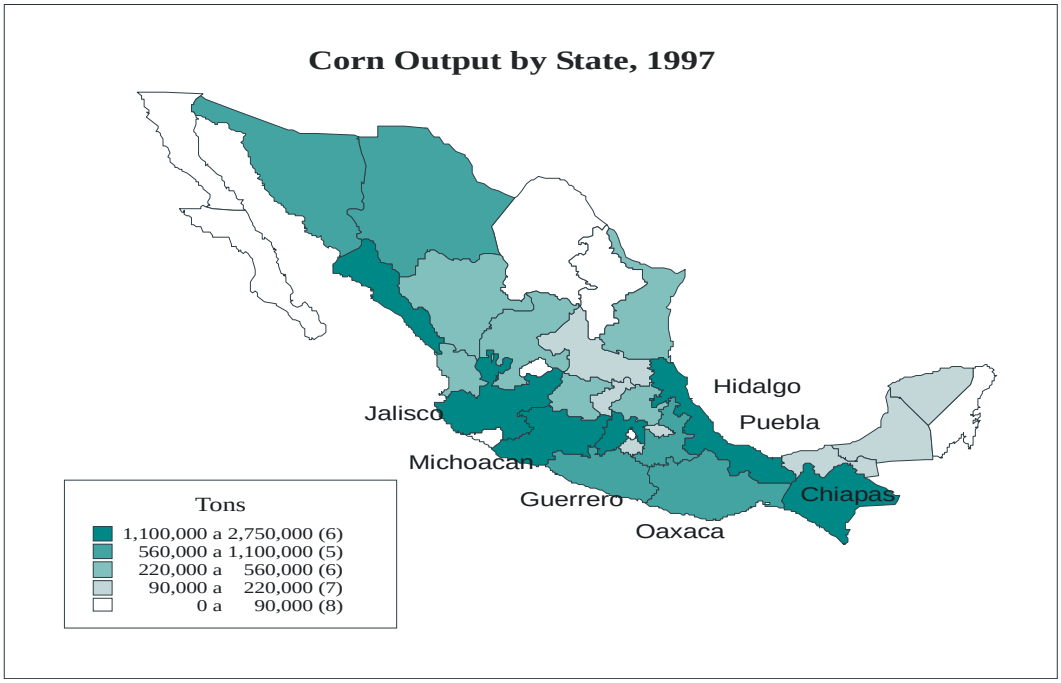
Table 3.5

Mexico: Corn Output by State, 1991-1997 (tons)

	1991	1992	1993	1994	1995	1996	1997
Nacional	**14251500**	**16969724**	**17961730**	**18235826**	**18352856**	**18023626**	**18085405**
Sinaloa	821000	1080913	2442387	2762275	2027474	1696177	2743653
México	1755997	1901211	1233449	1561746	2146471	2250753	2309412
Jalisco	2310590	2414243	2379659	2125336	2231290	2328157	2074195
Chiapas	983415	1607369	1593298	1096254	1696001	1543675	1485970
Veracruz	797570	852557	761335	929953	1104281	1182712	1186726
Michoacán	979195	919481	1039760	1042268	1293058	1130533	1102230
Puebla	1020398	1161287	944037	881146	1063857	1182504	869402
Guerrero	786516	989801	886835	765736	1112254	1072124	867374
Chihuahua	739955	948238	880086	487031	303627	412303	688196
Sonora	393714	295566	455175	542981	457480	834116	641216
Oaxaca	422014	512818	547654	623953	720714	683624	625462
Hidalgo	383867	484984	362081	453166	406140	427970	465226
Guanajuato	532760	777912	1255706	1020245	824005	757368	558236
Tamaulipas	443304	746921	1108759	1355550	818609	230338	262950
Nayarit	177992	170275	181221	317063	225790	224996	242109
Durango	239127	248487	289217	325088	291280	288146	238427
Zacatecas	216683	243900	243814	277618	296450	302291	229651
Tlaxcala	262051	376081	263250	310065	297076	328046	217356
Campeche	55565	111163	82135	115314	54889	133041	189481
Querétaro	60640	137515	111906	168409	186173	169207	161791
Tabasco	74294	67025	71255	125365	99995	140937	154920
Yucatán	131844	154166	116300	94582	73136	45049	143180
San Luis Potosí	210361	149713	88618	193209	160989	169285	120785
Morelos	67511	102928	94950	97599	115943	100732	98534
Baja Calif. Sur	77843	85203	89562	97492	40484	85065	89267
Colima	65372	57709	76546	90568	90654	94318	70147
Nuevo León	91140	92629	99730	159112	54759	43347	64661
Aguascalientes	47420	73188	65994	74037	85562	77249	63085
Quintana Roo	16227	33546	16848	6616	10410	37778	49917
Coahuila	62955	130384	104002	96172	44855	31851	49446
Distrito Federal	22168	16599	16071	16216	12826	12758	15696
Baja California	2012	25912	60090	23661	6324	7176	6704

Source: Centro de estadísticas agropecuarias. Secretaría de agricultura y ganadería (SAGAR).

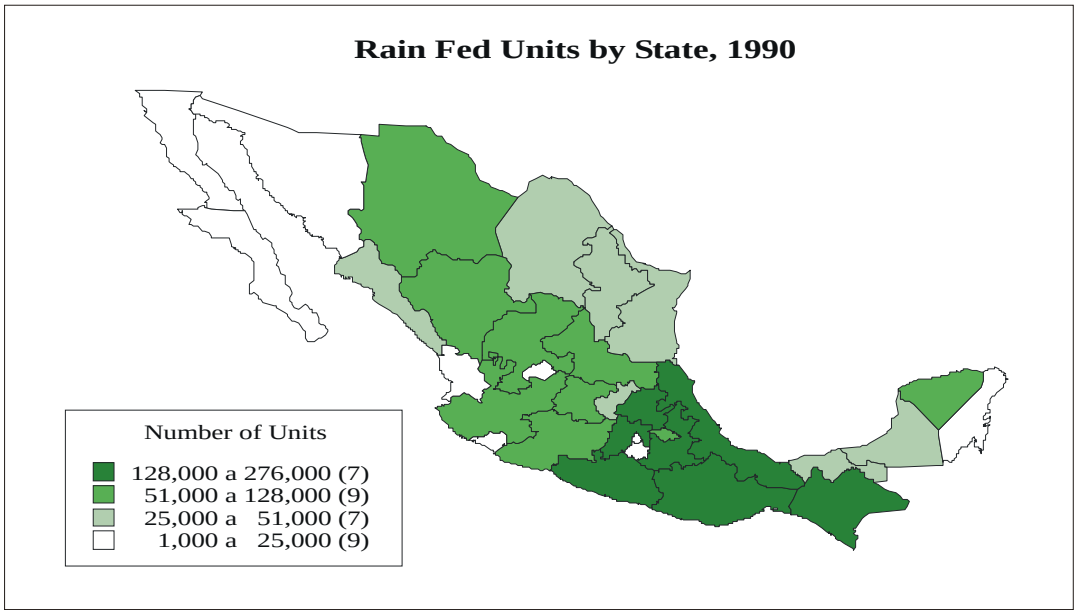
Map 3.1



Source: Author's calculations based on National Agricultural and Livestock Census, 1991

In some of these states, such as Guerrero and Oaxaca, production units have low yields even in comparison with other rain-fed regions of Mexico. This attests to the very difficult conditions under which producers operate, both in terms of geographical conditions (especially sloping terrain and unreliable rainfall patterns), as well as in terms of their ability to obtain credit and other inputs. The lack of adequate infrastructure is also a problem. Variations in altitude, climate, rainfall and wind patterns, as well as soil characteristics, make many of these regions particularly challenging for agriculture in general, and for corn production in particular (see Map 3.3.).

Map 3.2

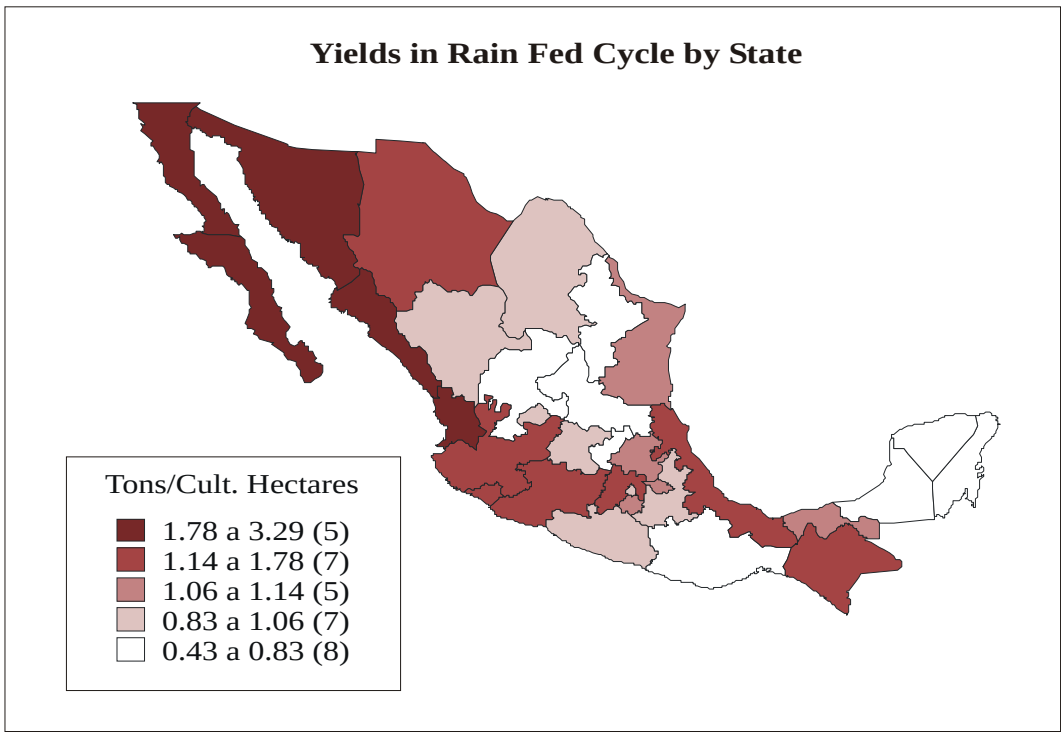


Source: Author's calculations based on National Agricultural and Livestock Census, 1991

The states of Chiapas, Oaxaca, Guerrero, Puebla, Hidalgo and Mexico have significant concentrations of smaller production units which operate mainly on a subsistence basis. These are states with a generally low-income population and they are important for the present study as they involve a high number of producers working with little or no irrigation. The production strategy depends critically on the resource management capacity of these households.

Key environmental services, such as conservation of genetic resources and soil, provided by poorer producers, have often been overlooked.[xxxi] On one hand, it has been argued that growth of vegetative cover in land left fallow will contribute to the restoration of top soil. On the other hand, as poverty becomes pervasive, producers resort to survival strategies based on small animals and there is liable to be severe overgrazing, especially on terraces and ridges along contour lines. In addition, soil conservation infrastructure (e.g. terracing, hedging) lacks adequate maintenance as producers migrate.

Map 3.3



Source: Author's calculations based on National Agricultural and Livestock Census, 1991

Production for household consumption is a clear sign of poverty and harsh economic conditions. It is not surprising to find a strong positive correlation between subsistence production and incidence of poverty. An important aspect of the poverty problem concerns women. Today, almost 50% of total rural population (23 million) is composed of women. The number of women who are the rightful owners of their plots has risen to 22% (up from 2% in 1975) in recent years. Where poverty is more intense, life expectancy is lower and the risks of death from pregnancy and birth are high. The duration of a typical woman's working day is more than 18 hours and in these states it exceeds that of men by as much as 43%.

Malnutrition is another element to be considered. Map 3.4 shows data from the 1996 survey on nutritional and health standards in rural Mexico (carried out by the National Institute for Nutrition). States where subsistence production of corn is important (and yields are low) have high levels of infant malnutrition.

Migration is an important linkage between NAFTA's corn regime and its social and environmental consequences. The relationship between NAFTA and migration cannot be ignored. After all, one of the central objectives of the trade liberalization agreement was to displace a significant number of people from their current livelihood into activities regarded as more efficient and profitable.

Recent studies show that migration remains a serious issue in Mexican agriculture. Focusing on international migration, Tuirán (1998) emphasizes the fact that supply of labour is determined by insufficient dynamism of Mexico's economy. From the perspective of Mexico's agricultural sector, Tuirán's findings, as well as those of other studies (Hinojosa and Robinson 1992; Levy and van Wijnbergen 1992) conclude that agricultural restructuring is a major cause of observed migration patterns.

Map 3.4

Source: Author's calculations based on National Survey on Rural Nutrition, National Institute for Nutrition, 1997.

A study focusing on Mexico's corn producers (Salas 1997) characterized the regions with the highest probability of generating migrants within its agricultural labour force. These regions have a predominance of poor *campesino* producers, small plots, poor soils, restricted scope for production alternatives and reliance on technologies structured around local landraces (i.e. very low penetration of hybrids and improved varieties).

This study also shows that the probability of definitive migration from rural areas increases if intermediate producers abandon production as a consequence of deep restructuring caused by corn imports. This has the effect of restricting the supply of jobs and poor producers (including subsistence growers) find it more difficult to satisfy their need for basic cash flow.

3.4 Summary and Conclusion

Corn remains at the core of Mexico's agricultural sector. Production is concentrated in five states, with a trend towards increased concentration in recent years (the top five states accounted for 48% of national corn production in 1990 and 52% in 1997). The composition of the top five states has changed and Sinaloa has become the biggest producer. This change is important as most of the output from this state comes from irrigated land and mostly from richer and more competitive producers.

'Modern'producers rely on capital-intensive production technology requiring intensive use of chemical inputs and irrigation. The environmental impacts of these production methods include salinization, soil erosion and aquifer pollution due to chemical residues.
One of the main conclusions of this chapter has been that subsistence production correlates positively with poverty and with greater reliance on genetic variability of corn (i.e. local landraces).

Heterogeneity of production conditions is one of the most important traits of the corn sector. This is due to the geography of Mexico, with its rich variety of landforms, climates, soil classes and

hydrological regimes. In addition, social differences in terms of property rights and economic power have also contributed to this diversity. Under these conditions, it is difficult to classify producers. However, for the purposes of the present study, three broad categories of producers have been identified:

(a) **'Competitive producers'** operate mostly under irrigated systems, or optimal rain-fed regimes, and good soil conditions; use input-intensive technologies, including hybrids and laser tools for optimum land levelling. Yields are competitive at the international level. The drop in domestic prices has reduced profitability, but does not threaten survival. These producers could switch to horticultural production, or other grains. However, entry barriers to the North American horticultural market, the fall in relative prices of other basic grains and possible substitute crops, suggest that they will not change production for the moment.

(b) **'Intermediate producers'** operate mostly on rain-fed land and lower quality soils, with fewer inputs, and use a combination of improved varieties, hybrids and local landraces. Growers in this category produce for the local or regional markets, as well as household needs. They are net sellers, and buy very little corn. Output has remained more or less stable, but profits have been significantly reduced or cancelled out. Continued presence in the corn sector is uncertain. Some might be forced to leave corn production altogether, but the same economic pressure forcing them out might push them to maintain at least part of their land and resources in corn production for household consumption. This is important as final consumer prices (especially in rural areas) continue to increase. If there is a significant decline in the number of intermediate producers, there will be a corresponding reduction in employment opportunities for poorer rural producers or landless workers.

(c) **'Subsistence producers'** operate on poor soils, mostly with animal traction and under rain-fed conditions. These growers usually rely on landraces which are better adapted to local conditions than hybrids. They do not sell a surplus in the marketplace and their harvest is stored for consumption during the year. However, this group of producers does not exist in economic isolation and is strongly affected by monetary flows and changes. To meet liquidity needs, they sell household assets, including labour and part of their stock of maize.

The strategies and responses of each one of these three classes of producers are analysed in depth in the following two chapters with a view to examining the social and environmental effects of NAFTA following implementation.

4. Production strategies at regional and household levels: environmental and social effects

This chapter presents the results of fieldwork and focuses on the household-level impacts of trade liberalization for each of the three producer groups identified in chapter 3. The effects of falling corn prices include loss of income, devaluation of land and other assets, disintegration of social structures, and impaired resource management capabilities.

4.1 Description of fieldwork

During 1998, corn producers were interviewed with the aim of obtaining information on the social and environmental consequences of the post-NAFTA fall in corn prices. The interviews covered relevant social, economic, technical and environmental issues, taking into consideration property rights, farm size, use of technology, off-farm activities, community relations, and the role of producers as consumers of corn and other products.

The interviews provided information on the nature of changes in the corn producing sector although it should be noted that the sample size was relatively small. Efforts were also made to gather data at a regional level, as many social or environmental processes may not be clearly identified by individual producers. Working at both local and regional levels also facilitated a degree of cross checking and verification.

Producers were interviewed as shown in Table 4.1.[xxxii]

Table 4.1

Corn Producers Interviewed

State	Municipalities	Interviewees	Interview Date
Chiapas	Venustiano Carranza	5	October 1998
Guerrero	Atoyac de Alvarez	3	November 1998
	Coyuca de Benítez	1	“
	Ajuchitlán	3	“
	Coyuca de Catalán	1	“
Jalisco	Cuquío	3	October 1998
	Ixtlahuacán del Río	3	“
Michoacán	Ario	5	November 1998
Puebla	Mazapiltepec	2	November 1998
	Nopalucan	9	October 1998
	Soltepec	3	“
		Total 38	

The regions where corn producers were interviewed are located in states that are important producers. Chiapas, Jalisco and Michoacán each contribute between 6% and 12% of total national production, with Guerrero, Oaxaca and Puebla, each responsible for between 3.5% and 6% of national production. Due to its small size, Hidalgo ranks lower on the scale of production.

Jalisco is part of the group of north-western states with the highest yields per hectare, where modern input-intensive agriculture is predominant. Chiapas, Michoacan, Hidalgo, Puebla and Guerrero have a greater diversity of producer types and thus lower yields. It should be noted, however, that in some regions of these states, yields are comparable to those of north-west Mexico. Oaxaca stands apart, having low yields and a predominance of production for household consumption.

Table 4.2 (page 50) summarizes the socio-economic characteristics of areas covered in fieldwork and Table 4.3 (page 51) summarizes the environmental characteristics.

4.2 Strategies in the 'competitive' sector

More than 463,000 corn growers operate at levels of profitability higher than 35% of total costs. Since 1998, these levels of profitability have been eroded, and in some cases, have even disappeared due to the elimination of price differentials between domestic and international prices.

Despite the assumption that modern corn producers will remain competitive under the new corn regime, there is little empirical information about the cost structures within which these producers operate. There is also little information on the economic, social and environmental problems that they face, or the technological and economic options that could be available in the future.

The competitive sector includes two groups of producers. On one hand, some growers utilize very capital-intensive technologies and attain high yields per hectare, and are thus able to make sufficient profit even after the drop in corn prices. On the other hand, some producers using less capital-intensive technologies attain modest profitability. Fieldwork concentrated on these producers, for example in Central and Northern Jalisco and the southern part of Nayarit.[xxxiii] Future sales are governed by advance contracts and intensive production methods may include the use of laser technology to check field levels, the use of computers, hybrid corn varieties, and high levels of fertilizers and pesticides. The use of genetically modified corn may also develop.

Competitive producers are found primarily in north-west Mexico, where public investment in hydro-agricultural infrastructure is concentrated, even though the southern half of Mexico has much higher rainfall. It is interesting to note that the states with the highest percentage of irrigated corn-growing land are not necessarily the most important in terms of national corn output. For example, the states of Baja California, Baja California Sur, Durango and Coahuila are unimportant in terms of national corn production, although there are large areas under irrigation. The north-western and north-central states of Sonora and Sinaloa are arid and semi-arid, but rivers provide the water necessary for commercial agriculture in the coastal plains. However, these water resources have been overexploited, and salinization is adversely affecting soil and land quality.[xxxiv] In addition, wastage levels are very high, especially in units where gravity irrigation is used. It is in these states that corn production has increased, since the profitability of corn still supersedes that of other crops.

Maps 4.1 and 4.2 show that the distribution of irrigated corn production coincides with high levels of fertilizer and pesticide use. The environmental impacts of intensive agrochemical use may include deteriorating soil and aquifer quality, whilst adverse effects on human health may also occur. The actual impacts of agrochemical residues have not yet been adequately studied in Mexico, but there is a risk that such impacts may limit productivity gains, in turn stimulating increased use of fertilizers to compensate for static or declining yields.

Other environmental risks potentially associated with competitive (intensive) corn production include the possible loss of landraces and wild relatives of cultivated corn varieties, the ecological hazards posed by genetically modified crops, depletion and contamination of water resources, and declining soil quality.

Table 4.2

SOCIO-ECONOMIC CHARACTERISTICS OF REGIONS COVERED IN FIELD WORK

	CHIAPAS		GUERRERO				JALISCO		MICHOACAN		PUEBLA	
	V. Carranza	Socoltenan.	Ajuchitlan	Atoyac	Coyuca	C. Catalán	Cuquío	Ixtlahuacan	Ario	Mazapilt.	Nopalucan	Soltepec
Population	51,756	13,819	38,107	62,039	67,490	44,834	17,034	19,248	31,254	2,358	16,974	10,906
Pop. Density (habs./km2)	37	18	19	37	42	21	19	34	50	52	96	78
Marginalization	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	MEDIUM	MEDIUM	MEDIUM	HIGH	HIGH
Infant Mortality Rate	3.80%	3.50%	3.20%	5.40%	4.40%	2.80%	3.70%	3.70%	2.80%	n.a.	5.70%	7.40%
Migration Dynamics	Attraction	Attraction	Stable	Stable	Stable	Stable	Expulsion	Expulsion	Expulsion	Stable	Attraction	Expulsion
Overcrowded housing	73%	78%	79%	73%	70%	69%	58%	59%	63%	64%	77%	74%
Dwellings w/out piped water	18%	36%	73%	20%	45%	76%	54%	35%	15%	33%	7%	8%
W/out connection to sewer system	30%	56%	95%	58%	48%	82%	49%	32%	48%	71%	62%	83%
Illiteracy rate	33%	34%	32%	18%	22%	31%	18%	16%	21%	13%	17%	16%
Persons per medical doctor	8,677	11,368	3,673	948	2,250	1,063	2,496	2,790	4,271	1,720	4,566	6,444
Population older than 15 years:												
Without schooling	38%	31%	34%	23%	27%	34%	23%	20%	23%	14%	20%	19%
With incomplete primary	30%	39%	29%	26%	21%	25%	39%	41%	31%	36%	33%	43%
Indigenous Population	18%	6%	0%	1%	0%	0%	0%	0%	0	0%	0%	0%
Self-employed workers as % of EAP	57%	61%	54%	53%	53%	52%	53%	50%	44%	47%	46%	68%
Income levels as % of EAP:												
Without income	15%	**15%**	**27%**	**20%**	**17%**	**22%**	**28%**	**28%**	**20%**	**18%**	**32%**	**45%**
< than 1 min. wage	41%	**49%**	**18%**	**18%**	**16%**	**16%**	**25%**	**18%**	**15%**	**22%**	**23%**	**25%**
between 2 - 5 min. wage	35%	**32%**	**37%**	**52%**	**49%**	**42%**	**34%**	**45%**	**48%**	**49%**	**36%**	**24%**
Agricultural Information												
Total surface (hectares)	38,862	18,541	17,657	66,329	46,423	59,028	52,975	64,082	37.707	2,822	10,379	7,015
Production Units	5,694	1,998	4,344	6,564	6,475	5,118	2,278	1,982	2,391	562	1,860	1,701
Private Property	51%	32%	19%	7%	4%	39%	85%	88%	55%	55%	43%	23%
Cultivated w/ corn & beans	100%	53%	100%	23%	43%	95%	99%	84%	100%	65%	60%	72%
Irrigation	12%	24%	23%	5%	3%	4%	6%	2%	7%	6%	8%	0%
Technology User (a)	92%	94%	80%	59%	49%	85%	77%	86%	79%	75%	92%	84%
Units selling agric. produce in market	77%	80%	32%	64%	60%	35%	70%	68%	55%	49%	37%	42%
Units selling livestock produce in market	13%	17%	17%	18%	14%	21%	49%	59%	22%	6%	4%	15%
Obtained credit	20%	53%	0%	15%	5%	6%	7%	14%	14%	7%	2%	12%

Table 4.3

MAIN ENVIRONMENTAL CHARACTERISTICS OF SELECTED REGIONS

Locality	Altitude (masl)	Climate	Rain fall (mm/year)	Soils	Vegetation	Infrastructure	Main Environmental Problems
Chiapas							
V. Carranza	600-1000	Subtropical	800	Warm climate podzols,	Transition between	The region has access to one of the largest	Soil erosion important due to irrational felling of trees (fuelwood, clandestine selling of wood)
Socoltenango	600-1000	(16-28 C)	-1100	alfisols, vertisols, oxisols.	tropical rain	dams in Mexico (La Angostura, 1976).	and aggravated by irrational cultivation practices (no minimum or zero tillage practices). In many
				Great diversity of soils, silt and	forest and deciduous forests	But irrigation is not generalized. Inadequate maintenance and little or no	cases, there is evidence of accumulation of chemical residues from irrational use of pesticides. Fertlizer use also poses serious problems. In the case of genetic resources, use of land races is
				clay-sized particles, particles, deep shallow (from 10-55 cm).	of dry climates.	new investment in infrastructure. Inadequate storage facilities favor purchases of harvests by large corporations (MASECA).	still widely spread. But in some cases, these varieties are crosses between older land races and improved varieties. Continued use of same variety without exchanging genetic material from other communities has impoverished germplasm: this is due to excessive endogamic production practices and lack of technical assistance.
Guerrero							
Atoyac de Alvar.	Coast Plains 0-150	Warm, humid	800	Cambisols, acrisols	Tropical and	Region well communicated through	Severe depletion of soil nutrients masked by excessive use of fertilizers. Soil erosion
C. de Benitez	Hills 150-1000	Mean temp.	-1330	and regosols	subtropical	federal highway system. Towns and villages	aggravated by lack of adequate cultivation practices, grazing by small animals in sloping
Ajuchitlán		28 C			rain forests.	connected through network of dirt roads.	terrain accelerates hydric erosive processes. Many new areas have been opened to grazing
		From warm			Deciduous forests.	There are no dams. Coastal region	and agriculture, enhancing erosion and accelerating deforestation. Accumulation of chemical
C. de Catalán	Ranging from Balsas river basin (250) to high sierras (3000)	sub-humid to cool, dry (sierra). Mean temp. 31 in *Tierra Caliente*			in sierras.	(Atoyac) has wells. There are no adequate storage facilities for grain. No new investments in infrastructure.	residues from pesticides (specially 2,4-D and Paraquat) and pollution of underground aquifers. Acidification of soils from excessive use of ammonium sulphate. Abandonment of local landraces serious threat from endogamic processes and from careless selection of seeds by inexperienced growers. All of these problems are getting worse.
Jalisco							
Cuquío				Regosol and feozem	Pine and	There are two important dams (one in Cuquío, one in Ixtlahuacán): insufficient capacity, and	Soil pollution by acumulation of chemical residues from pesticides, and soil depletion by excessive use of fertilizers. Deforestation from excessive felling of trees to build fences and
Ixtlahuacan	950-1700	Semi hot	801.5	(shallow soils), cambisol	oak forests,	dangerously low levels of maintenance	from forest fires that destroy a significant amount of woody areas. Soil erosion is also
	2000	sub-		(deep soils) and	subtropical	in past four yrs. Insufficient network	important due to lack of conservation in tillage practices (no minimum or zero tillage

		humid. Min. temp 7 C Max. temp. 38C		luvisols. Most soils of medium texture except luvisols made of finer silt textures). Mediocre drainage.	rain forest. Shrubs and and grasslands.	of dirt roads. Difficult passage in rainy season.	in region) and lack of adequate contour plowing. Moderate fall in water table depth.
Michoacan						Region is well connected by paved federal	Soil erosion processes, a constant in region, aggravated today by intensive and
Ario de Rosales	1950	Sub-humid to temperate with 10-20 C Temperate humid with 18-22 C	1028	Andosol (depth 20-40 cm), good for maize and avocado; litosol (10 cm) good for trees; vertisols fertile but with drainage problems	Pine, oak and cedar trees in sub humid areas; typical transition vegetation in in humid areas.	road system. Most townships communicated through system of dirt roads. There are no dams. Several small wells. Region has adequate storage facilities. No new public investments in infrastructure for agriculture in last four years.	careless cultivation practices (no minimum or no tillage practices in the region), lack of adequate infrastructure. Region needs live walls or barriers, alley cultivation, terraces, but none are being introduced. Deforestation accelerating erosive processes. Deforestation mainly due to overexploitation of forests, excessive clandestine cutting for fuelwood, and finally from uncontrolled forest fires (no resources to combat fires).
Puebla							
Mazapiltepec						Dust roads. No dams or drainage canals.	Soil erosion aggravated by lack of infrastructure to protect from eolian erosive processes.
Nopalucan	2490	Temperate	< 650	Litosols, regosols and feozen.	Pine and oak	Storage facilities: capacity of 2,450 tons	Deforestation has aggravated this negative trend (govt. policies have failed due to lack of
Soltepec	2490	sub-humid		Depth 60 cm, good drainage.	forests, evergreen	enough for normal production in region,	involvement by local producers). Minimum or no tillage techniques not used. Indiscriminate
	2490	Mean temps. 12-18 C.		Mediocre quality.	trees and shrubs; grasslands.	but facilities remain closed since 1996, have not received maintenance and are rapidly deteriorating (no electricity available). Zero public investment in agricultural infrastructure over past 4 years (a few streets in towns have been asphalted).	use of fertilizers: producers lack soil analysis and lack soil analysis and apply excessive doses without considering nutrient defficiencies or pH levels. Growers apply basically nitrogen, neglecting phosphorous and potasium. (Average application is 400 kg. per hect. of nitrogen sources (urea and ammonium sulphate). Soil and water pollution from accumulation of residues from fertilizers and pesticides. Important fall in water table. Deforestation caused by excess fuelwood consumption rates, local fuelwood market, opening new land for agriculture.

Notes and sources for Table 4.2

Population:	Conteo de población y vivienda, 1995. INEGI.
Marginalization:	This indicator measures four dimensions of social exclusion: housing conditions, education, income and rurality. Source: XI Population Census, 1990
Migration Dynamics:	Mortality and birth rates. Estadísticas Sociodemográficas, 1990-1995. INEGI.
Persons per medical doctor:	Boletín de información estadística, Sistema nacional de salud, 1994.
W/out connection to sewer system:	This indicator includes lack of indoor piping and flush toilets. Conteo de población y vivienda, 1995. INEGI.
Private Property:	Percentage of total productive surface under private property regime. Excludes ejidos and communal lands. Agricultural Census, 1991. INEGI.
Corn & beans:	Percentage of productive surface cultivated with corn and beans. Agricultural Census, 1991. INEGI.
Irrigation:	Percentage of land with some kind of irrigation system (by gravity or wells). Agricultural Census, 1991. INEGI.
Technology:	Percentage of land cultivated with one or more of the following: improved seeds, pesticides, fertilizers. Agricultural Census, 1991. INEGI.

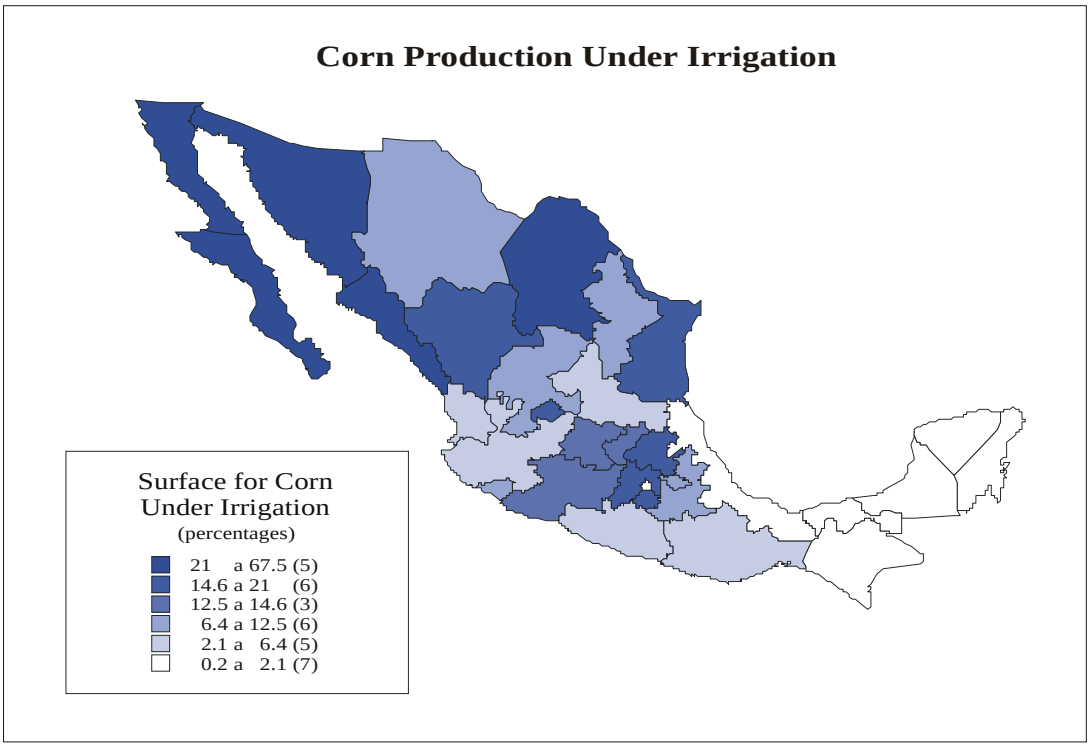
Corn producers already rely heavily on pesticides in the Pacific coastal states, where some of the top-producing states are located (e.g. Jalisco, Nayarit, Sinaloa). The impact on workers and human health are significant (see Alatorre 1997, Wright 1990). The capacity of the authorities to regulate the application of highly toxic chemicals has never been strong, and given the current lack of resources, there is no prospect of improvement. The intensive use of agrochemicals would also be maintained in the event of conversion from corn to horticultural production.

Horticulture is heavily dependent on pesticides (see Thrupp 1994:10-12). Integrated pest management (IPM) still has a long way to go before it is fully accepted by growers in developed countries (see Cowan and Gunby 1996), and is unlikely to be widely used in Mexico in the near future.

In order to sell to the North American market, stringent requirements must be satisfied. These include the following (see also Thrupp 1994): compliance with strict sanitary and phytosanitary standards, compliance with limits for chemical residues in products, high aesthetic quality standards,[xxxv] strict observance of delivery timetables and volumes. Because of high perishability rates, special production, packaging and handling technologies must also be used, and there is a need for well-developed marketing channels, transportation and infrastructure.

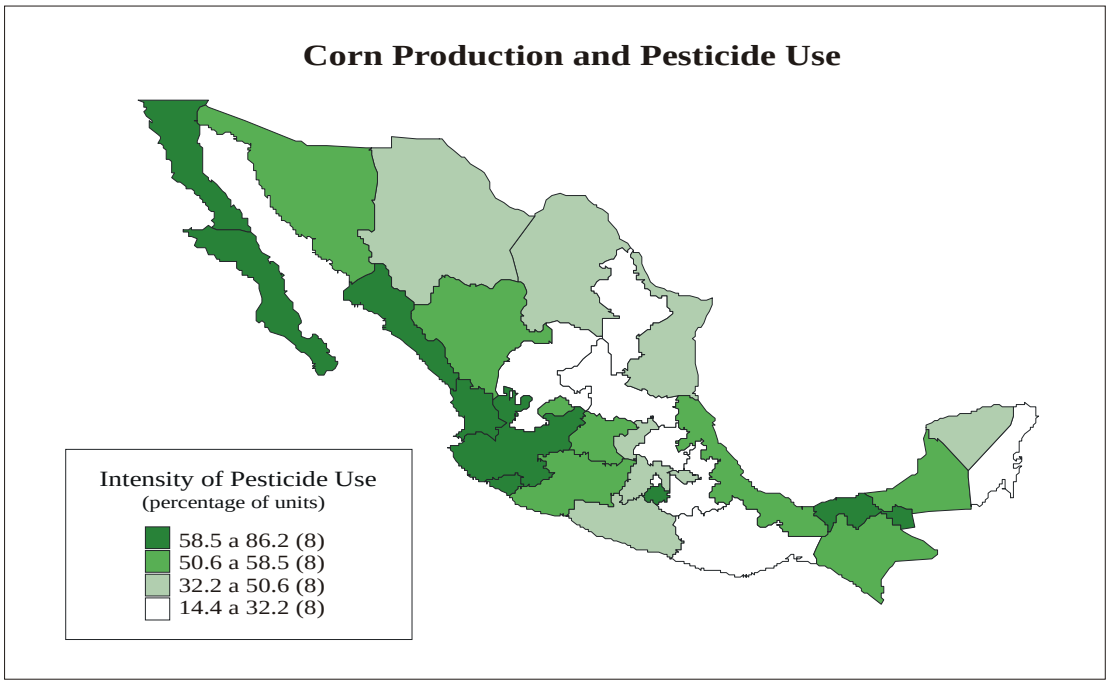
The demand from consumers to have 'blemish-free' fruit and vegetables is an additional factor encouraging heavy use of pesticides, especially for crops such as flowers, pineapples, mangoes and strawberries. Health hazards from the application of these pesticides are severe, as agricultural workers rarely use preventive measures. There is a clear trend to rely on cheap, unskilled labour, and most of the jobs created are temporary (Wright, 1990). In Mexico, Bustamante Alvarez (1996) has examined many of these issues in the context of melon harvesting, packing and marketing in the Tierra Caliente region of Guerrero. The study is particularly relevant as it covers a region where maize lost ground to non-traditional crops (sesame and melons).

Map 4.1



Source: Author's calculations based on National Agricultural and Livestock Census, 1991

Map 4.2



Source: Author’s calculations based on National Agricultural and Livestock Census, 1991

State of Jalisco

See Table 4.4: Corn production accounts of growers in Cuquío and Ixtlahuacán, Jalisco

In the regions of Cuquío and Ixtlahuacán de Rio in the state of Jalisco, there are competitive producers who operate on good quality, rain-fed land. Their yields are high enough to define them as competitive, but they are still below those of the more capital intensive producers in Mexico's north-west. Their production accounts serve as indicators of the problems encountered in this category of producers.

The cost structure of these competitive producers already shows the level of capital intensity. The largest unit (producer 2, Cuquío) owns 50 hectares, delivers 500 tons of corn to the regional market (most of this ends up in the corn flour industry), and owns 100 cattle which provide a significant revenue every year. The average yield is 10 tons per hectare at a cost $6,650 per hectare. With unit production costs below 50% of selling price, this producer belongs to the top category in terms of profitability, even in view of the post-NAFTA price reductions. Livestock provides an additional flow of income.[xxxvi]

In this unit, more than 70% of costs arise from tractor use, hybrids, fertilizers and pesticides. Fertilizers alone account for 20% of costs and this percentage is rising. Prices for tractor rental have remained more or less stable in the past three years. Other costs are related to employment of labour for soil preparation, harvesting and de-husking. Since this unit belongs to a large family, the labour supply is also domestic.

The use of hybrids in this region does not entail a serious risk of genetic erosion.[xxxvii] In fact major losses of genetic diversity occurred in most of Jalisco state several decades ago, when whole sets of corn varieties were abandoned in favour of new fertilizer-responsive varieties. In the 1940s and 1950s, varieties such as the *Tabloncillo* family were replaced by improved varieties (Wellhausen 1988:23), which have, in turn, been substituted by more capital-intensive hybrids. In the future, these may be replaced by transgenic corn and bio-engineered seeds.

Although this producer is by far the most profitable of the group shown in Table 4.4, the general pattern of cost structure applies to the rest of the group, with all but one showing a net profit. These competitive producers also have access to other sources of income (e.g. cattle sales, off-farm employment). Mechanization is high and thus competitive producers are not large contributors in terms of employment generation.

For the foreseeable future, these producers are likely to remain in the corn sector, delivering their produce to the regional market, either to small *nixtamaleros*, or to the large industrial flour companies, and other consumers (e.g. food, animal feed, or starch industries).

Table 4.4 contains one case of a producer operating close to the break-even point, or even with a moderate loss (producer 1, Cuquío). This unit covers 14 hectares, with an input mix that closely resembles that of the other producers in the group. However, yields are low at only 4 t/ha and this leads to inefficient unit costs. This producer is vulnerable and it is not clear that he will be able to remain in the corn sector. The main obstacles to continued production are the high cost of tractor rentals, erratic rainfall, and the increasing amount of fertilizer required as a result of soil acidification. The price of tractor rentals will continue to rise in line with the growing cost of diesel fuel.[xxxviii] If fertilizer prices are not reduced, the economic viability of the whole operation is at risk. Crop substitution could be one response, but whether or not it is a realistic option depends on the relative prices of other crops. Since

there are also costs involved in crop substitution, the shortage of credit availability is another important obstacle.

Intermediate capital-intensive production could continue in this region of Jalisco (Cuquío and Ixtlahuacán) for some time with important environmental implications (see Chapter 5, page 76).

Loss of topsoil and erosion are already serious problems in the state of Jalisco, which is particularly affected by water-led erosion. Annual precipitation is between 750 mm and 1,060 mm, whilst up to 77% of land suffers from erosion.

In effect, soil erosion is reducing the scope of Mexico's future development options. In the case of level ground under rain-fed cultivation, the main problems are loss of the arable segment of the 'A' (upper) horizon, which normally contains most of the organic matter, and the formation of scabs (hard, compacted layers).[xxxix] Erosion is accompanied by loss of soil productivity, and although the process is theoretically reversible, the costs involved may be prohibitive, and in many cases the threshold of reversibility has been crossed.[xl]

Although precipitation in Jalisco is less high than in tropical regions of Mexico, vegetative cover is less dense and the upper soil layer is thinner. This combination may have very negative effects if intensification of ploughing continues, if monocultures continue to expand, and if no conservation practices are adopted. Erosion also makes soil more vulnerable to the adverse effects of drought in areas of irregular rainfall.

Soil erosion leads to loss of fertility and a decrease in productivity when the epipedon (including parts of the B horizon) is truncated.[xli] Although this process may be temporarily retarded (e.g. if fertilizer use is increased) production may continue but profitability will decrease. Farmers may find themselves in the difficult position of continuing practices for short-term survival which they know to be unsustainable in the long term. Alternatively, they may put additional pressure on their land (or on common property resources) in order to counter the negative trend in yields. This launches a new round of increased erosion.

In the Cuquío-Ixtlahuacán region, ploughing and tillage practices could be changed in order to reduce costs and improve soil conservation. The necessary techniques are well known and readily available. They include *inter alia* contour ploughing and planting, terracing, planting of hedgerows and cover crops, application of mulches, use of crop rotations, leaving land fallow, adopting minimum- and no-tillage systems, ridge planting and alley cropping (see Villar Sánchez, 1996, for a good summary). Many of the techniques listed above involve significant labour costs or use of heavy earth-moving equipment. There may also be high maintenance.[xlii]

The erosion-control practice of 'contour ploughing' where the plough follows the contours of different levels of cultivated land, may not be compatible with use of large machines, which have limited manoeuvrability, especially on sloping land.[xliii] There are no studies of this issue in Mexico, but it is reasonable to assume that where contour ploughing is required to reduce erosion, costs increase, particularly when ravines, hedges or trenches have to be negotiated.

Data on mechanized corn production by state (see Map 4.3) show that mechanization has been greater in the northern half of Mexico, where rainfall is less intense but where the topsoil is generally thinner and the risk of wind erosion is greater. Intensive ploughing and grazing both further increase the rate of erosion.

Minimum- or no-tillage practices (conservation tillage) have been recommended for these areas. This involves leaving post-harvest plant material on the ground, instead of traditional ploughing-in or burning. This helps to retain moisture and protects the soil from wind erosion.

Many case studies report significant increases in yields at the same time erosion is reduced (see for example Villar Sánchez 1996 in La Fraylesca, and Cadena Iñiguez 1995, for the Sierra Madre of Chiapas). However, more intensive use of herbicides is needed in order to eliminate weeds which would otherwise be removed by ploughing.

One of the most important methods for controlling erosion is to maintain good vegetative cover. Plant cover intercepts and dissipates the energy from falling raindrops before they strike the soil, minimizing salinization effects and reducing the volume of sediment released by the falling drops. In addition, plant roots and stems diminish runoff and facilitate infiltration of water. Soil humidity increases and further facilitates plant growth in a self-reinforcing process. Unfortunately, in the case of producers in Cuquío and Ixtlahuacán in Jalisco, this alternative is incompatible with present-day commercial production.[xliv]

The findings of the present study indicate that the interaction of NAFTA trade liberalization with restrictions on public investment are inhibiting measures to tackle soil erosion and even leading to faster rates of erosion by encouraging continued intensive corn production.

4.3 Intermediate producers

A significant number of corn producers maintained adequate levels of profitability (profits less than 33% of total costs) in the past, before domestic prices were aligned with international prices for yellow corn. According to the 1990 census, this category accounted for more than 473,682 units, covering 1.7 million hectares.

Following the NAFTA-induced price reductions of the past three years, this group has probably lost its capacity to maintain profitable production. The present study examined the situation in three regions: Ajuchitlán and Coyuca de Catalán in the state of Guerrero; Venustiano Carranza in the state of Chiapas; and Mazapiltepec and Soltepec in the central state of Puebla.

State of Guerrero (Ajuchitlán and Coyuca de Catalán)

In the state of Guerrero the area known as 'Tierra Caliente' lies in the basin of the Balsas River, a giant east-west depression more than 300 kilometres long and 50 kilometres wide. The Sierra Madre del Sur flanks its southern margin, with numerous streams and rivers feeding the Balsas River. The alluvial valleys and plains in this region are suitable for agricultural production, and the region has been marked by significant transformations of land-use patterns and crop substitution over the past fifty years. Construction of crop irrigation began in the 1940s and 1950s, and continued until the early 1990s. Nowadays, there are problems resulting from inadequate maintenance, and although some areas are officially described as 'under irrigation', the canals and ditches have no water (Bustamante Alvarez 1996:160-161). Nonetheless, the basic infrastructure ensures considerable irrigation capacity that is mainly utilized for commercial crops.

For the purposes of the present study, this region is doubly important: first, because corn production has persisted in the context of deep processes of transformation in land-use patterns; second, because corn production today co-exists with the production of cantaloupe melon, a crop earmarked basically for export to the United States. It should be noted that intermediate corn producers are not themselves producing melons, rather they may benefit from melon production by gaining off-farm employment in melon cultivation. The dynamics of the economic forces unleashed by NAFTA can be observed here in the context not only of the income effects that price reductions have on corn growers, but also in relation to the

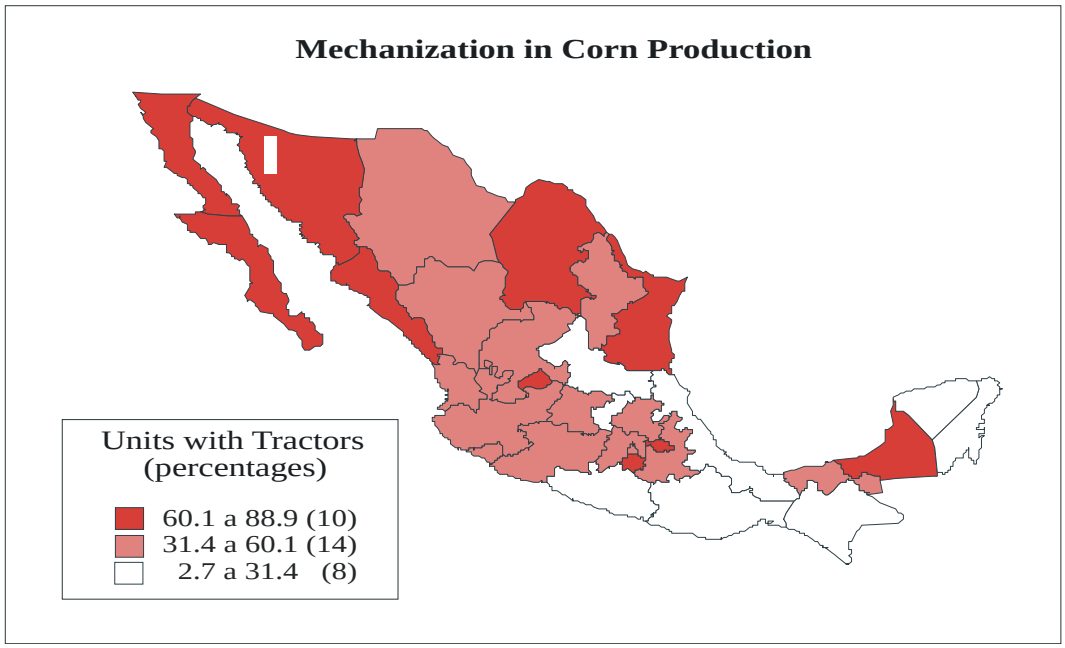
Table 4.4

Corn Production Accounts of Growers in Cuquío and Ixthlahuacan, Jalisco

	Cuquío		Ixtlahuacán del Río		
Activities & Inputs	**Producer 1**	**Producer 2**	**Producer 1**	**Producer 2**	**Producer 3**
Plowing operations					
Preparation	$500	$250	$300	$250	$500
Sowing	250	300	250	280	250
Secondary operations(a)	300	200	400	300	300
Seed	900 (HY)	900 (HY)	670 (HY)	900 (HY)	672 (HY)
Fertilizer	1,300	1450	1290	1750	1290
Fertliz. Labor costs	90		60	90	60
Weeding and Pest Control	615	600	600	580	600
Labor costs	120	100	120	120	150
Harvest	500	800	500	900	950
De-husking of grain	400	600	300	400	350
Transportation			380		380
Other activities	750	1450		900	575
TOTAL	**$5,725**	**$6,650**	**$4,200**	**$5,570**	**$5,455**
Land Owned (has)	14	50 (private)	10	83 (private 53; ejido 30)	21 (private)
With maize	14	50	10	36	16
Average Yield (ton/hect.)	4	10	5	7	6.25
Unit Cost per Ton	$1,431	$665	$840	$924	$873
Total Corn Output (tons)	55	500	50	260	100
To Market	97%	94%	100%	100%	85%
To Household Needs	3%	6% (including for feedstock)	0%	0%	15% (human and cattle feed)
Surface w/ other crops (hs.)	0	0	0	Not reported	5 (beans)
Intercropping	No	No	No	No	No
Family Size	7	10	3	7	5
Revenues from PROCAMPO	$6,950	$25,000	$6,650	$25,020	$17,000
Livestock	No	100 cattle	25 cattle	62 cattle	52 cattle
Other Sources of Income including off farm sources)	Employment in same locality	Employment in same locality. Sale of 20 cattle per year. Migration.	Employment in same locality Sale of cattle. Migration.	Cattle sales, employment in same locality.	Cattle sales, employment in same locality.
Main Problems Encountered	Yearly rainfall patterns vary widely. High pH in soils. High and increasing tractor costs.	Increasing use of fertilizers, erratic rainfall.	Tractor costs, lack of credit. Reduced employment opportunities.	Rising tractor rentals due to rising fuel costs. Rainfall patterns.	Rising tractor rentals. Erratic rainfall patterns. (Sometimes hail and excess humidity).

Source: Data generated by fieldwork.

Map 4.3



Source: Author's calculations based on National Agricultural and Livestock Census, 1991.

substitution effects implied by the shift to melon production. To understand this process, it is important to review some of the salient features of production in the region.

There has always been corn production in the Tierra Caliente, but during the 1940s the production of oil seed, especially sesame, began to expand considerably, displacing corn as the main crop in the 1960s and reaching a peak in the early 1970s. By the end of that decade, the downward trend in international and domestic prices of sesame led to the collapse of sesame production in the region. In the 1980s, corn production regained its previous importance in the region. In 1991, the area cultivated for corn was 70,000 hectares, while sesame covered only 2,000 hectares.

During the phase of sesame production, producers lost the capacity to generate food for their families and livestock, and community life was disrupted as migration increased. These effects were particularly serious for poor corn producers who, lured by the promise of sesame as a cash crop, entirely abandoned corn production. They were bound by schemes of production by contract, where access to credit was conditioned by entry into the sesame circuit. When the sesame market started to decline in the 1970s, these producers were caught in a crisis.[xlv] However, corn production soon recovered its pre-eminence.

Nowadays, production of corn on rain-fed land coexists with production of cantaloupe melon on irrigated land. Other commercial crops grown under irrigation include perennials such as mango, lemon, papaya and bananas. Melon production generally occurs in the valleys that were opened to irrigation 30 years ago. A study by Bustamante Alvarez (1996:209) indicates that the area of irrigated land has decreased in the last few years and that there is a significant wastage of water.

Production of melons can be labour intensive, but in this part of Mexico, there has already been a significant degree of mechanization in order to minimize costs. Expansion of production has also been the result of more capital-intensive processes, including mechanization, improved (and costlier) seeds, better fertilizers, and greater use of pesticides.

As pests and insects become resistant to toxic compounds, pesticides need to be applied with greater frequency. In the early '80s, pesticides were used six to seven times during the plants' lifecycle. By the middle of the decade, the number of applications rose to nine and to 11 by the late 1980s. During the 1995 cycle, pesticides had to be applied up to 14 times in some parts of the region (Bustamante Alvarez 1996:248). The long-term environmental consequences of this have not been evaluated, but it is obvious that the discharge of 500 tons of pesticides and 5,000 tons of fertilizers every season for melon production alone will have severe adverse consequences (Ibid.).

For corn producers in the region, there are few new employment opportunities from melon production. The increment in production has not been accompanied by growth of area under cultivation.

The intermediate corn growers in the Tierra Caliente region are operating on land where yields were sufficiently high to give limited profitability under the old price regime. Nowadays, as can be seen from the corn production accounts in Table 4.5, profitability has virtually been eliminated. Producers in Ajuchitlán remain slightly below the break-even point, meaning that migration and off-farm employment (partly in melon cultivation) are vital livelihood strategies. The sesame and melon revolutions led to the dismantling of many rural social structures, reducing the capacity of entire communities to make a living from local resources. The release of labour when sesame prices dropped was the beginning of a major migration process which led to the development of new and very different social networks in many cities in Mexico and the United States. Because mechanization and more capital-intensive methods are being used in melon cultivation, and as corn prices have decreased, migration remains an important option for many households.

See Table 4.5: Corn production accounts of growers from Ajuchitlán and Coyuca de Catalán, Guerrero

For intermediate corn producers, the persistence of low prices, lack of credit, and stagnation of infrastructure, is combined with the impact of melon production on tractor rental, and fertilizer/pesticide costs (the latter now average 32% of total costs).

In the near future, these producers will probably remain in corn production, at least to meet household needs. Other options include growing alternative basic grains, or turning land over to grazing. Melon production is not an option because of the hydrological regime required. From a purely technical viewpoint, other cash crops, such as peanuts or alfalfa, might be possible.

State of Chiapas (Venustiano Carranza)

See Table 4.6: Corn production accounts of growers from Venustiano Carranza, Chiapas

Corn producers interviewed in Chiapas and Puebla showed clear operating losses. This is particularly striking for Chiapas, a region that has traditionally been an important centre in the corn sector. Chiapas is located on the north side of the Grijalva River valley, near the large 'La Angostura' dam, built in the 1970's. Venustiano Carranza today benefits from good communications, but its productive capacity is facing severe problems, from both socio-economic and environmental perspectives.

The level of corn prices recently acquired life-or-death proportions in the region. In November 1996, corn growers from Venustiano Carranza set up road blocks in protest against the drop in corn prices. CONASUPO had virtually withdrawn from the region and, in any event, the limited corn purchases it had been making were at very low price levels.

Table 4.5

Corn Production Accounts of Growers from Ajuchitlán and Coyuca de Catalán, Guerrero

Activities & Inputs	**Ajuchitlán** Producer 1	**Ajuchitlán** Producer 2	**Ajuchitlán** Producer 3	**Coyuca de Catalán**
Plowing operations				
Preparation	1000	1000	650	1000
Sowing	200	250	250	200
Seed	540	450	540	540
Fertilizer	1160	565	1160	1160
Fertliz. Labor costs	200	200	200	200
Weeding and Pest Control	346	351	351	351
Labor costs	200	200	200	200
Harvest	400	400	400	400
De-husking of grain	240	250	720	640
Transportation	80	160	160	80
Other activities				
TOTAL	**$4,366**	**$4,626**	**$4,631**	**$4,771**
Land Owned (has)	11	4	2	7
With maize	3	4	2	7
Average Yield (ton/ha.)	3	4.5	4	3
Unit Cost per Ton	1455	1028	1158	1590
Total Corn Output (tons)	9	18	8	21
To Market	80%	80%	80%	66%
To Household Needs	20%	20%	20%	34%
Surface w/ other crops (hs.)	Not reported	No	0	0
Intercropping	No	No	No	No
Family Size	5	5	5	8
Revenues from PROCAMPO	$626	$1,800	$1,200	$1,871
Livestock	48 cattle (on common lands)	0	0	0
Other Sources of Income (including off farm sources)	Strong migration: five family members in USA. Small commerce.	Rural employment in locality.	Rural employment in locality. Migration.	Employment in local agricultural activities. Small commerce.
Main Problems Encountered	Rising costs of inputs.	Rising costs of inputs.	Rising costs of inputs, erratic climate conditions.	Incidence of pests and excessive reliance on fertilizers.

Source: Data generated by fieldwork.

State troopers were sent to reopen roads, but support for the corn growers was strong and the roadblocks were maintained. The authorities sent reinforcements, including helicopters, and shots fired from one helicopter killed three of the demonstrators. Public outrage led to a redefinition of CONASUPO's role in the region and it resumed operations at higher prices.

Unit production costs have remained below domestic price rates, so that intermediate corn producers continue to make a modest profit. As can be seen from Table 4.6, unit costs are approximately 25% lower than post-NAFTA corn prices. However, most of these producers still need to obtain additional income. Producers interviewed for the present study expressed concern about the future of employment opportunities in the region. It appears that profitability is currently being maintained somewhat artificially by excessive reduction of operating costs.

Soil erosion is an important environmental problem in Venustiano Carranza and producers have had to rely on increasing use of fertilizers. Run-off from cultivated fields inevitably ends up in La Angostura dam. There is no tradition of crop rotation, leading to depletion of organic matter and nutrients in the soil and a build up of pests. This can be disguised for a time by increasing fertilizer and pesticide doses, but this eventually raises costs beyond the threshold of economic viability. In addition, assiduous corn cultivation without rotation also leads to a greater incidence of pests.

Deforestation is also significant because many producers have had to put increasing pressure on forested areas, either due to the opening-up of new land to agriculture and grazing, or to increased use of fuelwood. Part of the fuelwood harvest is sold in smaller villages or even at the market in Venustiano Carranza.

As can be seen from Map 4.4, forest cover is most seriously damaged in the states of Chiapas and Guerrero, which (together with Michoacán) have extensive forests and large numbers of intermediate corn producers. In these three states, the expansion of the area under corn cultivation has been significant, as shown in Table 2.6 (see Chapter 2). There are clear signs that the agricultural frontier was extended at the expense of forested areas during the first years of NAFTA implementation.

Since they operate primarily on rain-fed land, corn producers in Venustiano Carranza do not have much alternative in terms of switching to other cash crops. One of the viable alternatives is sugar cane, while beans and sorghum remain a possibility. However, as explained in Chapter 1, the sugar cane sector is unlikely to expand due to last-minute changes in NAFTA definitions. Beans and sorghum may become more attractive in the future, depending on the evolution of relative prices. However, if tortilla prices keep rising, producers will continue to produce corn to cover household consumption needs.

Introducing intercropping and techniques such as minimum tillage, integrated pest management, better soil analyses and improved fertilizer dosage and composition, could help to reduce costs, increase welfare and minimize environmental impacts. However, this would require adequate investment and accessible credit, two elements currently missing from the regional economy.

If domestic corn prices continue to be aligned with international (U.S.) prices, growers in Venustiano Carranza will have to obtain income from other employment. Even if they continue to produce corn for household needs, they will be forced to look for other sources of income. This is partly explained by the extremely low level of rural wages (the 1991 Agricultural Census reported that 41% of the population of Venustiano Carranza earned less than one minimum wage, making it one of the poorest areas covered in the present study). Beans and sorghum are unlikely to provide sufficient additional earnings and off-farm sources of cash will probably be needed.

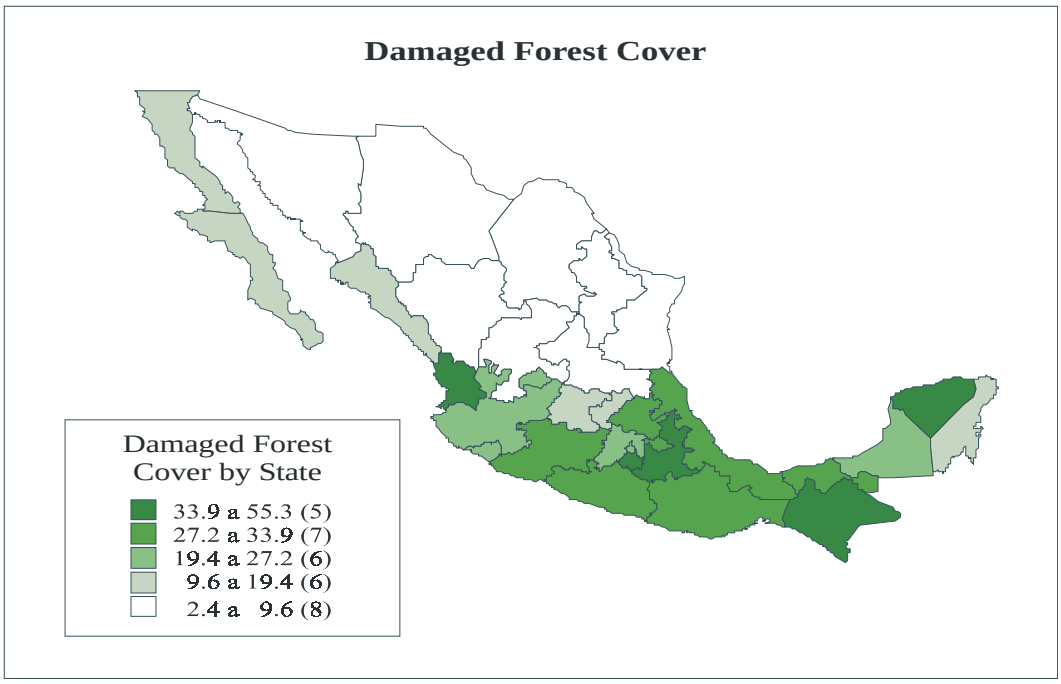
Table 4.6

Corn Production Accounts of Growers from Venustiano Carranza, Chiapas

Activities & Inputs	Producer 1	Producer 2	Producer 3	Producer 4	Producer 5
Plowing operations					
Preparation	420	420	420	400	420
Sowing	120	180	120	210	180
Seed	350 (HY)	20	350	350 (HY)	150
Fertilizer	750	768	750	720	720
Fertliz. Labor costs	90	90	90		90
Weeding and Pest Control	400	362	510	448	100
Labor costs	200	180	30	120	60
Harvest	300	360	300	600	600
De-husking of grain	180	255	180	365	125
Transportation	520	110	100	150	100
Other activities		60	60	30	
TOTAL	**$3,390**	**$2,805**	**$2,910**	**$3,393**	**$2,545**
Land Owned (ha)	3	6.5	27	7.5	5
With maize	3.75 (access to communal land)	6.5	9	7.5	5
Average Yield (ton/h.)	3	3	3	3	3
Unit Cost per Ton	$1,130	$1,130	$1,130	$1,131	
Total Corn Output (tons)	9	19.5 (5 in 1998)	27	10 (1998 was a bad year)	15
To Market	77%	88%	92%	90%	90%
To Household Needs	23%	12%	8%	10%	10%
Surface w/ other crops (hs.)	25 (beans in communal land)	No	.25 (beans), .5 (sorghum)	0	0
Intercropping	No	No	No	No	No
Family Size	5	8	6	4	7
Revenues from PROCAMPO	$1,875	$1,250	$5,677	$2,500	$1,875
Livestock	Pigs in common land	No	10 cattle	No	No
Other Sources of Income (including off farm sources)	Sales of animals, employment in corn production in same locality.	Employment in corn production in same locality.	Sales of animals, employment in corn production in locality.	Employment in corn production in same locality.	Employment in corn production in same locality.
Main Problems Encountered	Lack of rain; incidence of pests; lack of adequate fertilizers	Drought; deterioration of soils; incidence of pests.	Drought; deterioration of soils; incidence of pests.	Erratic rainfall; incidence of pests; loss of nutrients in soils and need to increase fertilizer doses.	Weeds and other pests have increased; loss of soil fertility; erratic rainfall.

Source: Data generated by fieldwork.

Map 4.4



Source: Semarnap, Inventario Forestal Períodico, 1994

Because all producers in the area face the same problems, it is liable to become a source of migration. The region is already showing signs of a greater outflow of young men and women seeking jobs elsewhere, leading to an increase in mean age of the population. It is more difficult now to find a job in Venustiano Carranza than four years ago.

State of Puebla (Mazapiltepec and Soltepec)

See Table 4.7: Corn production accounts of growers from Mazapiltepec and Soltepec, Puebla

Intermediate corn producers in Puebla are also experiencing great difficulties, with very narrow profit margins or even losses. In the case of the Mazapiltepec and Soltepec areas, migration has intensified in the past three years, with 30% of Soltepec's population migrating to the urban centres of Puebla and to Mexico City in 1997. In Mazapiltepec, the proportion of the population engaged in migration increased from 32% in 1996 to 39% in 1997.[xlvi]

The reasons behind this process are clear. The region lacks industry, tourism or potential for large-scale development of commercial crops. In view of the recent evolution of corn prices, the bigger growers have started to leave the sector, further reducing employment opportunities and exacerbating pressures to increase migration. Smaller producers who continue to grow corn rely more on small animals and other off-farm activities, such as operation of small commercial units.

There are several important environmental problems that afflict the region. Of the six regions covered during fieldwork, Puebla is the least well endowed in terms of water resources. Rainfall is low (650 mm) and irregular and there are no dams or irrigation canals flowing into

the area. As a result of the low supply and relatively heavy use, water tables are dropping at a rapid rate (e.g. from 39 metres depth in 1985 to more than 83 metres in 1998) and the region faces regulatory restrictions. All of the corn producers interviewed for this study regarded inadequate rainfall as their worst problem.

Another important problem is the accumulation of chemical residues from intensified use of fertilizers. The production accounts presented in Table 4.7 show that in spite of severe economic difficulties, producers regularly invest significant amounts in fertilizers. However, these chemicals are applied with inadequate analyses of soil properties and plant requirements, leading to excessive use, accumulation in soils and, probably, deposition in aquifers through filtration.

Erosion is another serious issue in the region, as well as in the state as a whole. Most agriculture in Mazapiltepec and Soltepec takes place on gently sloping terrain, where intensive cultivation with little crop rotation promotes erosion. This is exacerbated by the practice of removing the vegetation cover at the beginning of each growing cycle, thereby allowing rain drops to hit soils directly and maximizing release and transport of sediment. This loss of topsoil reduces fertility and is countered through increasing use of fertilizers.

Some producers in the region have tried to increase yields by planting corn more densely (35,000 to 40,000 plants per hectare). However, as plants compete for water, nutrients and sunlight, the result is often a drop in yields, and higher costs (e.g. due to higher dosage of fertilizers). This is what has happened to several producers in Mazapiltepec.[xlvii] Growers in the region are normally entirely self-sufficient in corn and do not need to purchase grain, dough or tortillas in their local markets. Local landraces are used, which favours selling to local community markets since landraces are considered most appropriate for direct human consumption, in the form of tortillas, corn on the cob or tamales.

Loss of genetic resources through introduction of improved varieties and/or hybrids is not a serious risk in this region. The harsh environmental conditions generally conspire against the full productive potential of hybrids being met, although the producer interviewed in Soltepec is an interesting exception.

Migration has been the region's single most important means of finding alternative income in the face of declining profitability from corn production. Strong urban social networks have been established to facilitate travel and settlement of new migrants and it is likely that regions such as Mazapiltepec will remain important sources of migrants in the future.

Public investment in the region has remained low, and maintenance of agricultural infrastructure has been seriously neglected.

4.4 Subsistence producers

Corn production is the pillar of the household economy for many growers. Although it may be unprofitable, growing corn enables households to avoid the high costs involved in purchasing tortilla or hominized dough (*nixtamal*) in local markets. In some cases, a small surplus output may be generated for market sales, though this is not the primary purpose of production.

As emphasized previously, subsistence production does not translate into self-sufficient household economies. All producers engage in petty corn sales to meet their needs for cash during the year, but they are confronted with a buyers' market in which they have very little bargaining power. At the same time, tortilla prices have risen.

Table 4.7

Corn Production Accounts of Growers from Mazapiltepec and Soltepec, Puebla

Activities & Inputs	**Mazapiltepec** Producer 1	**Mazapiltepec** Producer 2	**Soltepec** Producer 1
Plowing operations			
Preparation	470	400	510
Sowing	100	100	90
Seed	50 (HY)	50 (HY)	600 (HY)
Fertilizer	800	480	544
Labor costs			
Weeding and Pest Control	80	0	
Labor costs	40	100	150
Harvest	300	150	360
De-husking of grain	100	120	450
Transportation	2140		200
TOTAL	**$2,190**	**$1,640**	**$3,254**
Land Owned (ha.)	6	4.5	7
With maize	3	3.5	2
Average Yield (ton/ha.)	2	1.25	4
Unit Cost per Ton	$1,070	$1,312	$813
Total Corn Output (tons)	6	4.3	8
To Market	75%	50%	70%
To Household Needs	15%	50%	30%
Surface w/ other crops (hs.)	2 (beans) 1 (sorghum)	1 (beans)	n.a.
Intercropping	No	No	No
Family Size	6	5	7
Revenues from PROCAMPO	$3,130	$1,304	$2,500
Livestock	20 sheep	Poultry	Small scale
Off Farm Sources of Income	Migration	Migration	Small commerce activities.
Main Problems Encountered	Erratic rainfall; weeds.	Rainfall; marketing.	Rainfall; growing need for fertilizers.

Source: Data generated by fieldwork.

The VIIth Agricultural Census (INEGI 1994) indicated that 45% of all corn growing units produce exclusively for household consumption. According to CONASUPO (1993) production for household consumption represents 38% of total production.[xlviii] The 1994 *ejido* survey found that 41% of the *ejidatarios* questioned were selling part of their production (Gordillo *et al.*, 1995). According to other sources[xlix], 59% of corn producing *ejidatarios* produce exclusively for home consumption.[l]

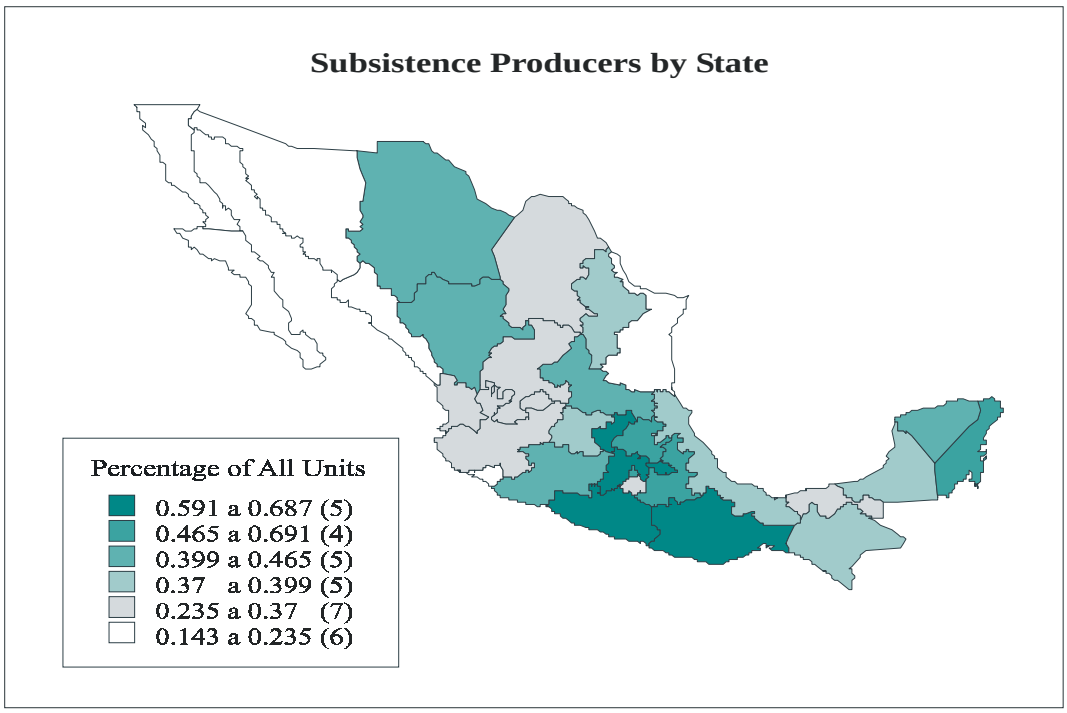
Subsistence production is closely associated with poverty and income is dependent on employment opportunities in local or regional labour markets, as well as on the evolution of rural and urban wages. Mexican subsistence producers find themselves in the trap of low producer prices, high consumer prices, significant inflation rates, stagnation of GDP growth, and insufficient employment opportunities in other sectors of the economy.

Subsistence producers normally have no capacity to convert to other crop types or alternative land uses. Their land plots are usually small (less than 5 hectares and frequently less than 2 hectares) and are located on poor land, with shallow soils.

As can be seen from Map 4.5, subsistence producers are distributed throughout Mexico, but are more concentrated in southern and central states, where up to 68% of all corn growing units belong to subsistence producers. In these states there is a high proportion of units smaller than 5 hectares. Map 4.6 shows the incidence of poverty in terms of the number of persons earning less than two minimum wages (i.e. the official poverty line at the time of the 1990 census).

Corn producers interviewed for the present study were located in three different regions: in the state of Guerrero (Atoyac and Coyuca de Benitez), Michoacán (Ario de Rosales) and Puebla (Nopalucan).

Map 4.5



Source: Author's calculations based on National Agricultural and Livestock Census, 1991.

State of Guerrero (Atoyac and Coyuca de Benítez)

See Table 4.8: Corn production accounts of growers from Atoyac and Coyuca de Benítez, Guerrero

These two settlements are located between the coastal plains and the foothills of the Sierra Madre del Sur. Coyuca is 20 miles from Acapulco, and Atoyac 30 miles away. The agricultural landscape is a complex combination of hills and plains, with some mountainous areas reaching 3000 m. Climate is tropical humid and rainfall is quite abundant. Corn cultivation is generally carried out on sloping land, while fruits and copra grow in the lowlands.

Table 4.8

Corn Production Accounts of Growers from Atoyac and Coyuca de Benitez, Guerrero

Activities & Inputs	Atoyac de Alvarez **Producer 1**	Atoyac de Alvarez **Producer 2**	Atoyac de Alvarez **Producer 3**	Coyuca de Benitez **Producer 4**
Plowing operations				
Preparation		400	525	180
Sowing	80	240	210	90
Seed	(Own landrace)	120	24 (see remarks)	
Fertilizer	160	120	135	80
Fertliz. Labour costs		320	210	
Weeding and Pest Control	244	330	224	480
Labour costs	400	280	210	760
Harvest	480	800	490	320
De-husking of grain	280	210	140	810
Transportation	200	120	140	90
Other activities				60
TOTAL	**$1,844**	**$2,940**	**$2,308**	**$3,320**
Land Owned (has)	10	14	6	2
With maize	3	3	3	1
Average Yield (ton/hect.)	1.5	3	1.5	2
Unit Cost per Ton	1229	980	1539	1660
Total Corn Output (tons)	4.5	9	4.5	2
To Market	0%	50%	30%	0%
To Household Needs	100%	50%	70%	100%
Surface w/ other crops (hs.)	2 (coffee)	1 beans	.5 (beans)	1 (jamaica flower, watermelon)
Intercropping	Pulses, chile, other	No	No	Pulses, chile, other
Family Size	5	5	8	7
Revenues from PROCAMPO	$1,668	$1,668	$1,668	$1,230
Livestock	Small animals	Starting (2 cattle)	15 goats	3 mules, small animals
Other Sources of Income (including off farm sources)	Employment in maize production in same locality.	Migration, small commerce		Employment in agriculture and construction in locality. Small commerce.
Remarks			Producer relies heavily on cooperative schemes for labour inputs where reciprocity is critical. Four corn varieties used delay rotting and prevent weevils infesting stored grain	Four maize varieties used: early harvesting and greater yields are key objectives. Grazing takes place in steeply sloping terrain.
Main Problems Encountered	Employment opportunities have diminished. Deterioration of soils by erosion and excessive use of fertilizers.	Depletion of nutrients in soils has increased need for fertilizers. Soil erosion and erratic rainfall patterns.	Reduced employment opportunities. Depletion of nutrients in soils has increased need for fertilizers. Soil erosion and erratic rainfall patterns	Incidence of weeds and pests, as well as erratic climate conditions.

Source: Data generated by fieldwork.

Table 4.8 shows that producers interviewed in these two localities have negative profitability, but most of them are self sufficient in terms of the volume of corn consumed by the household. Production does not rely on capital intensive methods, while mechanized ground preparation and secondary operations are reduced to a minimum. Local land races are utilized, but chemical inputs are still needed.

As soil deteriorates, fertilizer use has increased to make up for declining soil quality. Pesticides are widely used because insect pests proliferate in the region. Although most of the production is devoted to household consumption, significant monetary inputs are required to make production viable.

Different varieties of land races are sown, depending on the type of soil under cultivation (the property of a household is usually divided into several plots). Up to four different varieties are sown by a single producer in Coyuca de Benítez, who owns only two hectares. The names of these varieties (*pronto, prieto, colorado* and *híbrido*) illustrate the different needs satisfied by the harvest.

Pronto is a variety that matures fast and provides grain before the month of August, thus ensuring a minimum harvest in case rains stop prematurely, or in case of damage caused by wind, pests, or heavy rain. *Prieto* and *colorado* (dark red or purple), are preferred for certain types of food preparations. *Híbrido*, as its name suggests, is probably the end result of a series of crosses from hybrids or improved varieties once introduced to the region. The last variety provides the most important part of the harvest in volume terms, but *prieto* and *colorado* have the highest selling prices due to their texture, flavour and colour.

Producer 1 in Atoyac uses only one variety of land race: *zapalote*, a very old variety that is particularly well suited for low altitudes, able to resist pests (notably weevils) and remains edible after long periods of storage, even in the tropical climate prevailing in this area.[li]

Sowing different varieties of corn is a key element of production strategies in the case of many poor producers and depends on the capacity of individual producers to choose their seeds for each growing cycle. In the case of the Atoyac-Coyuca de Benítez region, fieldwork showed that the capacity to select suitable seeds is gradually being lost. Seed selection is one of the most important tools for resource management at the household and community levels. As the quality of this tool deteriorates, severe negative social and environmental impacts ensue.

Migration is an important factor affecting subsistence corn growers and their communities, particularly as the tourist centres of Acapulco and Ixtapa-Zihuatanejo are nearby and are important poles of attraction. Migration contributes to deteriorating resource management capabilities, whilst critical information is not transmitted from older producers to a new generation. Migration frequently disrupts the social structure of the community. For example, traditional knowledge is lost and co-operative labour structures needed to maintain corn production are abandoned. As a result, some corn varieties may be lost forever.

State of Michoacán (Ario)

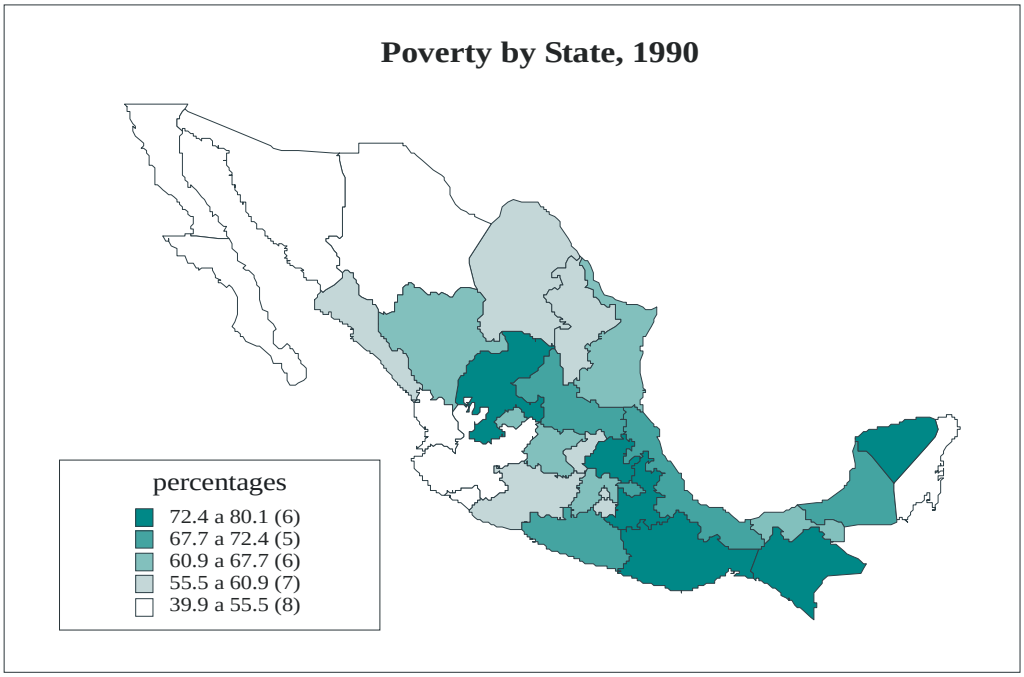
See Table 4.9: Corn production accounts for growers from Ario, Michoacán

This region is located in hilly terrain, where soils are suitable for perennial crops such as avocado, and where wooded areas are still important. Rain is abundant, but given mean altitude (1,950 m), climate is temperate sub-humid. The risk of early frost is a serious concern for producers of upland maize.

In the case of Ario, negative profitability rates are observed (with one exception). Producers rely on local land races, with no use of pesticides or herbicides (using manual weeding and pest control), but important doses of fertilizer inputs are required, although in smaller quantities than in the coastal region of Guerrero.

For most of these producers, profitability rates are negative or only marginally profitable. A significant share of output is sold in the local markets, but this source of income is not enough. Intercropping and crop rotation appear to be a well established practices, but this has not prevented rising fertilizer usage. This is possibly due to insufficient technical assistance to producers.

Map 4.6



Source: Author's calculations based on Population Census, 1991.

State of Puebla (Nopalucan)

See Table 4.10: Corn production accounts for growers from Nopalucan, Puebla

Nopalucan is close to the other two areas of Puebla covered during field work for the present study. Rainfall is moderate and the region's climate can be rather extreme. Producers in Nopalucan also have negative profitability rates and their cost structures are clearly not competitive at post-NAFTA prices.

As in the case of the other regions covered for this report, infrastructure is sparse. Most of what could be described as 'agricultural infrastructure' exists in the form of dirt roads between towns and villages. There are no significant investments for optimizing water management and reducing wastage. Basically, where water conservation practices are most needed (e.g. Mazapiltepec-Soltepec), no appropriate water management policy is in place.

Fertilizer use has risen, but pesticide use is limited, since insect pests are not so prevalent as in other areas studied.

Some subsistence producers in Nopalucan are relying increasingly on goats for survival. This is a typical response to poverty in the Mixteca region of the state of Oaxaca, where livestock provide an alternative source of income for households, whilst severely aggravating soil erosion. (e.g. Oaxaca has the highest rates of soil erosion of any state). If this trend continues in Nopalucan, growers will be destroying the capacity of their land to sustain future corn production.

One producer from Nopalucan has a small herd of goats that are fed on common land in an area where migration is important. Because of the outflow of migrants, the herd is cared for by the family's children, aged 6-12. Although it was not possible during fieldwork to establish exactly where and how the community's institutions had been weakened since NAFTA implementation, it is likely that migration has weakened community bonds, as elsewhere in Mexico.

Public policies to mitigate poverty may exacerbate some of the problems encountered. In the state of Oaxaca,[lii] some subsistence producers interviewed were obtaining yields as low as 0.3 t/ha, which is enough to meet household needs for no more than three months. During the rest of the year, purchases of corn are required and producers migrate to obtain the necessary income for these purchases. They also need to hire a labourer to gather the harvest at the end of the cycle, if the migration season starts earlier. The *Programa Nacional de Jornaleros Agrícolas* (a programme designed to provide temporary employment for rural labourers) provides small loans for the purchase of goats.[liii] However, because the labour force has been reduced by migration, shepherding is handed over to children (as in the case of the Nopalucan producer reported above). Grazing animals may destroy terrace walls and ledges in a single season. If damage is not repaired, terraces rapidly become useless and erosion is aggravated (Cerda-Bolinches 1994 and references therein).

The ensuing stress is part of a cumulative process that increases vulnerability of small producers as their resource base deteriorates. Their response may trigger another round in a self-reinforcing process. Gordillo *et al.* (1995) show strong growth in the percentage of producers grazing their animals on common land between 1990 and 1994 (from 25% to 31%).[liv]

In Nopalucan, as in Atoyac (Guerrero) and Ario (Michoacán) respectively, producers also rely heavily on the genetic variation of corn as a form of insurance. All of the growers interviewed used local land races, but there was a strong difference in comparison with growers in Guerrero and Michoacán. Producers in Nopalucan could not name the seed varieties they were using. One producer stated that he was using *criollo* seeds, which are the equivalent of land races. In one instance (producer 4), the process of seed selection was not considered important (only the largest cobs were chosen). This shows that either the identity of the seeds has been lost, or that growers are unable to recognize and use the specific genetic traits of land races. This is an indicator of deteriorating resource management capabilities at the household and community levels. It is also confirmed by Ortega (1997) who emphasized the carelessness with which many corn growers are selecting their seeds.

4.5 Summary and Conclusions

The three categories of producers analysed in this chapter are adapting their production and survival strategies to the new conditions brought about by trade liberalization and the economic policy package implemented in Mexico. This adaptation is taking place under adverse conditions and there is little evidence to indicate that the government's objective of reallocating productive resources to more profitable activities is being met.

Table 4.9

Corn Production Accounts for Growers from Ario, Michoacán

Activities & Inputs	Producer 1	Producer 2	Producer 3	Producer 4
Plowing operations				
Preparation	500	660	550	730
Sowing	100	250	150	280
Secondary operations(a)	300	400	700	220
Seed		90		
Fertilizer	685	870	525	605
Fertilizer Labour costs			100	80
Weeding and Pest Control Labour costs		400		80
Harvest	300	250	250	200
De-husking of grain		280		125
Transportation	200	120	100	120
Other activities				
TOTAL	**$2,085**	**$3,320**	**$2,375**	**$2,440**
Land Owned (ha)	24 (private)	12 (ejido)	12	11.5
With maize	18	8	12 (every two years)	9
Average Yield (ton/ha)	2	2	1.5	1.5
Unit Cost per Ton	$1,040	$1,660	$1,583	$1,626
Total Corn Output (tons)	36	16	6	13.7
To Market	50%	50%	60%	30%
To Household Needs	50%	50%	40%	70%
Surface w/ other crops (hs.)	1 (beans)	2 (avocado); 2 (feedgrain)	2 (oats in AW cycle)	See remarks
Intercropping	Yes: corn-beans	No	No	See remarks
Family Size	7	8	3	6
Revenues from PROCAMPO	$7,512	$6,260	$2,504	$3,756
Livestock	15 cattle; 30 sheep	No	6 cattle (on common land)	0
Other Sources of Income (including off farm sources)	Migration, small commerce	Heavy reliance on jobs in locality: maize production, including cajete system and avocado	Off farm employment in the locality.	Migration to U.S. and employ-ment in locality.
Remarks				This producer engages in crop rotation: the 9 has are sown with beans every other year.
Main Problems Encountered	Rising tractor rental costs, low pH in soils, incidence of pests, and erratic climate patterns.	Increasing difficulty in getting jobs in locality due to exit of larger producers. Rising tractor rentals. Erratic rainfall. Climate.	Rising tractor rentals; erratic climate and rain. Soils very alkaline.	Poor soils.

Source: Data generated by fieldwork.

Profitability has deteriorated significantly for all producers, notably those in the intermediate and subsistence categories. This is the result of the fall in prices which has diminished already low or negative profitability rates, together with the rising costs of inputs.

A third general conclusion is that public investment in support of corn producers has failed. This is apparent in the level of prices, PROCAMPO payments, credit availability, and the quantity and quality of infrastructure.

For competitive producers, the most important obstacle to continued production is linked to the reduction in profitability levels as costs of tractor rentals and chemical inputs have risen. Unsustainable production practices have led to increasing soil erosion and loss of fertility. The decline in fertility is masked artificially through increased use of fertilizers, but this can only be a temporary answer. Lack of official support in the form of technical assistance to promote wise use of fertilizers further aggravates these trends.

Water usage is another serious problem, with ongoing aquifer depletion in some regions and a lack of public support for improved irrigation and water management.

The formerly modest profits of intermediate producers have been wiped out by the fall in corn prices and rising production costs. These producers do not have the capacity to develop alternative production systems or shift to more profitable crops. Eventually, they are faced with the need to find new employment opportunities. Concerns about employment opportunities in the local labour market are intense and migration may be the only alternative for many household members.

In regions where intermediate producers operate, new land has been opened to agriculture, with a consequent increase in deforestation. This is consistent with the data at the national level showing expansion of cultivated land devoted to corn production (see Chapter 2). Another source of deforestation identified during fieldwork is fuelwood consumption. The economic stress under which these producers are operating puts additional pressure on forested areas as households sell fuelwood in local markets.

One important finding is that subsistence producers are affected by price changes. Although in principle these producers do not engage in the production of marketable surpluses, they rely on additional income to meet many of their economic needs (e.g. food, medicines and tools) and have been severely hit by the rise in tortilla prices. Subsistence corn growers are also seriously affected by the decline in rural employment opportunities. Migration, an attractive option for intermediate and subsistence producers, provides only a short-term alternative, and has substantial social and environmental implications.

The genetic variability of corn remains the most important asset of the survival strategy adopted by subsistence producers. However, there is evidence that migration and declining resource management capabilities are leading to a form of genetic erosion and, in some cases, to the irreversible loss of genetic resources. The weakening of social institutions associated with migration negatively affects the capacity to monitor and oversee collective resource management. It also reduces the community's capacity to engage in maintenance and development of soil conservation structures.

Table 4.10

Corn Production Accounts from Growers in Nopulacan, Puebla

		(Production Costs per Hectare)			
Activities & Inputs	**Producer 1**	**Producer 2**	**Producer 3**	**Producer 4**	**Producer 5**
Plowing operations					
Preparation	600	800	535	580	450
Sowing	150	250	160	130	130
Secondary operations(a)	420	600	200	260	260
Seed	Own landraces	Own landraces	Own landraces	112 (LR)	120 (LR)
Fertilizer	656	656	630	280	260
Labour costs	90	90			
Weeding and Pest Control	No weeding			No weeding	
Labour costs		90	90		
Harvest	120	180	180	210	210
De-husking of grain	180	30	125		
Transportation					
TOTAL	**2216**	**2696**	**1920**	**2882**	**1310** *1440*
Land Owned (ha)	3	10.5	6	3	1
With maize	3	4	3	3	1
Average Yield (ton/ha)	1	1.5	0.83	0.5	1
Unit Cost per Ton	2216	1797	2313	5764	1310
Total Corn Output (tons)	3 tons	6 tons	2.5	1.5	1
To Market	50%	60%	50%	0%	0%
To Household Needs	50%	40%	50%	100%	100%
Surface w/ other crops (hs.)		6 (beans, barley)	3 (beans)		
Intercropping	No	No	No	Yes (squash, beans)	Yes (squash)
Family Size	6	4	6	6	8
Revenues from PROCAMPO	$625	6,250	3,750	1900	$625
Livestock	Small scale	Small scale	Small scale	Small scale	15 goats, poultry
Off Farm Sources of Income	Employment in region's corn production	Employment in region's corn production	Employment in region's corn production	Migration, employment in region's corn production	Employment in region's corn production
Main Problems Encountered	High fertilizer costs and loss	High fertilizer costs	High fertilizer costs	Rainfall, weeds	High fertilizer costs

Source: Data generated by fieldwork.

5. Regional and household perspectives in resource management capabilities and trade liberalization

This chapter focuses on soil conservation and genetic resource management as two of the major effects associated with implementation of NAFTA.

5.1 Soil erosion and soil conservation practices

There is a serious lack of reliable information on soil erosion in Mexico. Although statistics are available for three different levels of erosion intensity, the degree of resolution is low.[lv]

Nevertheless, available information is sufficient to indicate that erosion is a major problem in Mexico today. The negative effects are, in most cases, extremely difficult to revert, and in some instances the threshold of irreversibility may have been crossed. The magnitude of the problem already poses a significant threat to prospects for sustainable development.

Evidence indicates that in many instances NAFTA may enhance these negative trends, either through more intensive use of soils, including through the extension of the agricultural frontier to marginal lands, or through the deterioration of the social institutions that enable communities to maintain adequate soil conservation infrastructure/practices.

5.2.1 Erosion trends at the national level

Loss of topsoil, fertility reduction, salinization and accumulation of agrochemical residues, are important problems in Mexico. Both water and wind erosion affect a significant proportion of arable land. For example, 67% of Mexico's agricultural land by surface area is affected by water-led erosion (Turrent 1997).

One of the central reasons for this is that whilst most Mexican agriculture takes place on land with slopes of at least 4%, tilling practices are not adapted to preventing or arresting erosion processes.

Because of the slow rate of soil formation, it may effectively be impossible to revert the negative effects of accelerated erosion. Global studies show that in tropical and temperate agricultural areas, from 200 to 1,000 years are required for the renewal of 2.5 cm of topsoil, which is equivalent to a rate of 0.3 tons per hectare per year (t/ha/yr) (Pimentel, Allen *et al*. 1993:278). Although it is difficult to identify regional erosion trends in Mexico, several studies indicate that rates are much higher than the permissible levels of topsoil loss.[lvi] For example, a study of slopes under corn cultivation in Los Tuxtlas region of Veracruz state showed that loss of soil was as high as 43 t/ha/yr. This is at least two or three times greater than the maximum permissible rate determined by soil formation rates (Turrent, 1997). Studies in northern Veracruz have recorded rates of up to 100 t/ha/yr (Ibid.).[lvii] Another study in La Fraylesca region, Chiapas, found that under conditions of conventional tillage for corn cultivation, erosion rates exceeded the permissible limits of soil loss where slopes were greater than 6% (Villar Sánchez, 1996). Figueroa (1991) has estimated rates of permissible loss of topsoil (i.e. the maximum annual rate of loss that continues to permit a high degree of productivity) to be within the range of 25 - 45.5 t/ha/yr.

Water-led erosion in Mexico has a greater effect in the southern tropical regions because of the more intense precipitation (and greater frequency of steeper slopes) than in the semi-arid northern regions. However, it is also important to note that vegetative cover is less dense in the drier north and the upper soil layers tend to be thinner. This combination has also led to serious erosion leading to thinner soils and increased vulnerability to drought (Turrent 1997). As discussed in Chapter 4, erosion generates a vicious circle, with loss of soil fertility and a decrease in productivity.

Table 5.1

Mexico: Surface Area Affected by Different Degrees of Erosion

(Hectares)

	Degrees of Soil Erosion				
	I	II	III	IV	V
Chihuahua	4,250,23	13,187,688	2,108,766	680,766	20,277,667
Sonora	2,507,527	10,869,618	3,254,781	166,168	16,798,094
Baja California	1,146,032	2,363,691	1,790,675	859,524	6,159,922
Baja California Sur	1,014,510	2,173,950	2,029,020	1,159,440	6,376,920
Sub Total	8,918,300	28,594,947	9,183,458	2,865,898	4 9,563,623
Durango	4,078,912	5,511,612	862,760	298,395	10,751,679
Zacatecas	2,056,712	367,270	3,085,068	1,469,080	6,978,130
Sinaloa	1,169,760	1,111,272	1,228,248	1,169,760	4,679,040
Sub Total	7,305,384	6,990,154	5,176,076	2,937,235	22,408,849
San Luis Potosí	1,666,464	2,810,533	575,241	31,947	50,084,185
Tamaulipas	796,020	2,388,060	1,353,234	1,194,030	5,731,344
Nuevo León	1,692,678	1,497,369	2,734,326	325,515	6,249,888
Coahuila	1,654,345	4,662,315	6,918,170	1,503,950	14,738,780
Sub Total	5,809,507	11,358,277	11,580,971	3,065,442	31,804,197
Jalisco	81,058	1,459,044	4,133,958	567,406	6,241,466
Nayarit	1,218,851	607,053	76,152	6,574	1,908,630
Colima	20,820	88,485	223,815	62,460	395,580
Aguascalientes	82,290	192,010	109,720	137,150	521,170
Sub Total	1,403,019	2,346,592	4,543,645	773,590	9,066,846
Michoacán	1,911,980	2,246,810	440,958		4,599,748
Guerrero	1,978,402	2,500,379	559,695		5,038,476
México	919,140	611,436	28,430	6,642	1,565,648
Guanajuato	505,825	873,749	382,783	217,894	1,980,251
Sub Total	5,315,347	6,232,374	1,411,866	224,536	13,184,123
Oaxaca (1)	1,413,165	2,724,220	1,844,220	2,026,330	8,007,935
Veracruz	3,461,667	96,339	1,806	945	3,560,657
Puebla	1,922,848	850,584	357,243	131,463	3,262,138
Tlaxcala	70,645	209,207	77,346	9,596	366,794
Morelos	293,193	109,724	13,487		476,404
Hidalgo	746,188	669,937	147,917	19,799	1,583,841
Sub Total	7,907,706	3,819,911	2,482,019	2,988,133	17,257,724
Chiapas	2,124,444	447,407	64,284		2,636,135
Campeche	2,038,080	917,136	305,712	203,808	3,464,736
Quintana Roo	1,913,000	503,500	251,750	755,750	3,424,000
Tabasco	886,795	380,055	126,686	350,055	1,763,590
Yucatán	192,540	1,193,748	192,540	1,694,352	3,273,180
SubTotal	7,154,859	3,441,846	940,972	3,033,965	14,571,641
Distrito Federal	61,757	11,877	1,380		75,014
Querétaro	332,805	312,926	287,681	15,910	949,322

Sub Total	394,562	324,803	289,061	15,910	1,024,336
Total Sums	44,208,684	63,108,904	35,608,068	15,904,709	148,881,339

Notes: I Superficial erosion; II Moderate erosion; III Accelerated erosion; IV Total erosion; V Total erosion by state; VI Total erosion by state as percentage of total state surface.
(1) Oaxaca: The figure for column II is a residual of the others.
Source: INEGI, *Estadísticas del medio ambiente, México 1994*. Table II.A.4.8.

In the case of level land with rain-fed cultivation, the main problem is loss of the arable segment of the upper 'A' horizon (normally containing most organic material) and the formation of scabs, leading to loss of productivity.[lviii] Whilst reversible in theory, the costs of arresting the process and redressing the damage are, in many cases, prohibitive.

5.2.2 Soil conservation and competitive producers

Under NAFTA, the most productive land is liable to be used for commercial agriculture, with the driving force being pressure to minimize unit costs. The long-term effects on land quality occupy a secondary place in production strategies.

Although corn cultivation requires the soil surface to be broken up, the soil structure does not have to be as fine as that demanded by some other crops. Nevertheless, deep ploughing and subsequent harrowing are necessary in areas where soil is compacted. Otherwise, plant roots and rainfall have difficulty in penetrating. Tillage is required but excessive tillage may result in the deterioration of soil structure, particularly if performed in wet conditions.

The area of Mexican arable land of reasonably good quality, which could, in principle, be subject to land-use changes driven by NAFTA is estimated at between 16 and 18 million hectares. Approximately half of this is sloping land and therefore at serious risk of increased erosion. Even on level terrain, highly intensive cultivation could increase vulnerability to erosion (Turrent 1997). Crop rotation is not a practice readily used in Mexican agriculture due to the irregularity of the rain-fed cycle. The model of modern agriculture promoted by NAFTA may further emphasize monoculture and discourage crop rotation.[lix]

Map 4.3 (Chapter 4) showed that mechanization of corn production has been stronger in the northern half of Mexico, where rainfall is less intense, but where vegetation covers is less dense, soils are thinner, and there is increased risk of wind-led erosion. Where more intensive ploughing persists, wind erosion is accelerated.[lx]

Contour ploughing is one of the key techniques for reducing erosion.[lxi] However it is not compatible with the use of large machines that are unable to follow contours on sloping land.[lxii] Furthermore, where contour ploughing is practised, costs increase since farmers have to manoeuvre their machinery around obstacles. In some cases, the benefits of contour ploughing may be cancelled out by a tendency to remove physical barriers which played an important role in controlling erosion. The availability of labour to carry out such maintenance has been seriously affected by increased rural migration; part of which is a consequence of NAFTA implementation (see Chapter 4).

Example of Jalisco state
Loss of topsoil is already a serious problem in Jalisco, which is particularly affected by water-led erosion. Annual precipitation is between 750 mm and 1,060 mm, and the percentage of eroded land is between 67% and 77%. Although rainfall is less intense than in tropical regions, vegetation cover is less dense and soils are thinner.

Box 5.1

Soil Degradation and Time-scales

In this context it is important to recall the fragility of soils and the extraordinary economic and social costs that accompany soil degradation. Time scales do not need to be exceedingly long to bring about severe soil deterioration. On the other hand, extraordinarily long periods of time and significant financial and human resources may be required to restore soil quality.

One example of this is provided by the Dust Bowl in the United States (an area covering more than 150,000 square miles encompassing parts of Kansas, Oklahoma, Texas, New Mexico and Colorado), where changes in land use brought about between 1880-1910 increased vulnerability to wind erosion as natural grasslands were replaced by wheat and cattle grazing (Worster 1979). Exposure to wind, combined with severe droughts in the early 1930's intensified erosive process at great social cost: 3.5 million people migrated from the Dust Bowl towards cities in the North and West.

In a few decades, the region's environmental vulnerability increased exponentially as the land was stripped of the native grasses which had helped preserve its topsoil. Analyst George Borgstrom has repeatedly drawn attention to the speed at which this entire process unfolded (Borgstrom 1973).

Rehabilitation has been slow, costly and incomplete. In order to maintain yields, fertilizer input has grown steadily and in many parts of this region (e.g. the southern part of the Dust Bowl) sinking deep wells into the huge Ogallala aquifer is the only way that production has been maintained. However, some wells have already started to dry up and drilling has had to go deeper. The cyclical droughts in the panhandle region will continue to plague the territory (Worster 1979; Borchert 1971). In fact, dry spells between 1950-1980 were responsible for recurrences of dust storms.

The experience of the Sahelian dust bowl after 1970 is another reminder that soil degradation induced or aggravated by aggressive agricultural methods can have deleterious and irreversible effects in very short periods of time (Wade 1974).

From an environmental perspective, capital-intensive cultivation by 'competitive producers' in the regions covered in the present study (Cuquío and Ixtlahuacán) could continue for some time. If ploughing practices continue with the same intensity, the impact on soil properties will be masked for a certain period by increasing use of fertilizers. Where monocultures are maintained, this trend will be reinforced. If more appropriate tillage practices are not adopted, loss of topsoil will result in ever-higher rates of fertilizer usage.

However, these competitive producers could change ploughing and tillage practices in ways which would both reduce costs and improve soil conservation. The appropriate techniques are well known and are readily available. They include contour ploughing and planting, terracing, hedging, use of cover crops, mulching, crop rotation, fallowing, minimum and/or no tillage, ridge planting, alley cropping and many others (see Villar Sánchez, 1996, for a good summary).

Whilst these techniques have often been available for a long time, they often involve significant labour costs and/or the use of heavy earth-moving equipment. An adequate supply of labour is also required for the maintenance of structures put in place.[lxiii]

5.2.3 Traditional producers

Mexican officials have argued that NAFTA would enable the setting aside of marginal land, thereby relieving it of the tillage and ploughing pressure which may trigger and/or accelerate erosion (Téllez 1992). According to this line of reasoning, the land on which poor growers operate would then recover its normal soil formation rate.[lxiv] This notion fails to take account of either the strategies adopted by poor producers under economic stress, or the high labour inputs required for maintaining soil conservation structures. In fact, migration in response to the NAFTA corn regime may accelerate erosion if insufficient labour remains.[lxv]

Areas subject to heavy migration are liable to see an increase in grazing pressure as livestock-rearing replaces labour-intensive cultivation such as corn. Goats and sheep tend to pluck plant roots from the soil, thereby increasing vulnerability to erosion. In a large part of Mexico's southern sierras there is evidence that goat herding expanded in response to labour shortages and degraded capacity to manage common land (García Barrios and García Barrios, 1990). Data from the 1994 *ejido* survey (Gordillo *et al.* 1995: 7.1) shows that 37% and 35% of *ejidatarios* own goats and sheep respectively. Cattle grazing may compact land leading to increased runoff and a higher risk of erosion.

Poverty abatement programmes have specifically offered small loans to poor corn growers for the purchase of goats and sheep. This may have unforeseen negative effects when land quality and productivity is damaged by the very animals which were supposed to help improve farmers' livelihoods. For example, in the state of Oaxaca, a programme designed to provide temporary rural employment provides small loans for the purchase of goats. Grazing pressure may destroy soil conservation structures in one season, with little prospect of repair due to the shortage of labour.

Traditionally, poor *ejidatarios* who own only small plots of land for corn growing, have benefited from access to communal grazing land. However, social disintegration and decay of social institutions charged with managing common land have progressively eroded this benefit, with overgrazing a major problem.

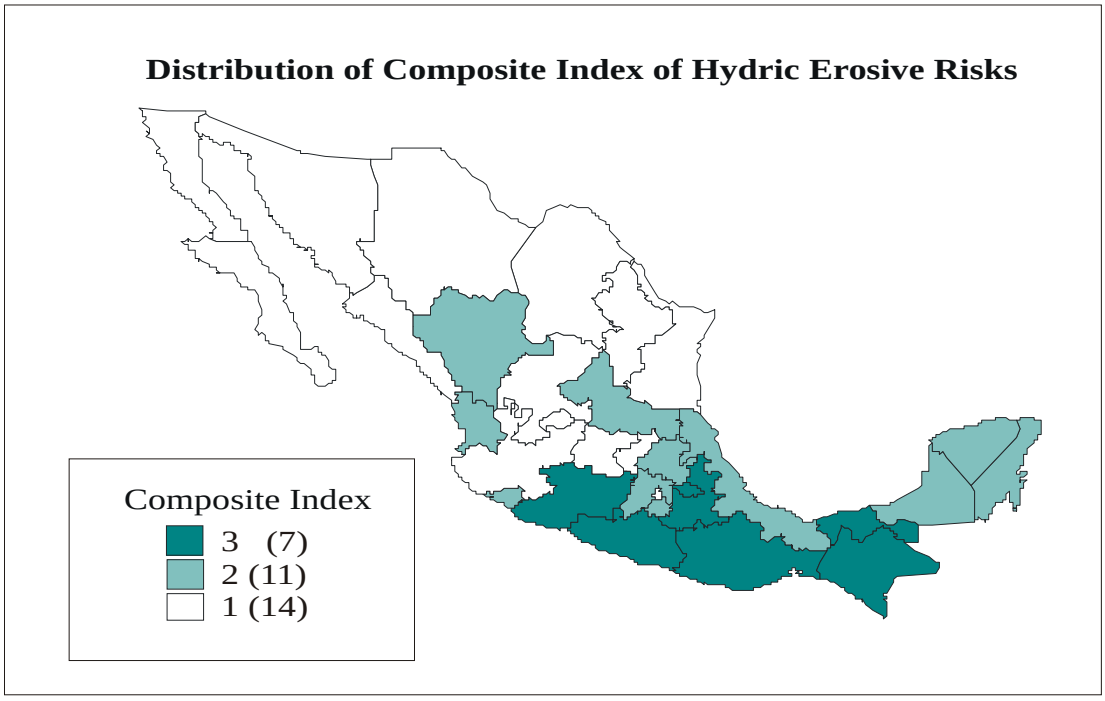
Reduced corn prices mean that poor producers have to rely more and more on wood gathering as a source of fuel for heating and cooking. Map 5.1 shows the geographical distribution of a composite index combining poverty data, levels of wood usage for domestic fuel, and precipitation rates. Though not weighted to the variable importance of corn production from region to region, the index provides a rough indicator of the inter-relationship of these variables. In those states marked in darker shades, corn production takes place on predominantly sloping land.

Some of these states are already subject to very heavy erosion, and many of the states with more degraded forests occur in regions with higher precipitation, where much corn cultivation is on sloping land. Hence, erosive processes may be exacerbated by additional pressure on lower quality soils.

Many of the states where expansion of cultivated surface area coincides with reduction or marginal improvement in yields, also show higher rates of fuelwood consumption. This is the case in Veracruz, Oaxaca and San Luis Potosí, where fuelwood consumption exceeds the national average. These are the corn producing regions where plots are smaller, poverty is pervasive and production for self consumption is prevalent. Poverty and consumption of fuelwood (and other biomass) for energy needs are intimately correlated. When fuelwood consumption exceeds the rate of forest growth, deforestation follows. The use of wood for cooking and heating also depends on the prices of alternative sources of energy, particularly natural gas and oil. Clearly, the higher the price of these alternatives, the greater the pressure on forests. Generally speaking, harvesting of fuelwood is not followed by replanting.

Furthermore, increased wood prices, combined with high rural unemployment, may lead to increased cutting of forests as poor rural inhabitants seek to provide urban fuelwood markets.

Map 5.1



Source: Author's calculations based on National Agricultural and Livestock Census, 1991.

5.2.4 Summary

Soil erosion is a serious problem in Mexico. Negative trends are not being curtailed, and the restructuring of the agricultural sector required by NAFTA does not include any decisive action to tackle erosion. In fact, as long as specialization and monoculture remain important elements of economic competition, erosion and soil degradation may even be intensified. In the more traditional sector, economic pressure on producers may force them to remain in the corn producing sector under very difficult conditions. This will prevent individuals and communities from taking appropriate action to halt and reverse soil erosion and may force them to open new land for production.

5.3 Poverty, migration and new forms of genetic erosion

Manipulation of germplasm in corn varieties has been a fundamental element in the production strategies of corn growers in Mexico. This capacity has developed within a web of interrelated elements at the community and family levels, forming a social and environmental matrix – or 'SEM'. If the constituent parts of the SEM are degraded, the information and skills for effective genetic manipulation will be impaired, eventually leading to loss of the resource itself.

Because many Mexican farmers rely heavily on the wide variety of landraces available to them, and because Mexico continues to be a centre of corn diversity, it is important to examine the processes through which genetic erosion may occur.

Box 5.2

Genetic Erosion

Genetic erosion is traditionally defined as the loss of useful genotypes and alleles in landraces or local cultivars as they are replaced by modern improved (open pollinated) varieties or hybrids, or as a result of clearing of vegetation on a sufficiently large scale (National Research Council 1993). Once the allele is lost, it is irretrievable and comparable in its definitiveness to an extinction. Genetic erosion, which leads to greater genetic vulnerability and, eventually, to extinction of races and even species, is a matter of growing concern. The hazards of genetic vulnerability in the case of corn were demonstrated in 1970 during the southern corn leaf blight epidemic that wiped out a significant proportion of the crop in the United States. In addition, the need to conserve genetic diversity allows for the use of primitive varieties of corn with genes controlling attributes such as drought and pest resistance. In the developing world, genetic erosion of corn is a real hazard and has been recognized by the world's leading experts in this field (see Taba 1995). Germplasm banks aim at preserving the gene pool by conserving samples of genotypes for later use by plant breeders and the public at large. This process is described as *ex situ* conservation to mark the fact that the genotypes in the samples have been removed from their original habitat.

5.3.1 The strategic importance of genetic diversity in Mexican corn

Mexican producers using traditional methods on rain-fed land rely heavily on genetic diversity as a strategy for survival.[lxvi] Sowing of several different varieties, with different abilities to withstand a range of environmental conditions, offers a certain degree of insurance for an adequate harvest. However, striking the right balance requires sophisticated handling of a complex set of inter-relations between seed characteristics, soil quality and conservation, surrounding topographic features, weather and climate, etc. Corn cultivation is combined with the production of other plants and crops in a process known as intercropping. A good example is documented by the study of Cuevas Sánchez (1991) among the Totonacan peoples.

In most mountainous areas of Mexico, environmental heterogeneity results in a rich diversity of productive spaces which are exploited in different ways.[lxvii] In many agro-ecological systems, producers normally sow at least two varieties of corn: one for early maturity which is less productive but more able to cope with the onset of freezing weather in mid-Autumn; and one which is more productive, but prone to suffer in cold weather. In the case of two communities in southern Chiapas, at least eight varieties are regularly employed (Cadena Iñiguez, 1995: 84). Many subsistence producers plant early-maturing varieties to supplement household consumption when the stock from their main harvest is exhausted (Ortega Paczka 1997). The ability to select an appropriate combination of seed varieties and date of sowing has been considered as the most powerful technological resource available to these producers (García Barrios *et al*., 1991:174-175).

A study by Bellón and Taylor, quoted by Ortega Paczka (1997), identified six factors used by farmers in Chiapas to select seed: soil type, drought resistance, wind resistance, response to inputs, vulnerability to weeds, fertility, yield. No cultivar showed high performance in all of these areas, so, on average, the majority of producers used three different cultivars. Other factors, according to Ortega Paczka (1977) include: rainfall, the 'end use' of the crop (for sale, domestic and/or ritual uses), and dietary considerations (grain texture and flavour). This complex range of factors may explain why Mexican corn varieties differ greatly in terms of productivity, ranging from low-yield forms such as *Nal-Tel* and *Chapalote*, to the high-yielding races *Tuxpeño*, *Chalqueño* and *Celaya* (Wellhausen 1988).

Mexican germplasm complexes are rich in gene-based mechanisms for drought resistance and adaptation to environmental change. Two characteristics mentioned in Wellhausen (1988:22-23) which are particularly relevant in many developing countries are drought resistance of seedlings and drought resistance in the middle of the growth cycle. The first is related to the capacity of the plant to endure dry periods after it has started to grow. In Mexico, the first rains after the 6-8 month dry season provide sufficient humidity to a depth of 10 centimetres for the seed to germinate and grow to a height of 15 centimetres. However, there may be a long interval between the first and second rains and many Mexican corn varieties are able to endure this stressful situation. They also exhibit resistance to frost, probably because a variety delayed in its first growth may get caught by frost at the end of its cycle, especially at altitudes above 2,200 m.

Drought resistance is also an important characteristic for older plants, since drought is liable to occur at any stage in the plant's growth. A hybrid developed at the International Center for the Improvement of Maize and Wheat (CIMMYT) – H220 – is a three-way cross with two lines derived from a *Celaya-Conico Norteño* germplasm complex, and a third derived from a collection of the race *Bolita* which originated in a valley in Oaxaca where rainfall is low and irregular. Under conditions of severe drought, this hybrid yields more grain than any improved variety in the *Bajío* region.

Other traits are important and may be associated with key economic benefits in the future. Several populations with improved performance in acid soils were developed in a recent programme (Pandey, Ceballos and Granados, 1994) using Mexican germplasm. Variable maturity rates are an important factor for reducing damage from early frost, whilst variation in height is critical for increasing resistance to wind and maximizing ear size.

Map 5.2 shows which Mexican states have the highest rates of landrace use. This map is limited to corn producers only and is built with data from the VII Agricultural Census. It shows that local landraces are more frequently used in the southern and central highland states. Hybrid penetration has been very low in regions where upland production of corn prevails, where poor quality soils are frequent, and where a range of environmental risks is encountered. The map also shows that those states where hybrids have not gained a strong foothold are those with the greatest concentrations of corn producing units, where poverty is pervasive, and where migration pressures are strong (see maps in Chapter 3). The vulnerability of these producers, which has increased as a result of NAFTA implementation, threatens not only their welfare but also the genetic resources which they manage.

5.3.2 Genetic erosion from social and institutional deterioration

Among traditional producers, adoption of hybrids will continue to face the same technical obstacles as it did in the past. On the other hand, an intensive technology package will continue to be promoted in regions that have not relied much on landraces (e.g. Northern Guanajuato, Jalisco, and Nayarit). Overall penetration of the commercial seed industry is not proceeding as fast as originally planned in the more traditional regions. In fact, the introduction of hybrids for corn production does not pose a serious threat to genetic diversity of corn in Mexico. Fears that a rush to 'modernize' maize production as a result of NAFTA would cause massive genetic erosion are groundless.[lxviii] However, NAFTA poses a new and more serious threat of genetic erosion, arising from the socio-economic changes the agreement has initiated and/or accelerated.

Box 5.3

Mexico's Corn Genetic Diversity and Future World Supply

Germplasm from Mexican corn has played a key role in global food production. The main varieties in the US corn belt are descendants of Northern flints and Southern dents which were derived from Mexican ancestors, showing special affinities with the cylindrical *Tuxpeño* of Mexico's eastern coastline (Wellhausen, Roberts, Hernández X. and Mangelsdorf 1951) and with other racial complexes found in Mexico (Hernández Xolocotzi and Alanís Flores 1970). Mexican corn germplasm is present in significant amounts in varieties used in tropical countries around the world (Ortega Paczka 1997), where it is been crucial for improving corn yields, protein content, pest and drought resistance, and growth cycles. Mexican varieties and their derivatives (especially from the *Tuxpeño* and *La Posta* complexes) have been used to improve corn production in 43 countries in Latin America, Africa and Asia (Taba 1995, Edmeades, Lafitte *et al*. 1994). Most of the growth in demand for corn in the next decades will come from developing countries where demand has been projected to grow at 4% *per annum* but output has only risen at 3%. A significant part of world agricultural growth will occur in the humid tropics and in the more acidic soils of the savannahs (Pandey, Ceballos and Granados 1994). Most of the future increments in production will have to come from greater yields since little additional land is expected to come into cultivation in most developing countries (CIMMYT 1994:27; Plucknett and Smith 1982). Genetic resources from (*inter alia*) Mexico's corn producing regions will play an important role.

Mexican germplasm has also been instrumental in increasing yields in high-latitude temperate regions (Ortega Paczka, 1997). The development of new pathogens, patterns of climate change, and enhanced capacity of biotechnologies to manipulate genetic material may make Mexican corn germplasm much more relevant for US conditions in the future. It is very difficult to predict what plant/crop characteristics might be sought in the future (National Research Council 1993:43).

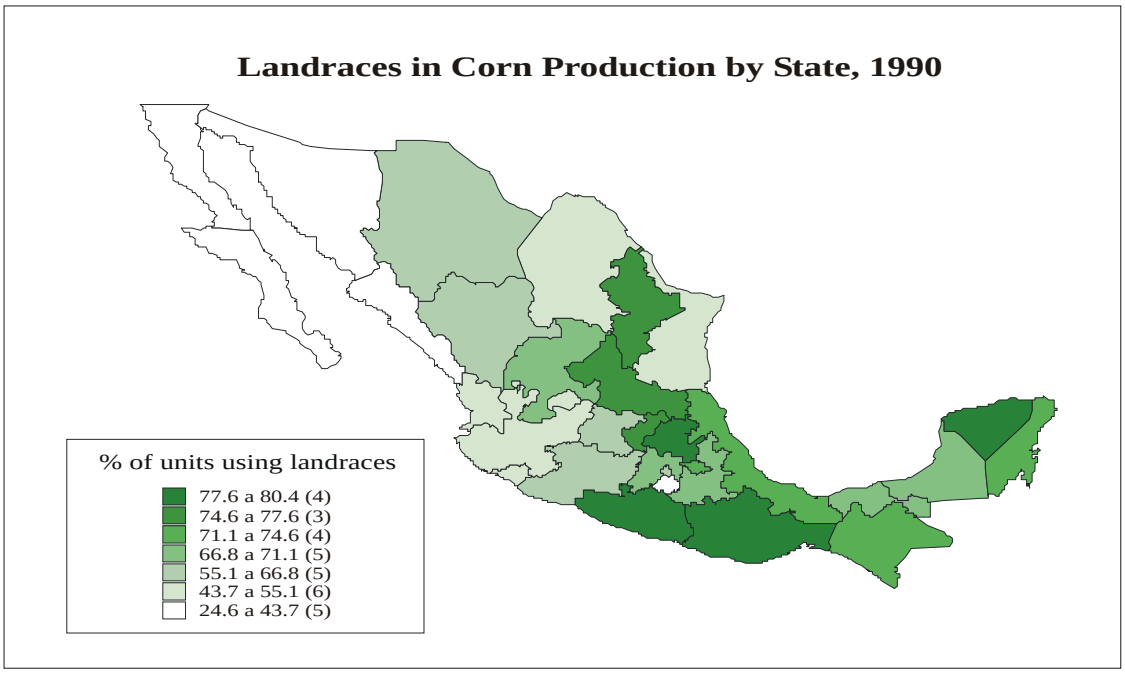
The genetic diversity of Mexican corn is directly related to intense interactions between genotypes and diverse agro-ecological environments, together with the role of genetic diversity in providing producers with insurance against various environmental risks. Other factors include the need to accommodate different final uses of corn and variable patterns of land ownership. If producers own scattered plots with wide variation in soil quality, depth, drainage, etc., they need to use a mixture of landraces adapted to different conditions. This is typical of many producers in Mexico's *ejidos*.

Closely related to these environmental elements is the fine matrix of social relations based on blood or ritual kinship, lineage, extended families, reciprocity, and other forms of association in traditional communities. In many cases, these relationships provide institutional support for producing certain types of corn, either because collective work is needed (as in the case of *cajete* cultivation in the Mixteca region) or because of the positive externalities derived, especially where ownership of land plots is scattered between many individual households.

Genetic diversity is also related to the presence of indigenous peoples for whom maize cultivation is not only a means to ensure subsistence, but also part of a deeper social and religious process. Indigenous peoples account for approximately 60% of all Mexican corn growers.[lxix]

Traditional producers are the curators of the stock of genetic resources used for their survival strategy. This information on agro-ecological systems and on genetic resources is lost when institutions of collective resource management or for cooperative labour deteriorate, or if the age pyramid in a locality is modified and the best-trained labour migrates (Ortega Paczka 1997). This is not necessarily a rapid process, but over time, information about seeds is relegated to a secondary place in current productive practices, and eventually lost forever.

Map 5.2



Source: Author's calculations based on National Agricultural and Livestock Census, 1991.

Because of the extremely close interactions between social diversity and genetic diversity, genetic erosion takes place through the displacement of people and the destruction of social institutions that enable diversified production systems based on a wide variety of landraces.

Social institutions are undermined by poverty and rural unemployment. As has been pointed out elsewhere in this report, the capacity to manage productive resources (including genetic resources) is degraded by increasing poverty.

From the above, it can be concluded that a more rigorous definition of genetic erosion is needed, one which includes loss of knowledge and skills pertaining to use of landraces, as well as degradation of the social structures necessary for cultivating these traditional varieties.[lxx]

There are many examples of this wider process of genetic erosion. In the Mixteca Oaxaqueña, systems of deep planting are being abandoned, and with them, the use of certain local cultivars (Ortega Paczka 1997, García Barrios *et al.* 1991). In the Puebla valley, producers have almost entirely abandoned a traditional system based on local varieties which could germinate using residual moisture from modest winter rainfall (Ortega Paczka 1997:16). Varieties with long maturity periods, such as the *Tehua* race in the Grijalva Valley, Chiapas, are being abandoned. Because of migration, varieties with extremely rapid maturity rates are also being abandoned. In Yucatán, and many other regions, similar processes of genetic

erosion are linked to the gradual elimination of intercropping practices that had positive effects on soil conservation.

The corn-producing households operating in the poorest states of Mexico are under severe pressure from many sides: reduced corn prices as NAFTA-related imports expand, higher tortilla prices, stagnation – in real terms – of rural and urban wages, dramatic reductions in public investment for agricultural development, and significant reductions in income support mechanisms. As resource management capabilities dwindle, poverty and migration will take a heavy toll on genetic resources.

5.4 Summary and conclusions

The inclusion of corn in NAFTA was officially presented as a strategic decision that would bring greater economic efficiency together with environmental benefits. There were no technical studies to support the latter contention but some positive environmental consequences were mentioned and expected in speeches and in the press (Téllez 1992). This chapter suggests, however, that the potential environmental effects of NAFTA are far more complex and that in many instances NAFTA has contributed to enhancing existing environmental problems. Soil erosion and genetic erosion are the two elements examined in detail in this chapter.

While trade liberalization is not the primary cause of soil erosion in Mexico, surveys and interviews conducted in the course of this study suggest that the restructuring of the corn sector following NAFTA does not include any action to tackle soil erosion and may in fact contribute to accelerating these trends, particularly in regions where modern corn producers exist and in those where local subsistence farmers are located. Specialization and monoculture, coupled with increased use of fertilizers, as is observed in the case of the more competitive producers, are intensifying the process of soil degradation and erosion. For traditional producers, economic pressure is leading to a more intensive use of soils, including though the extension of the agricultural frontier to marginal lands, or through the deterioration of the social institutions that enable communities to maintain adequate soil conservation infrastructure. In addition, the technology and cultivation practices that help prevent this loss of soil quality will continue to be inaccessible to a great majority of corn producers.

As previously indicated, the vulnerability of subsistence and intermediate corn producers has increased as a result of NAFTA and this is having a negative impact of their capacity to manage productive resources, and in particular their ability to sustain the genetic variability of corn. This is all the more important as many Mexican corn growers rely heavily on a variety of land races to ensure adequate levels of production in the context of the range of environmental, topographic and geographic conditions they face. Migration and the weakening of social institutions, which are also related to NAFTA implementation, are contributing to genetic erosion as traditional knowledge on corn seeds is lost. Finally, if traditional growers abandon corn production – as the NAFTA strategy foresees – then even more significant genetic erosion will occur.

6. Policy alternatives blueprint for sustainable development of the Mexican corn sector

This chapter presents concluding remarks and policy recommendations covering both agriculture and broader aspects of economic policy-making in Mexico.

6.1 Introduction

The conclusions and policy recommendations presented in this final chapter are based on two important premises. First, the agricultural sector has a very important role to play in Mexico's development. This role is related to its capacity to supply basic foodstuffs and tradable commodities, but also as a key generator of jobs. Second, the capacity of agricultural producers and their families to carry out the task of healthy environmental stewardship depends critically on their welfare and living conditions. Poverty, marginalization and economic stress often translate into higher pressure on scarce natural resources such as land and forests. In this context, the set of policy recommendations outlined in this chapter ultimately aim at increasing economic security for Mexico's rural population, which is in itself a prerequisite for the sustainable management of the natural resource base, and in particular corn.

This chapter begins with a concluding section on some of the main linkages that have been identified between trade liberalization under NAFTA and environmental and social changes in Mexico's corn sector. The following sections provide a number of policy recommendations covering not only the agricultural sector, but also changes related to macroeconomic policy-making.

6.2 Environmental and social effects of NAFTA: main conclusions

On the basis of field surveys and interviews, the present study has examined the different social and environmental implications of NAFTA for the various categories of Mexican corn growers and the strategies adopted to respond to changes brought about by NAFTA. Three general types of responses or strategies were identified, which correspond to the three main categories of corn producers.

The first is modernization of corn production to meet the challenges posed by increased competition from cheap imports ('high profitability producer'). Depending on the relative profitability of other crops, these producers may or may not exit the sector. Since horticulture has failed to be a realistic and viable alternative, they seem unlikely to leave the sector at this time. Given the high use of pesticides in horticulture production, this could be environmentally positive. However, capital-intensive corn production also has adverse environmental effects, the most critical being soil erosion (loss of topsoil, salinization due to inadequate irrigation system). Soil erosion, a major problem in Mexico, leads to loss of soil fertility and decreasing productivity, which in turn contribute to increased use of fertilizers and more intensive production practices to counter the negative trends in yields. The study suggests that existing trends have been intensified by trade liberalization under NAFTA in order to meet the challenges posed by increased competition by cheap US imports.

The second response is crop substitution or changes in patterns of land use, either in the basic grain sectors or in other sectors, e.g. horticulture, forestry or livestock ('intermediate producers'). Owing to the NAFTA-induced price reductions, this category of producers has

lost its capacity to maintain profitable production: input prices increased, credits have been curtailed and infrastructure investments have stagnated. The study suggests that, while corn production for household consumption will continue, intermediate producers may choose several other options: other basic grains, turning land to grazing fields, or cash crops such as melon, peanuts or alfalfa (these producers have the required resource endowment to switch production).

For many intermediate producers, alternative techniques such as - corn production with intercropping, introduction of minimum tillage and integrated pest management systems, better soil analyses and adequate fertilizer use- would help to reduce costs and increase welfare, as well as minimizing many environmental impacts. However, in regions where intermediate producers are experiencing difficulties in sustaining their thin profit margins, the following social and environmental effects are observed: i) migration (and social implications of 'ageing populations' as young men and women leave); ii) intensified fertilizer use (to maintain productivity levels or because of new cash crop production); iii) soil erosion; and iv) deforestation (for fuelwood purposes since the financial resources to buy natural gas or oil are lacking).

The third response is that local traditional corn production is maintained for consumption by the producer ('subsistence farming'). Corn is the pillar of the household economy for subsistence farmers. This production does not rely on capital intensive methods, although chemical inputs, pesticides and fertilizers are often used. Consequently, although most of the production is for household consumption, important monetary inputs are required to make production viable. Sowing different varieties of corn (depending on types of soil, climate) is a crucial aspect of production strategies for many poor producers. For example, up to four different varieties are sown by one sole producer in Coyuca de Benitez, who owns only two hectares. However, migration and the weakening of social institutions have a direct impact on the loss of traditional knowledge about corn seeds; this contributes to genetic erosion. In addition, where labour intensive maintenance tasks are required, e.g. for maintaining terraces systems, migration directly contributes to accelerated erosion since these tasks can no longer be performed adequately.

While there are still some uncertainties as to the overall effect (both in quantitative and qualitative terms) of the policy regime put in place, the study shows that NAFTA’s agricultural chapter magnified some of the negative impacts created by Mexico’s package of policy reforms, of which trade liberalization in the corn sector was part, on the social and environmental conditions of corn farmers. In addition, the study does demonstrate the importance of a comprehensive assessment of trade-related effects before rushing into liberalization. Due to lack of proper social and environmental impact assessment, many of the initial predictions about the agreement’s effects were based on doubtful assumptions. Consequently, the negative environmental and social effects were underestimated and not addressed prior to finalizing and implementing the NAFTA agreements.

The following sections on policy recommendations suggest that there is a clear need for a package of support policies directed at Mexican corn growers to ensure that trade liberalization translates into sustainable economic development. From an environmental and social perspective, it emphasizes the importance of a regulatory framework to provide the necessary mechanisms to address environmental problems and the need for a series of complementary social policies.

6.3 Why it makes macroeconomic sense to support Mexico's corn producers

Trade liberalization was justified as an appropriate policy response to a deteriorating macroeconomic environment in Mexico in the early 1980s. The Mexican authorities reached the conclusion that that it was necessary to curtail support for the agricultural sector in order

to achieve its macroeconomic targets. Here, the argument is reversed and it is argued that it makes good macroeconomic sense to support Mexico's agricultural sector. The reasons for this are threefold and pertain to the external trade balance, inflation and employment.

6.3.1 Effects on trade balance

Mexico's external accounts have been a problem for the past twenty years. The old economic model organized around a strategy of import substitution was unable to sustain adequate growth rates without destabilizing the trade and current account balances. But the new open economy model has failed to succeed in this same aspect of basic macroeconomics.

Trade liberalization has brought neither growth, nor the development of inherent comparative advantages to Mexico's agricultural sector. The sector's GDP performance has been mediocre for the period in question (the average rate of growth for the period 1994-1998 is less than 1%). This pattern is better described as stagnation than growth.

The agricultural trade balance has shown negative results, with an accumulated trade deficit which weighs heavily on Mexico's foreign accounts. Corn has become the most important item in agricultural imports, making a strongly negative contribution to an already substantial trade deficit.

It has been argued that the fiscal cost of providing direct support to producers is too great, and that opening the agriculture sector to foreign competition is a more cost-effective means of stimulating reform. However, the advantages of reducing fiscal expenditures are cancelled out by the drawback brought about by higher trade deficits. These trade deficits have to be financed somehow, either through a better export performance, through foreign direct investment, short term capital, higher debt or use of reserves. Exports have not been sufficient to maintain a positive trade balance. If the current account deficit is too high, foreign direct investment is unable to provide the required resources to bridge the gap.

It has been Mexico's recent experience that financing external deficits has resulted in one or more of the following: greater debt, high interest rates to attract (mainly) short-term capital and rapid reduction of reserves. In all of these cases, the direct and indirect costs of the external deficit have by far exceeded the costs of a programme of support policies for the agricultural sector as a whole, and corn production in particular.

The cost of corn imports over the past five years has reached historically high levels ($3.5 billion dollars). It is foreseen that corn imports will continue to increase, following the time schedule established by NAFTA, and therefore, this negative contribution to the trade balance will grow.

Between 10% and 18% of the country's negative trade balance is already accounted for by corn imports (depending on international corn prices), but this negative contribution will continue to grow. The cost of these imports is still well below total appropriations for the main income support mechanism, PROCAMPO (approximately $5 billion for the relevant period).

However, resources used to cover foreign purchases of corn will continue to increase as imports expand. It is estimated that once NAFTA has reached a more stable phase of implementation, total corn imports may well exceed 9 – 10 million tons. With international prices oscillating between $170 and $220 dollars per ton, total yearly imports may cost between $1.5 and $2.2 billion dollars, a sizeable contribution to Mexico's growing external deficit.[lxxi]

One issue for immediate consideration by government is whether it makes more sense to allocate scarce foreign exchange for corn imports, or to provide adequate resources to support corn growers and their families.

6.3.2 Inflation

One of the objectives of trade liberalization in the corn sector was to reduce the price of tortillas and other final products using corn as a basic input. The rationale was that foreign competition, together with liberalization of markets for inputs and machinery, would force final consumer prices downwards. This is an important objective considering that corn continues to be the most important staple food in Mexico. If there is a return to NAFTA's original time schedule of tariff-free imports, and if the corresponding tariffs are charged on the over quota, how will this affect inflation? And if there is a return to something resembling price support policies, at least during the transition period for corn, will there be an impact on inflation?

The first consideration here is that the objective to reduce final consumer prices through the effects of trade liberalization has not been attained. In spite of the fact that corn imports far exceeded the tariff-free quota, and even though the corresponding tariffs were not applied, the prices of tortilla have continued to increase. At the beginning of 1998, prices in Mexico City were of the order of $3.50 pesos per kilogram, but in many areas today the price per kilogram has risen to $5.50. The local press continues to report increases in the price of tortillas, with news that in some rural areas the price may reach $6 pesos per kilogram.

Why have tortilla prices remained so resistant to downward movement? In previous chapters it was explained that in many cases, market imperfections, asymmetry of information and market segmentation are powerful factors. In addition, there are market distortions related to the two largest industrial producers of tortillas, GRUMA and MINSA[lxxii], whose business interests extend into other sectors of the economy.

If, as foreseen by NAFTA, tariffs are applied to corn imports which exceed the permitted tariff-free quota, and if there is another mechanism to provide higher prices to corn growers, the price of tortillas may increase further. However, these price hikes need not be higher than those experienced in recent months. Furthermore, there are reasons to believe that any upward pressure may be countered by forces pushing prices towards greater stability. These forces lie on the side of supply. Improving productivity in the corn sector will provide a greater supply of this basic grain; an important element contributing to price stabilization. Although there are no reliable studies measuring price elasticity in relation to supply, corn deficits will be reduced in many regions, thereby bringing down prices in those areas.

6.3.3 Employment and Mexico's domestic market

The question of trade liberalization in the corn sector requires consideration of whether the productive resources controlled by existing growers can be reallocated to other productive uses. The notion that the labour force released by NAFTA-related economic forces can find a productive employment in horticulture has to be put to rest forever. Mexico's horticultural sector does not have the required absorption capacity. First, because the size of the final market in the United States for horticultural crops is limited and Mexico has already seized a share approximating its normal participation in that market, given the competition from American suppliers. Although Mexico already provides approximately 60% of total horticultural imports in the United States, this amount barely represents 2% of the overall North American market. Even if the share in the North American market can grow, technical change in the horticultural sector brings about factor substitution. Thus, production increases do not come from expansion of cultivated surface and more jobs, but from technical progress in seeds, fertilizers, mechanization and/or better irrigation techniques.

Can the labour force expelled from the corn sector be absorbed by the rest of the economy? It could be thought that as the economy expands, and jobs are created rapidly, the labour force released from corn production could find jobs in other sectors. It has been estimated that Mexico's economy needs to grow at a rate of at least 5% per annum in order to generate the 1.2 million jobs required to meet the demand of a growing labour force. But in the past ten years, growth rates averaged less than 2.8%, and this means that a huge jobs deficit has been accumulated.

Will Mexico's economy fulfil the promise of higher growth rates in the future? The prospects are unclear but it is more than likely that higher growth rates cannot be sustained except for short periods of time. This results from chronic external disequilibria, or high volatility in domestic macroeconomic variables. In most scenarios, all of these variables would conspire against high growth rates.

Thus, prospects for absorbing the labour force dismissed from the corn sector are weak, at least in the medium term. Going ahead with a project based on the assumption that labour intensive crops, and/or the rest of the economy are going to take care of this labour force, will simply put additional pressure on Mexico's already congested urban areas, their infrastructure and the already damaged urban environment.

It is imperative to reconsider the role of these human resources in the agricultural sector. A programme providing adequate support for Mexican agriculture would be, by itself, the largest employment generator in the economy. Currently, although the share of agriculture in total GDP is small, at not more than 10%, this sector is responsible for more than 24% of total employment. This of course reflects the fact that productivity is low, and this is why agriculture is considered inefficient. But productivity increases could result from an appropriate programme of agricultural support without large-scale expulsion of the current labour force.

Improving living standards in rural Mexico would have the additional consequence of stimulating domestic demand. Mexico's rural population does not necessarily represent a high demand for imported goods. Many of the articles it consumes are produced by domestic industries, whether this concerns food, clothing, construction materials, or agricultural tools and implements. Thus, people living in rural Mexico could well stimulate domestic industries without a negative effect on Mexico's trade balance.

Thus, a series of productive 'ripples' may spread throughout the economy. Although agriculture does not command a very important share of GDP, it occupies a quarter of the active labour force. Therefore, its impact in terms of aggregate demand is much stronger than in terms of direct productive linkages.

An agricultural support programme could increase temporary employment, something that can help reactivate economic life in rural Mexico. A well-designed programme that includes irrigation projects directed towards the needs of communities would send an additional and more long-lasting message to rural producers, namely that of a firm commitment by the authorities at the highest levels. This message could help reduce the incentives to migrate and would retain a sizeable part of this labour force in rural areas.

6.4 Respecting NAFTA's terms, timetables and commitments

The first policy recommendation in this context is to return to the original time schedule for the transition period in the corn sector. The expansion of the tariff free quota set forth by NAFTA has to be respected in the absence of a revision of this chapter. But the most important issue here is the convergence of domestic prices to the levels of international prices.

This is the key indicator showing that the planned transition period has been prematurely truncated.

The first step is to restore the original NAFTA timetable for corn imports. The tariff free quota was deemed a reasonable approximation of the country's needs for corn imports. As much as possible, corn imports should remain within the range of the tariff free quota (which expands at a rate of 3% per annum).

The second step is to respect the original division between tariff free and tariff-liable imports. The second category must be subject to the corresponding tariffs, making imports more expensive and giving domestic production some degree of protection. As we have seen, fiscal revenues from this action can be estimated to reach between $600 million and $1 billion dollars. These resources can be targeted directly to the price support programme outlined above.

Given the importance of the corn sector in the country's agricultural system, and considering its enormous importance in terms of employment generation, the Mexican authorities should envisage the possibility of resorting to Chapter Eight of NAFTA. This establishes the possibility for a country facing serious difficulties to immediately suspend further tariff reductions and revert to pre-NAFTA level of tariffs. This reversion can last up to three years, after which the original schedule should restart. In the case of corn, reverting to pre-NAFTA tariff levels may not be necessary and Mexico could very well adopt a level corresponding to the 1995 *ad valorem* tax.

This recommendation may seem extreme and perhaps politically unrealistic. However, three considerations are critical in assessing the relative value of adopting this possible path. One is that it is a door opened by NAFTA's text, and should not be seen as a radical departure from this agreement, but rather as a normal step in its evolution. The second is that this measure should be accompanied by the series of actions outlined in this chapter, especially those related to public investment in agriculture. In and by itself, invoking NAFTA's safeguards measures would not be enough to reverse the negative trends we have identified in Mexico's agriculture. Finally, a third consideration concerns the fact that reverting to pre-NAFTA tariff levels for three years would at least have the beneficial effect of recovering the lost years after the 1995 crisis in the transition period for corn and would allow the effective period to approximate the original planned fifteen years.

6.5 Macroeconomic policy instruments

6.5.1 Fiscal policy

Trade liberalization in the corn sector is only part of a more general macroeconomic policy package. Within this policy package, the commitment to reducing state intervention far exceeded the consideration given to other policy goals. At the core of this policy package lies the belief that markets outperform governments in the task of resource allocation.

Public finance should strive to maintain balanced budgets as excessive public debt puts pressure on domestic capital markets, raising interest rates and crowding out private investment.[lxxiii] In this respect, it should be considered that the terms under which NAFTA was approved in Mexico included commitments on allocation of public expenditure to corn growers as part of a package deal. The fifteen-year transition period was presented as being the period over which adequate support would be provided.

However, as overall economic performance has been poor (low GDP growth rates and external deficits, both in the trade and current account balances), fiscal revenues have been affected negatively. Under these circumstances, the only means by which it has been possible

to maintain a balanced budget has been through cuts in expenditure. But as far as the cost of the public debt service is concerned, Mexico's economic authorities have no way to control expenditures (for example, they cannot reduce interest rates), so that the only cuts have come on the side of the so-called primary budget. This exercise in fiscal policy has had one dominant objective: to release enough resources to sustain the State's capacity to service its debt and, more recently, to provide support for the banking system.

This is how the stagnation in public expenditures which we have identified in previous chapters is explained. Among OECD countries, Mexico has one of the lowest levels of public expenditure as a percentage of GDP. Therefore, what may have started out as a prudent measure for public finance has been distorted and translated into a recipe for indiscriminate cuts in public expenditure, putting at risk crucial infrastructure projects, and maintaining at perilously low levels the State's budgets for health, education and housing. This is also threatening the key objectives of trade liberalization, as well as the commitments made to Mexican farmers who were promised adequate public support during the transition period.

6.5.2 Credit

Re-establishment of credit facilities for agriculture is probably the number one priority. As of 1998, credit for agriculture had suffered a severe drop in real terms and was virtually non existent if conventional indicators are used (cultivated surface covered by some form of credit).

This issue is related to the reforms of Mexico's banking and financial sectors during the period 1989-1993. Among other things, this reform rested on the assumption that deregulation would lead to higher capital inflows, and reductions in interest rates, as well as improvement in banking and financial services. As part of deregulation, the system of compulsory shares of the total credit allocated to agriculture was abandoned. As the crisis in the banking system extended to national development banks, credit for agriculture suffered severe cuts.
A major effort has to be made to rebuild the national development banks so as to have new credit lines for rural producers. These credit lines have to be subsidized loans, at preferential interest rates, and with great flexibility in terms of delivery of resources and types of collateral required. Quantifying financial resources needed is part of the exercise to investigate macroeconomic implications of these policies. These requirements do not pose an insurmountable obstacle in terms of fiscal policy. Besides, there can be regional priorities and definition of different types of banking (credit) services for different categories of growers.

6.5.3 Public investment

In rural Mexico, public investment has to tackle several objectives at the same time. It must be directed towards the following specific objectives. First, it is imperative to re-organize irrigation. Undertaking a new set of hydro-agricultural infrastructure projects in small-scale irrigation is of critical importance. This is especially relevant in the southern half of the country, where most annual precipitation occurs, but where very little infrastructure exists.[lxxiv]
In the highlands, and in the mountain valleys, these small-scale projects have been abandoned and only highly erratic maintenance operations take place. In many fertile valleys, drainage canals have remained blocked due to siltation. In other cases, water flows from torrential rains remain unharnessed because there are no water gathering systems. These systems could provide resources for different cropping systems, or for reducing risks from early interruption of rains. More importantly, these systems can reduce erosion (especially when used together with some of the vegetative techniques outlined in previous chapters) and help in watershed management. Of course, all of these schemes require community involvement and participation.

Second, investment is needed to rebuild and expand the country's general rural infrastructure. The reduction in public investment in road construction was accompanied by large-scale private sector projects. The system of public roads was consigned to a secondary level of importance and therefore deteriorated rapidly. The damage to existing roads is especially severe in the southern half of Mexico, where precipitation is torrential. Roads through Mexico's mountainous regions in the south are particularly vulnerable. Very little is allocated by way of public resources for these roads. The costs in terms of time and damaged transportation equipment are born by the individual user, normally rural inhabitants.

Rebuilding roads that are in very bad condition is a critical priority, but a second step is to build new routes to communicate with local and regional markets. That tortilla prices are capable of increasing at the alarming rates experienced in the past months is also due to the deplorable state in which small feeder roads are currently in Mexico as market structures become more segmented and information asymmetries are intensified.

An important way to signal to rural producers that public investments (and official support) are not temporary is to direct part of the effort towards improving the entire gamut of social services, starting with housing, sanitation conditions and health services, and proceeding with education. The lack of adequate investment in these items during the last ten years or more has led to development of a huge gap between actual needs and the supply of services. The housing, health and sanitation deficit is colossal by any standard, and will have very negative consequences if it continues to grow.

Another critical area for investment is in research and development. Incorporating technical progress into agricultural production is the most important instrument to ensure access to productivity gains. In the future, investing in this area requires devoting adequate attention to the issues raised by *in situ* conservation of genetic resources. Extension services must interact with producers and not repeat the mistakes of former schemes in which research results would to be handed down out to users from 'on high'.

Part of the support programme could be based on public works to repair and renew the already decaying infrastructure, and in a second stage, to expand the network of infrastructure projects. Large-scale irrigation projects are not a priority, but more attention should be provided to small-scale projects, for irrigation and water conservation, soil protection, and watershed management.

All of these investments must take local conditions into consideration in order to avoid compounding existing problems. This requires genuine community involvement. And this last aspect is of critical importance as it requires abandoning the old patterns of investment in which 'infrastructure' was conceived as a simple construction, and therefore a rigid, material and largely static project. In that old and conventional view, maintenance was a task to be performed by "technicians" that would periodically revisit the locality. The failure of this model is largely attributable to lack of participation and involvement by the community.

6.5.4 Incomes' policies

Adequate support for agriculture requires a form of income policy, either indirectly through higher prices of corn, or directly through a straightforward subsidy to supplement producers' incomes.

In theory, CONASUPO's role was to be gradually phased-out by 2005 as part of the reforms in the agricultural sector. However, the elimination of CONASUPO (the state-owned corporation in charge of marketing basic commodities) was recently accelerated as a direct consequence of corruption scandals. The policy answer to such scandals should have been the

establishment of mechanisms to prevent misallocation of resources, rather than the effective 'winding up' of CONASUPO.

If higher prices for corn are seen as the best option to ensure higher profitability to corn growers, it will be necessary to re-establish an agency with some leverage in the price-setting process. Such an agency could intervene with limited resources in key regions and at crucial times in order to help fix a target 'reference price'.

This reference price would be followed by other market participants so that limited fiscal outlay would support domestic prices throughout the country. This is the way in which CONASUPO operated in its last decade and there is nothing in NAFTA's rules to prevent Mexico from engaging in this type of action during the transition period established by the corn regime. A price level equivalent to current domestic prices plus a differential of 30% is an attainable goal, and one which would restore levels of profitability to corn growers.

Alternatively, the necessary income support can be provided through PROCAMPO. There is a considerable amount of confusion as to the scope and implications of this mechanism. Part of this confusion stems from the erratic manner in which PROCAMPO was implemented, including manipulation during election periods. Originally designed to act as a supplement to income, PROCAMPO payments were based on area under cultivation and considered to have no connection with production decisions (choice of crops) and technology used.

However, right from the start, PROCAMPO was linked to a group of strategic crops. In addition, as the 1995 economic crisis developed, PROCAMPO payments lost a significant proportion of their original value in real terms. Finally, as government fiscal resources dwindled, the need to further reduce PROCAMPO payments led to a further policy change. From 1997, it was decided to monitor production activities to verify 'compliance' of growers. This well-documented move totally contradicted the original nature and objectives of PROCAMPO.

It has been argued that price support mechanisms encourage producers to grow corn in marginal land because prices are linked to output decisions. Although it is true that guarantee prices link with output decisions, it does not follow that pressure on marginal lands or deforestation (to open new land for agriculture) result. In fact, in the absence of price support, producers are expanding their activities in marginal land. This suggests that supporting prices, and hence higher profitability, can lead to a reduction of pressure on marginal land. If this is combined with adequate productivity-enhancing measures (as outlined below), the trend to relieve pressure on cultivated land can be strengthened.

There are pros and cons in resurrecting either CONASUPO or PROCAMPO. However, given the current status of PROCAMPO payments, it is highly unlikely that they will be withdrawn. Thus, in the near future, either the value of payments must be restored through gradual increases in real terms, or higher prices will have to be stimulated by state intervention through CONASUPO.

One of the most important macroeconomic policy objectives in Mexico today is to increase domestic savings. This has hitherto remained an elusive objective, in part because income contraction has worsened during the past fifteen years. For a growing number of people, the capacity to increase or even maintain savings has been diminished. Establishing an adequate agricultural support programme would enable rural producers to increase their household incomes and thus their savings potential. Establishment of an effective institutional structure in rural Mexico, for example by re-establishing a nationwide network of government-organized savings unions and associations would facilitate the achievement of this objective. Such bodies could invest savings in productive infrastructure, thereby contributing to revitalization of the wider economy. Funds could also be made available to rural producers

under favourable terms and at preferential interest rates, as a means of gradually restoring credit availability.

6.6 Policies for sustainable intensification of land use and productivity enhancement

Previous chapters examined the structure of the corn sector from the perspective of different categories of producers. This section provides guidelines for different policy packages designed to enhance productivity increases for different producers.

One line of action that can be considered for productivity enhancement is the intensification of land usage rates. This implies increasing the number of crops harvested from the same surface area. In general, the cultivation coefficient for land under rain-fed systems is 0.83, which means that 83% of rain-fed arable land is harvested once a year, and 17% is left fallow.[lxxv] It is likely that some rain-fed harvested land is cultivated up to two times a year, while the rest is harvested only once.

Irrigated land has a cultivation coefficient of 0.94, which is rather low. The crucial limitation here is the availability of water to feed the irrigation systems. Water shortages may be partly climatic, but also due to inefficiencies in the distribution network. Modernization of infrastructure and technical support are sorely needed, but obviously require adequate financial resources.

In the case of rain-fed systems, the cultivation coefficient can be increased in areas with good productivity. On the other hand, in low productivity areas and marginal land, usage may already be at (or beyond) erosion tolerance limits. The risk of harvest damage is already very high due to poor soil quality and erratic climate patterns.

Intensifying usage of land already opened to agriculture can be an alternative to extending the agricultural frontier, but has to take place under conditions of sustainability or it will be a self-defeating venture. There are many examples of experimental plots being harvested according to some of the guidelines mentioned here. Sustainable intensification of land usage can be accomplished together with erosion control, *in situ* conservation and development of genetic resources, and reduction of pressure on biodiversity.

Other productivity enhancement practices also deserve attention. The case of maize-based cropping systems in the Santa Marta Sierra system of Veracruz (Buckles and Erenstein 1996) provides a telling example of how such policies can be implemented. In this region, cover crops, soil conservation practices and moderate amounts of external inputs, have led to significant productivity gains.

As fertilizer costs increase beyond the reach of poor producers, smaller amounts are applied and yields may drop. To counter falling yields, a poor producer may decide to expand the area of land under cultivation, perhaps putting additional pressure on poor quality soils or increasing deforestation. Hence, policy makers should give attention to providing adequate access to fertilizers.

In the Santa Marta example, improvements in land usage reduced the area of land needed to meet subsistence needs in corn (by up to 1.33 hectares per household in the lowland zone and up to 4 hectares per household in the upland zone). This land is potentially made available for the production of more commercially-oriented crops, forestry projects or conversion to natural forest reducing pressure on biodiversity.

The importance of social institutions in resource management and production in rural Mexico cannot be overstated when considering policies to intensify sustainable land use practices. As García Barrios and García Barrios (1990) point out, traditional techniques of land cultivation

usually depend on a large pool of labour, and the cooperative character of the labour process is a technical necessity. Extreme poverty and strong pressures to migrate in search of better economic opportunities have led in many cases to severe weakening of the social support matrix.

The question of property rights is another important variable. The *ejido* regime is not a common property resource management scheme, although it is frequently associated with collective ownership of land, forest and water resources. Thus, in a typical *ejido*, individual land plots are owned and exploited by a single producer, while the community is the owner and administrator of communal grazing land, forests or water sources. The processes of deliberation and collective decision-making in these indigenous peoples' communities are rendered less effective when social institutions are weakened by migration (see Argueta, Gallart *et al*., 1992).

Increasing efficiency on a sustainable basis requires greater attention to social institutions in rural areas. This means that improving welfare and living conditions is a crucial component of a strong policy package designed to improve production conditions in Mexico's agriculture.

6.7 Policies for *in situ* conservation of genetic resources

Germplasm banks are not up to the task of long-term conservation of genetic resources. Although they provide an important service and contribute to genetic conservation, they do not ensure conservation of the full range of genetic variability of corn seeds (see Box 6.1).

Another problem of *ex situ* conservation is that many of the varieties in INIFAP's bank have been carefully studied, but a surprisingly small number of accessions have been used in genetic improvement programmes. Ortega Paczka (1997) reports that no more than 100 have played an important role in these programmes and only 40 (0.04% of the total INIFAP base collection) have supplied genetic material to improved OPV's and hybrids used widely in commercial production.

Finally, INIFAP's installations leave much to be desired, and the cold storage system is not reliable. A new project in Zacatecas turned out to be a failure a few years ago. Together with the weak budget allocations for agricultural R&D, the lack of adequate support for INIFAP's activities is disturbing.[lxxvi]

Crop germplasm conservation belongs to a class of dynamic phenomena. The old idea that native land races remain static and do not undergo dynamic evolutionary processes is gradually receding and a more accurate view regarding dynamic conservation is gaining more supporters (Ortega Paczka, 1997 and references therein; Louette and Smale 1996). Landrace diversity comes from age-long cultivation by farmers who utilize as much as possible the genetic potential of their crops to suit their particular agricultural and ecological environments. These varieties are constantly subjected to selection, migration (mixing with other farmers' stocks) and mutation (see Taba 1994:22). Farmers are thus the key actors in the process of *in situ* germplasm conservation.

The advantages of dynamic or *in situ* conservation are many and examined in a growing body of literature (National Research Council 1993; Nabhan 1989; Louette and Smale 1996; Crucible Group 1994; US Congress OTA 1986). These advantages are summarized by Dempsey (1996:4-5).

Perhaps the most important advantage of *in situ* conservation is explained by Dempsey (Id.) as follows:

> "Preserving seeds alone ignores many dimensions of agricultural diversity which have helped to sustain communities and have generated many of the resources we wish to preserve. For example, local knowledge of complex cropping patterns may allow more efficient use of niches created by local climate and soil variation. Informal systems of seed exchange are important for many farmers with uneven access to water, chemical inputs, credit and markets. Some of these social defence mechanisms may be lost or threatened by the introduction of new varieties. In situ conservation implies the maintenance of an appropriate social environment, if possible. However, economic and political changes can undermine traditional rural livelihoods. Neighbourhood effects disperse pollen, seeds, chemicals, and price impacts across field and social boundaries".

One factor in favour of *in situ* conservation is that there are large regions with surviving areas of intercropped, open-pollinated, landrace production, with opportunities for hybridization among cultivars and with their wild relatives and for further farmer selection. The case of Mexico and many developing countries is a good example of this. The case for *in situ* conservation of genetic resources is strengthened by the fact that it is very difficult to predict what crop plant characteristics or features must be sought in the future (National Research Council 1993:43). A minor pest today may rapidly evolve into a major problem in the not too distant future. A good example is the recent development of grey leafspot disease (*Cercospora zeae-maydis*) of maize into a disease of potential importance in the United States.

Finally, there are strong indications that *in situ* conservation has the enormous advantage of being compatible with schemes to introduce elements from improved varieties to landraces without reducing their characteristics or their variability. This process of improving landraces would lead to the enhancement of their desirable characteristics. Marquez Sánchez (1993) reports of the application of limited back-crossing techniques to carry out selective flows of useful genes to improve performance of landraces. A study quoted by Taba (1994) considers that as many as 250 Latin American maize landraces could benefit from this kind of programme, but strong support is required.

The case for *in situ* conservation is strongly supported by the above technical arguments. However, it is important to recall that the poor *campesinos* in Mexico's corn producing regions are not be in a position to carry out this important task under the current conditions of increasing economic hardship. Furthermore, the NAFTA corn regime is not providing the mechanisms to redress the problems of rural poverty identified in the present study. The deterioration of poor producers' technological capabilities as poverty increases will undermine their capacity to carry out the crucial task of conserving and developing genetic resources in the medium and long-term future.

Consequently, a system of policy instruments designed specifically to improve resource management capabilities of the poorest corn growers in areas previously identified as sources of rich corn variability should be set up. The question of geographical scale would have to be resolved without too many restrictions placed on the definition of 'local' varieties. As

revealed by recent studies, the mechanisms that generate diversity are complex and frequently (perhaps normally) go beyond the limits of a given community (see Louette and Smale 1996).

Box 6.1

Germplasm Banks and *ex situ* Conservation

Genetic resources can be conserved for a long period of time under special conditions in germplasm banks. Thought to be the answer to genetic erosion many years ago, germplasm banks are today the object of heated controversy regarding their long term viability (Cohen *et al*., 1991). The first germplasm banks in Mexico were established some thirty years ago (for a summary of CIMMYT's seed bank, see Wellhausen, 1988). The CIMMYT maize stock currently totals 13,200 accessions (Taba 1995:16) divided between two collections: base or active. Base collection seed is kept in sealed containers at sub-zero temperatures and low humidity, allowing the seed to remain viable for 50 to 100 years. Seed in the active collection is kept at just above freezing (0-2° C) and constitutes the 'working' bank from which seed requests are fulfilled. CIMMYT also has a field collection in Tlaltizapán, in the state of Morelos, with approximately 1,000 accessions of *Tripsacum*, a wild relative of corn.

The germplasm bank of Mexico's National Institute for Agricultural Research (INIFAP) comprises approximately 10,000 samples from native landraces which have been collected over the past fifty years. There are also 1,539 native landraces from other countries, and 144 *teocintes*.

Routine operations include seed identification, collection of new acquisitions or replacements, seed regeneration, characterization, supplying requests, and maintaining so-called passport and seed storage information.

Germplasm banks face serious problems in their task to maintain genetic diversity. Replacing the seeds in an individual accession is critical. The sizes of population samples pose serious problems for seed replacement intended to maintain viability of accessions. Evidence of genetic drift and genetic shift are two of the most serious problems afflicting seed banks.

Genetic drift refers to changes in allelic frequencies among small populations. In very large populations the frequencies of neutral alleles remain stable between generations. But in reduced populations, random fluctuations in allelic frequencies will inevitably occur. Genetic shift is related to changes in allelic frequencies due to selection during regeneration of seed samples. When these phenomena occur, genetic erosion is the result.

When samples are reproduced in environments which are significantly different from their place of origin, there is effectively a strong process of artificial selection operating, leading to yet another form of genetic erosion. Finally the users of the conserved germplasm are normally big seed companies, not individual farmers.

The policy instruments should be oriented towards three different types of actions. First, they would directly offer a supplemental income in the form of a 50% bonus on their PROCAMPO payments. This payment would accrue to all poor producers identified with the conventional techniques currently used by Mexico's government to target directly the most impoverished populations. All producers in the relevant stratum of the definition of poor producers would be eligible for this payment. The payment would have the advantage of reducing pressures to migrate and to expand the agricultural frontier (thereby intensifying deforestation). It would

also ensure coverage of producers relying on genetic variability of corn as a critical tool in their survival strategies.

Secondly, these instruments would be accompanied by adequate technical assistance in order to interact with producers and, where resource management capacity has been deteriorated, restore these capabilities. Seed selection is based on a form of idiosyncratic knowledge, and it is not expected that field workers providing technical assistance will be able to provide guidance on selection criteria and parameters utilized. However, in some cases they can assist with more general information and techniques. In addition, seed management is intimately related to other resource management dimensions (such as soil conservation, weeding and irrigation practices), and field workers may be helpful on these other fronts.

Technical assistance (and the old services of extensionism) provided by official government centres has almost disappeared from the Mexican rural landscape. The official government objective is to leave technical assistance services to private enterprises. But there are no private firms providing technical assistance services on agricultural production per se. Firms that do provide some kind of technical assistance are companies engaged in producing and selling chemical inputs or improved seeds. In fact, the term technical assistance is misleading when used in this context because the service provided by these companies' agents is more related to a marketing effort than to an interest in assisting producers to increase productivity gains or to engage in practices of sustainable agricultural production. A recovery of the former class of fundamental services is required, and it must be organized around efforts to guarantee long term conservation and development of corn, as well as other genetic resources.

A final set of policy instruments should focus on the relation between intellectual property rights and access to genetic resources. Farmers' rights in the new international and domestic context of intellectual property rights need to be explained fully to Mexican rural producers. In many cases, the farmers acting as curators of genetic resources may be able to obtain legal rights over varieties they have been developing under the Union for the Protection of new Plant Varieties (UPOV), which has been ratified by Mexico. In addition, this might help develop greater awareness of other angles of intellectual property (such as origin denomination). Finally, greater awareness of the importance of genetic biodiversity will be enhanced if Mexico's rural producers are fully informed regarding current legislation regarding access to genetic resources.[lxxvii]

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Endnotes

[i] The actual process of domestication was relatively short, as demonstrated by recent research on the genes controlling morphological differences between teosinte and corn plants. One major difference is that teosinte typically has long branches with tassels at their tips, whereas corn has short branches tipped by ears. Domestication relied heavily on the gene controlling this morphological difference. (See Wang, Stec, Hey, Lukens and Doebley, 1999).

[ii] Corn is linked to different final uses that help break dietary routines and play an important cultural role. Typical uses include production of *tortillas*, *tlacoyos* (cooked corn pancakes with beans), *pozole* (corn grain in a broth), *tamales*, *atole* (a beverage made from maize dough), and *pozol* (a beverage made in Chiapas from a blend of cocoa and maize grains). Different uses require different corn size, texture, colour, flour/starch content, viable storage time, etc. In many cases, traditional cultivars are favoured because of their overall performance and contribution to final uses: grain for human consumption, cobs for animals, ear covers for *tamales*, etc. Also important are certain maize varieties for the preparation of ritual beverages (*tezhuino* in the Huicot region and bitter *atole* in the northern Puebla sierras), and the famous ramified ear corns which are used in fertility-related rituals in Chiapas (Ortega Paczka, 1973).

[iii] It should be noted that in the agricultural sector, NAFTA comprises two bilateral agreements (Mexico-Canada and Mexico-United States), whilst US-Canadian trade continues to be regulated by the previously adopted Canada-US Free Trade Agreement. NAFTA establishes certain trilateral commitments regarding sanitary and phytosanitary standards, safeguards and rules of origin.

[iv] These contradictions are identified and analysed elsewhere. See Nadal (1999). This paper is reproduced in SUNS (South-North Development Monitor) number 4476 (14/07/99).

[v] For a detailed analysis of the 1994 crisis, the stabilization programme and the lack of progress in terms of recovery, see Nadal (1996, 1997, 1998).

[vi] It should be noted that the goal of balanced budgets has not been reached in Mexico in the past ten years. Official statements usually refer to balanced *primary* budgets, i.e. without the financial cost of public debt and other financial transfers. The complete story is more complex. When the economic balance, i.e. including debt service payments, is considered, there is a deficit. Although the deficit may be moderate (for example, below 2% of GDP), the key question is not absolute magnitude, but rather the means used to attain this result, namely severe reduction in public expenditure affecting many key sectors of the Mexican economy.

[vii] Considering allocation patterns in 1989, this meant doubling cultivated area of fruit and vegetables, a scenario hard to imagine under existing conditions (see Gómez and Schwentesius, 1993). Flexibility may be a plausible assumption for modern corn producers, especially in irrigated systems in Northwest Mexico, where already well-established marketing channels exist. It may also be a possibility in other regions across Mexico. However, shifting to horticulture involves a change in product and process technology, which is not easily achieved by domestic producers. Furthermore, evolution of market share does not support this objective.

[viii] This part of the study cited agricultural experts whose identity was not revealed.

[ix] In spite of this, de Janvry, Sadoulet and Gordillo (1995) erroneously describe the 1992 Levy-van Winjbergen study as a general equilibrium analysis.

[x] Levy and van Wijnbergen (1995:742) assume neutral technical change in their model. This means that factor proportions remain constant over time, an assumption not supported by real world data.

[xi] In addition, mechanization is also increasing in those segments of the corn sector that have traditionally offered job opportunities to poorer or landless people. Fieldwork revealed this is already

taking place in regions as diverse as Mazapiltepec (Puebla), Ixtlahuacán (Jalisco), and Venustiano Carranza (Chiapas).

[xii] See NAFTA, Annex 302.2 in Schedule of Mexico, tariff item 1005.90.99. The starting point was set at 206.9% in 1994, to be reduced during the first six years of the agreement by 29.6%. The remaining tariff will be phased out progressively over the following nine years until a zero tariff is reached for all imports.

[xiii] It would be helpful to carry out a comprehensive study of the effect of NAFTA on such crops, notably kidney beans, *Phaseolus vulgaris*, the production of which is closely related to strategies of corn producers in Mexico.

[xiv] See NAFTA, Annex 302.2 in Schedule of Mexico, tariff item 0713.33.02.

[xv] Personal communication, Jubenal Rodriguez Maldonado, ANEC.

[xvi] Other policies and instruments are relevant for understanding the full impacts of trade liberalization. For example, there have been dramatic falls in credit, research and development expenditure and technical assistance for agriculture. Of paramount importance is the fall in investment for irrigation infrastructure (see Nadal, 1998).

[xvii] Personal communication, Mr. Flavio Odóñez Flores, Red de productores de maíz, Chilpancingo, Guerrero (October 1998).

[xviii] In most instances, horticulture requires heavy capital investments, as well as well established credit and marketing channels. Technology adoption trends will increase this requirement, both in production and harvesting, as well as in post-harvest handling and storage. In addition, new trends in agro-biotechnology will contribute to increase capital requirements.

[xix] Exporting to the European market is not an easy task and Mexican producers will encounter heavy competition from growers in Chile, Argentina, Brazil, Ecuador, and Colombia. These countries are already penetrating the European and North American markets. Programs by World Bank and other multilateral lending agencies tend to emphasize this type of activity in detriment of self sufficiency in basic foodstuffs. The consequence may very well be that there is a situation of over supply in the horticultural markets of Europe and North America.

[xx] Hominized corn is white corn crushed or coarsely ground and prepared for use as a food by boiling in water or a mixture of water and milk. The ago-old process is used to produce corn dough for tortillas. These producers are called ‘nixtamaleros’. The thousands of tortilla producing-units linked to nixtamal producers were the beneficiaries of the general subsidy for the so-called ‘maize-tortilla’ chain.

[xxi] Since 1985 the trend is for private importers to increase their share of corn imports: from 27% to 45% in 1989, and to 100% in 1994. In 1996, private importers were responsible for 72% of total corn imports (a record 5.9 million tons). These private importers include starch and flour industries, cereal manufacturers, and feedstock suppliers.

[xxii] Data analysis in this chapter is at the country or state level. Results of fieldwork carried out at the household/local levels are presented in the next chapter.

[xxiii] Note that these are average data.

[xxiv] Another good indicator of vulnerability is provided by other data from the 1994 *ejido* survey: 82% of the *sample* of corn producers are involved with only one cycle, either the Spring-Summer cycle (74%) or the Autumn-Winter cycle (8%). Only 18% of *ejidatarios* who are maize producers in the survey sample grow corn in both cycles. This means that for the vast majority of producers (and their families) corn supply comes from only one crop during the entire year. Half of producers (47%) had inventories of corn before the cycle started, but these inventories were rather small.

[xxv] The conventional interpretation of the NAFTA effects on producers who supply the household with corn has always been that these units will be not be affected by price reductions because their products are not valued at market prices as they produce for household consumption. This is a rather simplistic interpretation of what subsistence production is all about, and is radically contradicted by studies at the household level (see for example, García Barrios et al 1991).

[xxvi] Partial equilibrium analysis relies on the extremely restrictive assumption that equilibrium exists in all other markets, in such a way that whatever adjustment or variations take place in the market being studied, nothing will change in the other n-1 markets. This approach implies examining the economic behaviour of agents in the market being considered as if their supply and demand functions depended only on one argument, the price of the commodity whose market is being studied. Assuming away the effects of all relative prices on supply functions of corn producers thus allowed researchers to hastily conclude that a decrease in the price of corn would lead to a reduction of supply.

[xxvii] The *ejido* framework is the result of a complex legal regime with origins in land ownership patterns in Medieval Spain. After the 1910 Revolution, land which had been concentrated in large haciendas was distributed to peasant communities. In order to protect producers against loss of lands, the *ejido* system curtailed sales of plots, or their use as collateral in credit operations. In 1992 a set of important reforms was approved by Congress, generating a nation-wide debate. Before these reforms, land under the *ejido* system was subject to a social and administrative regime of ownership by which individual families possessed plots with the said restrictions. Although these plots were cultivated either under conditions of individual or collective exploitation, the vast majority of land under the *ejido* regime was and continues to be cultivated individually. The 1992 reforms allow *ejidatarios* to sell their plots, rent them or use them as collateral. The rationale of these reforms was to bring private capital into the agricultural sector as *ejidatarios* would be authorized to enter into new associations with private entrepreneurs. So far, this process of investment flows into rural areas has not taken place.

[xxviii] De Janvry *et al* (1997).

[xxix] An interesting element is that the data produced by the *ejido* surveys of 1990 and 1994 appear to confirm the positive relationship between higher yields and increasing plot sizes, but this trend is interrupted when larger sized plots are considered (> 10 has. in rain-fed systems, and > 18 has. in irrigated plots). This drop in yields for the larger producers may have been caused by a regression in their technological levels.

[xxx] Normally, ecological systems are conceived as topographical units of relative homogeneity in terms of soil types of soil, landforms, groundwater, biota and topoclimates (see for example Bailey 1996). But these systems are susceptible to forms of land management and agricultural practices which help define an agro-ecological system. In their study García Barrios et al (1991:134) coined the term agro-environment to describe in richer terms the geographical space in which ambient factors which act as constraints for agricultural production are relatively homogeneous in the view of a producer. The social component in their definition provides a powerful tool of analysis.

[xxxi] Local landraces are better adapted than hybrids to the rugged conditions of altitude, climate, rain and wind, as well as deficient soils and abundant pests which characterize these regions. Thus, although yields may be lower when these landraces are used, hybrids cannot compete with them.

[xxxii] Additional interviews were carried out for producers in Alfajayucan, state of Hidalgo, and Jaltepec, state of Oaxaca.

[xxxiii] References applicable to the highly capital-intensive sector are made in this chapter and elsewhere in the study.

[xxxiv] There are 459 underground aquifers in Mexico. Most of these aquifers are in the northern half of the country, where natural recharge rates are lower than in southern regions. The northern and central regions have negative replenishment ratios due to high extraction. Already there are 80 important aquifers where (20%) over usage rates persist. Seepage of sea water into aquifers has increased as a result in some of these overexploited aquifers. Pollution by industrial and municipal wastes is also a problem. See INEGI-Semarnap 1998.

[xxxv] Personnal communication, Steve Suppan.

[xxxvi] Two family members migrated to the United States and initially provided an additional source of income during several years. Their contribution ceased recently as they established themselves in the US and had to meet the needs of their own families. This pattern is typical of migrants: as they settle down in their new place of residence and acquire new responsibilities, their remittances start to diminish. In some cases, this may force the original household to assign an additional member to national or international labour, starting the process all over again. The pattern of gradually diminishing remittances per migrant is confirmed by recent research (Binational Study 1997).

[xxxvii] Genetic erosion has been one of the most important processes of environmental degradation. Genetic erosion is traditionally defined as the loss of useful genotypes and alleles in landraces or local cultivars as they are replaced by modern improved (open pollinated) varieties or hybrids, or as a result of clearing of vegetation on a sufficiently large scale (National Research Council 1993).

[xxxviii] Diesel and gasoline prices are increasing constantly because they are important elements of non-tax fiscal revenues. The distortions in fiscal revenues have compelled the government to establish monthly hikes in the prices of these items to compensate for the fall in the international price of crude oils.

[xxxix] Soil horizons are the distinctive layers of soil separated by differences in physical and chemical composition, organic content, structure, or a combination of these properties. Soil horizons are produced by soil-forming processes. Starting at the top, horizons are designated by block letters A, B, C. Typically, the A horizon consists of organic material, and the C horizon contains parent material and rocks.

[xl] Although it is difficult to identify regional trends regarding erosion rates in Mexico, several isolated studies do exist and in many cases, there are indications that erosion rates are much higher than the sustainable levels of loss of topsoil. Soil erosion rates of this magnitude may exceed soil formation rates by an even greater proportion if soil formation rates are slower. According to Pimentel, Allen *et al* (1993:278) in most of the world's major agricultural regions, soil formation rates are 1 t/ha/yr. For example, a study on slopes under cultivation (corn) in the Los Tuxtlas region in Veracruz state, indicates that loss of soil reaches 43 t/ha/yr. This is at least two or three times greater than the maximum permissible rate determined in terms of soil formation rates (Turrent, 1997). There are also studies in northern Veracruz where rates of up to 100 t/ha./yr have been recorded (Ibid.). Another study in Chiapas, covering La Fraylesca region, indicates that erosion rates exceed the permissible limits for loss of soil with slopes greater than 6% (Villar Sánchez, 1996) under conditions of conventional tillage for corn cultivation.

[xli] The epipedon is a superficial soil layer, comprising the A horizon, and exceptionally the B horizon in the case of shallow soils.

[xlii] This set of technical requirements imposes important demands on the communities adopting vegetative technologies. In the case of Cuquío and Ixtlahuacán, community bonds do not appear to have the linkages sustain these technologies.

[xliii] In the United States, the trend after World War II was to shift towards larger farms, greater mechanization and regional specialization. Accordingly, bigger machinery was introduced and contour ploughing modified to accommodate for the larger capital equipment. Former terraces, shelter-belts, and hedgerows have been removed because they restrict the operation of large machinery (Pimentel, Allen *et al* 1993:286).

[xliv] In the case of soils in level land under irrigation, the main problem is of course salinization due to the process of evapotranspiration. It is currently estimated that at least 560,000 hectares of irrigated land (approximately 10% of all land under irrigation) is affected. The problem may be mitigated if salts are flushed downward to lower soil levels through more water use, but this is not a practical remedy where water is a scarce resource. On the other hand, adequate infrastructure works providing for efficient drainage of salts can be incorporated into irrigation systems. High costs of these systems were

the main cause for not having adequate designs of irrigation infrastructure with built-in drainage systems in the past (Turrent, 1997).

[xlv] The crisis in the sesame market was caused by a fall in international prices following a switch in industrial processes away from sesame oils.

[xlvi] Personal communication, Ing. Miguel Ares, Baderas S. de S.S., San Hipólito Soltepec, Puebla.

[xlvii] Recommended plant densities vary from one region to another, and from one variety of corn to the other, and may even vary in the same field from one cycle to the other. See Lafitte, 1994.

[xlviii] Appendini (1992) gives another estimate for 1985 of 30%.

[xlix] de Janvry *et al* (1995) and de Janvry (1996), based on the *ejido* survey of 1994.

[l] According to the National Census, the number of agricultural producers who do not sell surpluses in the market is 1,757,611, representing roughly 46% of total agricultural producers. Although this is an aggregate figure for all types of producers (i.e., growers of all crops), it probably corresponds very closely to corn growers producing for household consumption since corn is the main staple food.

[li] For more details on the genealogy of *Zapalote*, see Wellhausen, Roberts and Hernández Xolocotzi (1987).

[lii] Personal communication, Ricardo Díaz Cruz, Programa de Jornaleros Agrícolas (SEDESOL), 6 de marzo de 1997.

[liii] In 1996, for instance, horticulture production suffered in the northern states due to the drought. Needs for migrant labour were posponed, and in some cases, significantly reduced.

[liv] When land is abandoned because of migration or simply because it is not profitable to cultivate it, overgrazing is a threat. In the case of poor producers with few alternatives this poses a real danger because a large percentage has small animals such as goats and sheep, and overgrazing may follow. Erosion is a real danger in this case. Data from the 1994 *ejido* survey (Gordillo et al 1995: 7.1) shows that 37% and 35% of *ejidatarios* own goats and sheep respectively. This is an important point in the context of economic vulnerability because animals provide means to compensate for lack of other assets. Also, the poor *ejidatario* who owns a small plot of land, but owns sheep and goats has access to communal lands allocated for grazing, partially compensating for the unequal distribution of land. In view of social disintegration and decay of social institutions to manage the common lands, overgrazing may become more frequent.

[lv] A few aggregate figures are available, and isolated studies focusing on certain localities also exist with detailed measurements of erosion rates or losses of topsoil.

[lvi] Indirect indicators of loss of topsoil can be identified in siltation of dams and drainage and irrigation canals.

[lvii] Soil erosion rates of this magnitude may exceed soil formation rates by an even greater proportion if soil formation rates are slower. According to Pimentel, Allen *et al* (1993:278) in most of the world's major agricultural regions, soil formation rates are 1 t/ha/yr.

[lviii] The epipedon is the superficial layer of soils, normally containing the organic material of the 'A' horizon and part of the 'B' horizon.

[lix] Traditional corn producers normally use intercropping and other methods for growing associated crops with corn. As a general rule, however, rotation is not practised.

[lx] Another problem which affects modern growers operating on plain land under irrigation is salinization due to the process of evapotranspiration. It is currently estimated that at least 560,000 hectares of irrigated land (approximately 10% of all land under irrigation, 5.6 million has.) is affected

by this problem. When the limits of plant tolerance are reached, land must be abandoned. The problem may be mitigated or even significantly reduced if salts are flushed downward to lower soil levels through more water use. This is not a practical remedy where water is a scarce resource. On the other hand, adequate infrastructure works providing for efficient drainage of salts can be incorporated into irrigation systems. The high costs of these systems were the main cause for not having adequate designs of irrigation infrastructure with built-in drainage systems in the past (Turrent, 1997).

[lxi] Contour ploughing is especially important in the case of Mexico where slopes of 4% or more are a key feature in more than 67% of agricultural land under rain fed conditions.

[lxii] In the United States, the trend after World War II was to shift towards larger farms, greater mechanization and regional specialization. Accordingly, bigger machinery was introduced and contour ploughing modified to accommodate for the larger capital equipment. Former terraces, shelter-belts, and hedgerows have been removed because they restrict the operation of large machinery (Pimentel, Allen *et al* 1993:286).

[lxiii] This set of technical requirements imposes important demands on the communities adopting vegetative technologies. In the case of Cuquío and Ixtlahuacán, community bonds do not appear to have the linkages sustain these technologies.

[lxiv] If corn production is abandoned in marginal lands as a direct consequence of the reduction in corn prices, soil erosion may be slowed down. As land is left fallow during entire seasons, the epipedon will see its qualities gradually restored. And weeds and grasses will return and grow again. The root system of these plants will help arrest loss of topsoil and prevent erosion. Thus, for marginal lands, there may be a positive effect in so far as reduced pressure is concerned. However, aggregate figures at the national and state levels do not seem to lend confirmation to this hypothesis. In fact, the opposite trend seems to be taking place.

[lxv] In cases where these structures are built with labour intensive techniques, the supply of labour is a critical element for the modification of the physical landscape to increase productivity and for soil conservation. Research shows erosion is more rapid and severe on sloping land unprotected by terraces (see Pimentel 1993 and references therein). The construction of terraces along slope contours is less practised today. Hastily built terraces on the upper slopes often begin to give way sooner than carefully constructed terraces. These ill-designed terraces contribute to landslides that frequently damage more cropland and sometimes destroy entire villages.

[lxvi] Approximately one million Mexican corn producers rely heavily on a wide variety of land races as an insurance policy against risk. The 1994 *ejido* survey showed that use of improved varieties and hybrids among corn-producing *ejidatarios* is quite low. This is true even in irrigated systems where the percentage of *ejidatarios* using improved varieties was only 16% in 1994. In the case of *ejidatarios* in rain-fed production, the proportion fell to 8.8% (Gordillo *et al*, 1995: Table 5.7). The same survey showed that 91% of producers who rely on land races used their own seeds during the Spring-Summer cycle. For this group of producers the need to conserve genetic variability is a matter of survival. This group is therefore the true centre of future conservation of genetic diversity. The fate of this group will be the fate of conservation of genetic variability.

[lxvii] Ecological systems are defined as topographical units of relative homogeneity in terms of soils, landforms, surface and groundwater, biota and topoclimates (Bailey 1996). Their susceptibility to certain forms of land management and agricultural practices helps define an agro-ecological system. More precisely, García Barrios et al (1991:134) coined the term agro-environment to describe the geographical space in which ambient factors which act as constraints for agricultural production are relatively homogeneous in the view of a producer.

[lxviii] This does not mean that there are no risks for continued genetic erosion from the introduction of new hybrids or transgenic seeds in the more capital intensive groups of corn producers.

[lxix] This relation between cultural variance and genetic variability has been studied by Ortega Paczka (1973) and Hernandez Xolocotzi (1985). A poorly understood aspect of this interaction between social organization and corn genetic diversity is the role of language in the conservation of traditional

knowledge about corn seeds. An illustration of this strong interaction is provided by the *Mixe* language which identifies a greater and richer number of stages of plant development (germination, flowering, leaf and whorl development, appearance of black color at base of kernels, etc.) than those existing in conventional scientific literature (Ortega Paczka 1997). Another illustration of the importance of vernacular language in conserving and transmitting these genetic resources from one generation to another in the case of Totonacan populations (in the states of Puebla and Veracruz) is provided by Cuevas Sánchez (1991). In many cases, plant variability is only identified in vernacular Totonacan, and, in fact, the influence of formal schooling was negatively correlated with the capacity to identify plant variability.

[lxx] This is comparable to what happens when tribal cultures disappear and information regarding specific plants' uses is lost. Thousands of years have elapsed and made possible a process of information accumulation. When cultures and lifestyles of these indigenous peoples are lost, all of this information is "forgotten" or irrevocably lost. Much of this information is transmitted orally, or encoded informally in agricultural and other practices (medicine, leisure, etc.). There is no written record on these items, and when social institutions are destroyed or undermined, the information is lost.

[lxxi] As a source of comparisons, consider Mexico's total oil exports in 1997 (before the most recent collapse in international oil prices), reached $11.5 billion dollars.

[lxxii] MASECA, for example, recently announced plans to penetrate the white bread market in Mexico, both in the regular lines of production, as well as in sweetened rolls. This market may be perceived as highly profitable in the future, once the group consolidates its position. But, the entry barriers are relatively high, and the corporation must allocate considerable resources to establish a brand and adequate marketing channels. Activities such as tortillas, for a long time the group's main line of activity, may be seen as generators of resources allowing for these new investments.

[lxxiii] Of course, there is some truth in this argument, and Mexico's experience during the late seventies is ample proof of the economic damage that uncontrolled public debt brings about.

[lxxiv] Historically, infrastructure investments in Mexico's rain fed agriculture has lagged well behind investment in regions where rivers provided easy opportunities to expand irrigated surface in the northwest. This could have made sense at an early stage, but precipitation occurs largely in the southern regions and they have been largely neglected, except for the case of hydropower generation..

[lxxv] Harvesting coefficients are determined by multiplying actual (physical) surface of land by observed cultivation coefficients and by the reciprocal of the index of crop damage.

[lxxvi] In addition to these two seed banks, there are several official banks operating in other countries, as well as private collections. The most important seed bank in the United States operates under the auspices of the US Department of Agriculture, National Plant Germplasm System. This bank has an active maize germplasm collection of more than 12,500 accessions, and is located in Ames, Iowa. Many of the accessions are duplicates of varieties in CIMMYT's and INIFAP's banks. But these varieties are kept under stricter and better physical conditions, eg. under cryogenic storage conditions which make the need for replacement less urgent as seed viability is expanded considerably. This comparative conditions under which the different germplasm banks operate raises serious questions regarding future control and ownership of maize genetic resources (especially under intellectual property regimes which actively protect plant breeders' rights).

[lxxvii] Article 87bis of Mexico's Law for Environmental Equilibrium and Protection states that exploitation of genetic resources through biotechnologies requires prior informed consent of the owners of the land where the resources are located. These owners will also have the right to a fair share of the benefits accruing firms exploiting these resources.