Third North American Symposium
on Assessing the Environmental
Effects of Trade

Montreal / 30 November – 1 December 05

RESEARCH PAPER

# Scale, Technique and Composition Effects in the Mexican Agricultural Sector: The Influence of NAFTA and the Institutional Environment

**Authors:** Silvina J. Vilas-Ghiso*
Diana M. Liverman*

**Date:** March 2006

* Environmental Change Institute, University of Oxford

**Third North American Symposium**
**on Assessing the Environmental Effects of Trade**



Commission for Environmental Cooperation
393, rue St-Jacques Ouest, Bureau 200
Montréal (Quebec) H2Y 1N9
Tel: (514) 350-4300 ; Fax: (514) 350-4314
E-mail: info@cec.org
http://www.cec.org

## 1. Introduction

The North American Free Trade Agreement (NAFTA) signed between Mexico, Canada and the USA came into force on January 1994. Eleven years since, the environmental effects of trade liberalization in Mexico are still controversial, emerging and not properly understood. In more recent years, a heated debate on the subject has sparked. Free trade advocates assert that NAFTA has brought environmental improvements through promoting the efficient allocation of natural resources based on comparative advantages, while also promoting yield-increasing technological improvements. Indirectly, higher incomes brought about by increased trade and the influence of the international markets have resulted in greater investment in environmental standards and regulation, particularly for the use of key inputs such as water, land and agrochemicals (USDA 2002). Opposed to this view is that of many environmentalists who argue that increased Scale and intensity of production has promoted the overuse of water, agrochemicals and machinery, as well as the use of monocultures and improved seeds. They claim that the wealth created by trade has not necessarily resulted in environmental improvements, as weak institutional frameworks and the unequal accumulation of wealth has not promoted the reinvestment in more sustainable methods of production or improved regulation and enforcement. Finally, there is also the perception that liberalized trade has promoted the adoption of lower environmental standards and that environmentally damaging production processes – such as those relying on heavy use of agrochemicals – have relocated to the least developed trade partner (Oxfam 2002; Khan and Yoshino 2004; Nadal and Wise 2004). These opposing views on the environmental effects of the agreement have been stimulated by the lack of environmental indicators, the delayed onset of some impacts, as well as by limited numerical research on the specific links between trade and environmental impacts within the agricultural sector at the national level. Moreover, a general picture of NAFTA's environmental impacts in the Mexican countryside – understood as the combined effect of the Treaty's rules and regulations, accompanying environmental accords, institutions and transition plans – is still missing.

This paper contributes to the small, but growing, literature that aims to explore the environmental impacts in the agricultural sector in Mexico during the post NAFTA period – both among Industrialized and Communal (ejido) farmers – as well as the influence of the national and multilateral institutional framework on these outcomes. The paper has a dual objective:

a) Decompose the post NAFTA period into Scale, Technique and Composition (STC) effects to estimate the impact that the trade liberalization process has had on the use of fertilizer and land, two key agricultural inputs for which reliable aggregate data is available. The analysis for each input will be conducted at a national level, as well as for Industrial and Communal farmers. See Box 1 for a brief description of Industrial and Communal farmers. The numerical analysis will then be complemented with more qualitative data obtained from existing literature on regional and crop-specific case study analysis, which will help to illustrate how agricultural input use trends may be affecting environmental quality in the countryside. Limited data points mean that the results of the analysis should be assessed as more exploratory than conclusive.

b) Seek to further our understanding of how the multilateral and national institutional framework has had a determinantal influence on the resulting SCT effects, particularly Technique and Composition. In particular, we will study the institutional determinants of agrochemical use among Industrial farmers as well as of land use among Communal producers.

This paper is divided into six sections including introduction, background, methodology, data trends, SCT results and institutional analysis. The paper finishes with conclusions and recommendations which highlight key interventions suggested to improve the environmental sustainability of agricultural production and trade in the Mexican countryside.

## 2. Background

The signature of NAFTA accelerated the reduction in trade barriers that commenced a decade earlier when Mexico joined the General Agreement of Trade and Tariffs (GATT). In the case of the agricultural sector, it established a ten to fifteen year transition period for agricultural produce centered on a tariff-rate quota-based import system. It is important to mention, however, that in response to Mexico's 1995 economic crises, the government has continuously exceeded the import quotas established for most of the agricultural commodities under NAFTA, effectively accelerating the agreed transition period to less than three years (Nadal 2000).

As in most economic sectors, the implementation of NAFTA was accompanied by a whole set of neoliberal policies pursued by the Mexican government during the 1980s and 1990s intended to increase the country's international competitiveness, including privatization, decentralization, deregulation and tighter fiscal policies. In the particular case of the agricultural sector, most controversial were the constitutional amendments in 1992, which restructured land tenure regulations, allowing for private ownership of the collectively held agricultural lands, known as *ejidos*. This change has allowed the sale and rental of collective lands and has prompted the re-concentration of land into large, privately owned farms, particularly in the northern states of the country. The role of the government as regulator and source of financial support also retrenched. By the mid-90's, the government had virtually dismantled the operations of Banrural - the government-owned rural development bank – and Conasupo – the price support agency in charge of setting guaranteed prices for most crops. Input subsidies on seeds, fertilizer, pesticides, machinery and diesel fuel were eliminated. Public investment in irrigation infrastructure, marketing, technical assistance and research and development were also halted (DeJanvry, Sadoulet et al. 1995; Appendini 1998; David, Dirven et al. 2000; Nadal 2000).

As a substitute for the previous government support schemes, the Ministry of Agriculture (SAGARPA) established two basic policy instruments – Procampo and Alliance for the Countryside. These instruments aimed to assist producers - especially low income farmers - during the transition period to an open economy (SAGARPA 2004). However, inadequate funding – partially as a result of the aftermaths of the 1995 economic crises – and a bias towards allocating the funds to commercially viable farmers, have limited the impact of the rural development plans during the transition period (Nadal 2000; FAO and SAGARPA 2002; Martinez 2003; Patel and Henriques 2003).

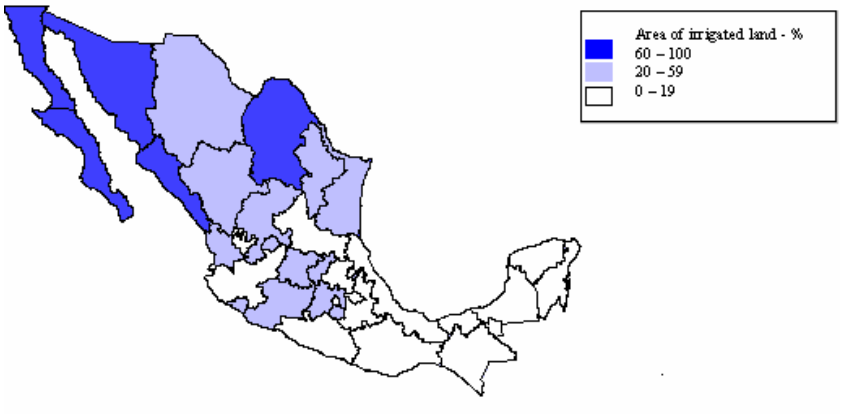
The complex interweaving of these policies make it impossible to disaggregate the socio-economic and environmental implications attached to each of them. However, it is also arguable that most of these policies where implemented in preparation to NAFTA and will thus be considered in the context of this paper as the "NAFTA package".

**Box 1 - The Mexican Agricultural Producers**

Mexico's agricultural producers can roughly be divided into two groups with contrasting economic and social realities, which also affect their environmental footprint. Although this division is an oversimplification of reality - as there is a range of producers falling in between these categories - it allows for a more structured analysis.

***Industrialized (northern) Producers***. Generally described as large agro-enterprises, which rely on input-intensive agricultural methods, and are thus heavy users of water, fertilizers, pesticides and mechanized traction. They are mostly located on irrigated lands and in plots of land that are larger than the average, with higher yields and better soil quality. Industrialized farmers are generally focused on the export market and have the flexibility to shift between basic grains, horticultural crops and other non-traditional commercial produce. They are economically competitive and enjoy relatively good profit margins. Although they are present throughout Mexico**,** they are mostly concentrated in the northwestern states - Baja California Norte, Baja California Sur, Sonora, and Sinaloa - and the northern state of Coahuila. For geographical clarity, the map below highlights in darker color the states with higher concentration of Industrialized farmers[i].

***Communal (southern) Farmers.*** Constitute 70% of Mexican farmers and some 15 million family members. They mostly operate under difficult conditions of inferior soil, sloping terrain, rain fed land, and small landholdings. Communal farmers do not usually participate in the international market. Approximately half of them are net sellers of grains to the domestic market, with the other half producing mainly for self-consumption. Poor soil quality and small plots of land - less than 5 hectares in average - means that there is usually no possibility of converting from traditional grain production to high-value crops. Although they are also present throughout Mexico, they are mostly concentrated in the southern, central and high parts of the country (as seen in the white sections of the map). Within this, the group of states with the highest concentration of production units, with smaller plots, lower yields and strong incidence of poverty are the southern states of Chiapas, Guerrero, Hidalgo, Oaxaca, and Veracruz.




Note: The map is based on Hectares of irrigated land. Access to irrigation is highly correlated to profitability, productivity and production for export markets (CNA 2001), and can thus be used as a suitable indicator of Industrialization.

Text based on (DeJanvry, Sadoulet et al. 1995; Nadal 2000). Map source: SIMBAD (2002)

Separately, the combined pressures of globalization and liberalization, which effectively started when Mexico joined the GATT in 1986 and where intensified with the signature of NAFTA and its environmental side agreements, appear to have stimulated a beneficial restructuring of the Mexican environmental laws, regulations, standards and institutional infrastructure (OECD (2003) and UNEP (2000). For example, this led to major regulatory reforms during the early 90s and to the reorganization of Mexico's disparate environmental agencies into a single, cabinet-level Secretariat of the Environment & Natural Resources (SEMARNAT). Despite these positive advancements, the national environmental institutional framework has been also criticized for lack of adequate funding, lack of qualified human resources to carry out environmental management and implementation and lack of political will (UNEP 2000). Particularly weaknesses have been highlighted in the integration of environmental concerns in sectoral decision making, specifically in economically depressed sectors such as agriculture (OECD 2003).

At a multilateral level, the signature of NAFTA's side agreements[ii] have been instrumental in the creation of three institutions intended to support national institutions in minimizing the negative environmental impacts of the treaty: The Commission for Environmental Cooperation (CEC), The Border Environmental Cooperation Commission (BECC) and The North American Development Bank (NadBank). In addition, three committees which do not necessarily have environmental aims but are relevant to agricultural issues were created under NAFTAs Free Trade Commission: the Committee on Sanitary and Phytosanitary Standards (CSPS), the Technical Working Group on Pesticides (TWG) under the CSPS, and the Committee on Agricultural Trade (CEC 1997). It has been argued that NAFTAs multilateral environmental institutions have positively impacted cooperation between the three countries. They have contributed to opening the communication channels and information sharing between countries, and have been successful in increasing intergovernmental coordination on the decision making process of environmental problems in the border region. However, their continuous under-funding and a lack of political support from the three national governments have curtailed their ability to more actively deal with many of the environmental stresses brought about by NAFTA (Mumme 1999; Torres 1999; McKinney 2000). Further, with the exception of the CEC in recent years, the active influence of these institutions on trade related environmental impacts in the agriculture sector have been limited.

## 3. Methodology

### The Scale, Composition and Technique Effects Theory

The Scale, Technique and Composition effect theory was originally developed to better understand how trade liberalization between developed and developing countries affected Industrial air-pollution levels. Many authors have applied this theory as a tool to disaggregate the air-pollution impacts of free-trade zones in Latin-American, including those created as a result of NAFTA (Grossman and Krueger 1991; Copeland and Taylor 1994; Husted and Rodriguez-Oreggia 1996; 2001; Antweiler, Copeland et al. 2001; Wheeler 2001). Other authors have used it to assess the effectiveness of regulation aimed at reducing Industrial air pollution (Selden, Forrest et al. 1999). See box 2 for a definition of the SCT theory and how it may apply to the agricultural sector. Given the complexities of the trade and environment links, this framework is a useful tool to

isolate the key influences that can have an effect on environmental quality, as well as in focusing the area of study.

**Box 2. Scale, Composition and Technique effect – Definition and application to agriculture**[iii]

**Scale effect.** Empirical evidence has long linked trade liberalization to economic and output growth, as it opens access to previously restricted markets, while encouraging Foreign Direct Investment (FDI) in productive assets. Increased Scale of production may place greater stress on the environment as, assuming constant Composition and Technique effects, more inputs and resources are required to satisfy the increased demand. Given this, the Scale effect generally indicates an increase in environmental degradation. In the agricultural sector, this can be translated into, for example, environmental stresses related to increased use of inputs such as water and agrochemicals or the expansion of the agricultural frontier to marginal land.

**Composition effect.** Trade liberalization may affect the Composition of national output by encouraging some economic sectors and limiting others and hence altering the incidence, type and level of pollution (or environmental degradation) across regions and countries. Thus, the Composition effect measures the change in environmental degradation due to changes in the range of goods produced, assuming constant Scale and Technique of production. Environmental effects can be positive or negative depending on the pattern of trade-induced specialization. In the case of agriculture, given that different crops require different levels and types of agricultural inputs, specializing on lets say, grains versus horticulture, will have on itself an effect on the use of environmental resources.

**Technique effect**. Economic theory predicts that output growth promoted by trade liberalization increases incomes, and wealthier countries tend to be more willing and able to channel resources into environmental protection through the establishment of higher environmental standards and the investment on more sustainable technologies. The Technique effect is then determined by the combined influence of incomes and a producers' response to market and institutional incentives The Technique effect thus measures the change in aggregate pollution (or environmental degradation) arising from a switch to more environmentally sustainable production Techniques, assuming constant Scale and Composition effects. In the case of agriculture, trade liberalization may affect the producers' choice of adopting expansive versus input-intensive agricultural methods, as well as the uptake of more sustainable agricultural technologies.

Adapted from (Grossman and Krueger 1991; Copeland and Taylor 1994; Copeland and Taylor 2003)

In recent years, the Organization for Economic Cooperation and Development (OECD) has promoted the use of this methodology in other economic sectors, including agriculture (OECD 1994; IISD 2000; OECD 2000). Despite this, and the fact that no other model currently exists to accurately assess the environmental impacts of agricultural trade (Carpentier 2001), few attempts have been undertaken to apply this framework in the agricultural sector of the America's[iv].

### The Numerical analysis

We start the analysis by determining three equations, each of which aims to isolate one of the SCT effects. Each equation will be applied to the agricultural inputs where reliable consumption data is available (fertilizer and planted area), both for the periods' pre and post NAFTA (1980-1993 and 1994-2003, respectively). All analyses will be conducted at a national level, as well as by Industrial and Communal farming. In addition,, aggregate and per-capita effects will be analyzed. Although both are closely linked, the former results are of interest as environmental degradation is generally linked to the aggregate amount of inputs used whilst the latter helps isolate the influence of population growth in input use. The per capita analysis is particularly important as national population grew 16% during the NAFTA period. One-sided two-sample t-tests assuming unequal variances are conducted to assess significant changes on each of the SCT effects pre vs. post NAFTA. Note that in the SCT analysis, agricultural output and inputs are measured in units – rather that in value – as given the significant drop in agricultural commodity prices during the last decade, a quantity measure gives a more accurate image of actual production trends.

a) Scale effect

To obtain the Scale effect, it is necessary to determine how trade induced changes in aggregate production output have affected input use. We define St to be the Scale effect in year t and Io to be the yearly agricultural input consumption – being it fertilizer or land – during base year (1980 for pre NAFTA and 1994 for post NAFTA). Yo reflects the aggregate agricultural output (in units of production) for the base year and Yt, the aggregate agricultural output in year t. Allowing the aggregate agricultural output to change throughout time while holding input use intensities fixed gives us the Scale effect. In other words, St is a measure of how much aggregate input use would have changed solely as a result of increases in agricultural output and assuming that the input-use intensity remained fixed at the 1980 and 1994 levels, for pre and post NAFTA respectively.

$$St = \left(\frac{Io}{Yo}\right)Yt - Io$$

b) Composition effect

To obtain the Composition effect, it is necessary to determine how trade induced changes in the ratio of grains to horticultural production have affected input use. We define Ct to be the Composition effect in year t. The Composition effect is calculated by letting the relative share of production of the two main crop types (grains and horticulture) Yj/Y change whilst holding input intensities (Ij/Yj) fixed in each sector. This allows us to isolate the pure effect of the Composition change.

$$Ct = \sum_j \left(\frac{Ijo}{Yjo}\right)\left(\frac{Yjt}{Yt}\right)Yt - \sum_j \left(\frac{Ijo}{Yjo}\right)\left(\frac{Yjo}{Yo}\right)Yt$$

By holding input use intensities at the base year levels, we are able to observe if changes in the relative production of grains vs horticulture have contributed to a reduction in aggregate

input use (as different types of crops require different levels of input use). Note that if the agricultural sector had experienced a homogenous growth in the production of grains and horticulture, Ct would equal zero.

c) Technique effect

Our numerical analysis of the Technique effect centers on understanding a producers' response to trade liberalization through the adoption of extensive and/or intensive agricultural Techniques. The impact that the agreement has had on real incomes, and thus on the feasibility of producers to invest in more efficient technologies, will be addressed briefly and at a conceptual level in the results section of this paper. To obtain the Technique effect, it is necessary to determine how trade induced changes in the amount of input use per unit of production –i.e. intensity of use - have affected aggregate input use. We define Tt to be the Technique effect in year t. To calculate changes in the intensity of input use per type of crop, we allow the aggregate input use intensity per sector (Ij/Yj) to change.

$$Tt = \sum_j \left( \frac{Ijt}{Yjt} \right) Yjt - \sum_j \left( \frac{Ijo}{Yjo} \right) Yjt$$

Tt indicates whether changes in input use intensity may have counteracted increases in aggregate input use resulting from output growth and/or changes in Composition of production. It also indicates the uptake of either intensive or expansive agricultural practices by Industrial and Communal farmers.

**Limitations of this Scale, Composition and Technique analysis**

There are some limitations to this analysis which stem both from the conceptual nature of the framework and from limited data availability. Firstly, the agricultural data available at SIACON-database only covers the period 1980-2003, thus there are only 23 yearly-data-points available to conduct the numerical analysis. Limited data-points mean that the results of the analysis should be assessed as more exploratory than conclusive. Further, the use of national indicators to assess the aggregate impacts of trade imply that more localized impacts, which may be more variable than the aggregate results, will not be evident. In addition, potential positive agricultural by-products, such as open space and scenic views, are currently not easily assessed within this framework, as they are abstract measures difficult to quantify.

The main limitation, however, is that the outcome of our SCT model does not provide us with an indication of how much pollution levels in the agricultural sector have been affected during the post NAFTA period, but of how trade incentives have affected agricultural input use. This stems from the lack of local and aggregate environmental indicators – such as land and water pollution due to fertilizer use, or deforestation due to agricultural expansion. Note that this also represents a key difference in our application of the SCT model from all other studies assessing Industrial air-pollution levels. As a way to address this issue, the numerical SCT analysis is complemented with more qualitative data obtained from existent literature on regional and crop-specific case study analysis, which will help to briefly illustrate how agricultural input use trends may be affecting the environmental quality of the Mexican countryside.

Another difference versus other SCT analysis, which may not be considered a limitation on itself, is that all numerical analyses are conducted using agricultural output and input in unit measures – rather that in value. Given the significant drop in agricultural commodity prices during the last decade, using a quantity measure gives a more accurate image of actual production and input trends.

**The Institutional analysis**

The second section of this paper seeks to reveal how the multilateral and national institutional framework has had a determinant influence on the resulting SCT effects, particularly Technique and Composition. In particular, theory suggests that the strength of the Technique effect depends on how quickly government policy is formed and adapted to new conditions (Vaughan and Block 2002; Copeland and Taylor 2003).

We focus on two case studies. On the first, we analyse the potential influences that the institutional framework has had on the intensification of agrochemical use among Industrial farmers during the post NAFTA period. We include in the analysis the institutions that we think have had greater influence on this subject, being these the NAFTA Committee on Sanitary and Phytosanitary Standards (CSPS), particularly through its Technical Working Group on Pesticides (at a multilateral level) and the Commission for the Control and Use of Pesticides, Fertilizers and Toxic Substances (CICOPLAFEST; at a national level). The second case study aims to clarify the influences that the institutional framework has had on the agricultural frontier expansion in Communal lands. Given the limited involvement of environmental and multilateral institutions in Communal farming so far, we focus on understanding how the implementation of SAGARPA's rural development plans - in particular Procampo and Alliance for the Countryside – have influenced the Technique and Composition effects in Communal lands. Given that the objective of this section can not be addressed through quantitative data analysis, it will be primarily based on the analysis of publicly available information, such as government reports, government or private sector websites, academic journals and other published literature.

## 4. Data & Trends

To conduct the SCT analysis, we use the following data: a) historic agricultural production data – yearly agricultural output, Composition of production, agricultural yields and hectares of planted area - obtained from the Ministry of Agriculture (SIACON-database 2004); and b) yearly fertilizer consumption obtained from the FAO statistical database (FAO-stat 2003). Note that fertilizer consumption is only available at a National level. The fertilizer consumption breakout between Industrial and Communal farmers has been calculated by the authors by estimating how, over time, changes in both the expanse of land under cultivation and yield per hectare reflect changes in fertilizer consumption patterns among both type of producers.

In order to better understand the results obtained from the SCT analysis, it is useful to have a clear picture of the agricultural trends observed through the analysis of raw data. Box 3 includes graphs for all relevant agricultural trends, which are briefly explained in the following paragraphs.

Agricultural Output Growth – volume

As we can see, agricultural production (in tons) increased 35% during the post NAFTA period, equivalent to a yearly average growth of 3.5%. This compares to a 22% growth during the pre NAFTA period, a yearly average growth of 1.6%. This growth was driven by Industrial (36%) and Communal (33%) output growth. Per capita output growth increases follow a similar trend, showing output growths of 17%, 15% and 27% for total national, Industrial and Communal producers respectively.

Agricultural Production Value (APV)v

The total Agricultural Production Value dropped soon after NAFTAs start of implementation – in association with a general economic crisis in 1995 - and has not yet recovered. In the years since, agricultural value growth has been consistently below the national GDP for all sectors, below pre NAFTA levels and below Mexico's population growth rate (Nadal 2000). As we can observe, APV has drop -13% during the post NAFTA period, compared to only a -3% drop before NAFTA. This decrease in production value occurred despite the Scale increases highlighted above and was evident in both, Industrialized and Communal producers, where reductions of -20% and -4% respectively were observed. Moreover, total APV per hectare of planted area also dropped -14% at a national level.

Although a drop in crop price in line with international prices was expected from the outset, its decline was exacerbated by the Mexican government allowing imports of grains from the USA –particularly corn – to constantly exceed the fixed quotas established as part of the agreement (David, Dirven et al. 2000; Nadal 2000; Patel and Henriques 2003). As a result, corn production value per unit of production decreased by -56% and -27% for the Industrial and Communal farmers respectively (SIACON-database 2004). For Communal farmers decreased incomes have translated into increased poverty incidence among the economically active rural population. Rural household poverty has increased from 57% in 1992 to 61% in 2000 (Cáceres, Hernández et al. 2002).

It is fair to say, however, that APV decline has not been necessarily caused by the agreement per se, but by the inadequate implementation of its rules and regulations. Further, although it seems that NAFTA has exacerbated economic scarcity in Communal lands, as extreme poverty has been characteristic of the southern states for many decades.

International trade of agricultural produce

Aggregate exports of Mexican agricultural produce to the USA –including grains and horticulture only – increased 112% to US$4.10 Billion during the post NAFTA period. The driver of this growth has been the increased export of fruits and vegetables, which grew 105% to US$3.8 Billion during the post NAFTA period Note that this upward trend started well before NAFTA, as evidenced by agricultural exports growing by 107% during the period 1989-1993. Interestingly, research by the World Bank (2003) suggests that Mexico's global exports – including all economic sectors - would have been about 25% lower without NAFTA , while FDI would have been 40% less.

Regarding aggregated imports of agricultural produce from the USA to Mexico, they grew 83% to $3.54 billion during the post NAFTA period, up from a 12% growth during the five-year period before NAFTA. In the case of imports, growth was driven by an increased influx of grains into the Mexican market, as evidenced by a 90% increase in cereal and feeds

imports to US$2.74 billion during the post NAFTA period. As mentioned before, the reader should keep in mind that the rapid increase in grain imports was not necessarily due to the NAFTA agreement itself, but to the fact that the import quotas established for most of the agricultural commodities – specially corn – have been continuously exceeded.

Composition of production

National grain production has increased by 40% during the post NAFTA period, whilst horticultural production has increased 32%. This has been driven by Industrial producers increasing grain output by 8% during the post NAFTA period, whilst increasing production of fruits and vegetables by 48%. This shows a bigger emphasis on production of more profitable, non-grain crops, and reflects a 57% increase in horticultural exports after NAFTA's start of implementation (Patel and Henriques 2003). At the Communal level, output of grains increased 77% post NAFTA, while other crops increased only 12%.

Agricultural Yields

Industrial producers have gone through a dramatic increase in yield of 54%, from 12.1 to 18.7 tons/ha. Indeed, their total production increased 36% despite a -12% decline in total planted area during the post NAFTA period. Industrial yield growth during pre NAFTA period was 17%. This coincides with the trend in OECD countries- such as Canada and the US - to decrease agricultural land use while increasing their reliance on input intensive production methods (Unisfera 2003).

In Communal areas, however, the average yield in 2003 was of 4.7 tons/hectare – a forth of the average yield for Industrialized producers – and reflected an improvement of 25% versus 1994 (27% growth during pre NAFTA period).

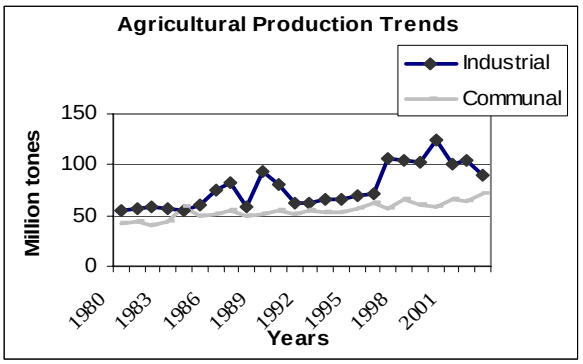
**Land use**

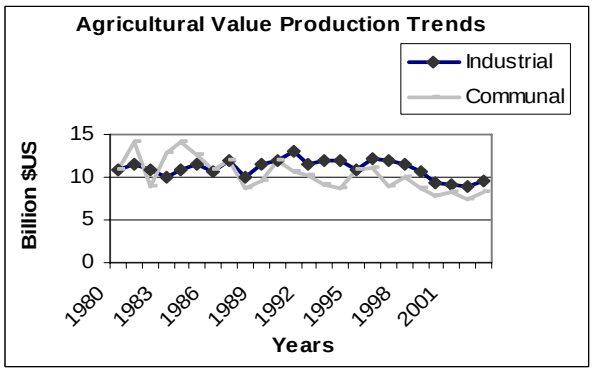
At a national level, land use appears to remain almost constant, increasing only 1% in 2003 when compared to 1994. However, when we analyze the land use patterns among Industrial and Communal farmers, we observe two evident and distinct trends. For Industrial producers, the fact that they have increased yields proportionally more than production has translated into a -12% decline in total planted area versus pre NAFTA years (-659,530 Ha). The opposite phenomenon has been observed among Communal farmers. Limited improvements in yields in Communal areas have meant that agricultural output growth has come mainly from a +6% increase in the area under cultivation (+865,550 Ha). The reader should keep in mind that Industrial producers are, in their majority, located in the northern drier areas of the country, whilst Communal farmers are mostly located in the tropical south, in or near increasingly fragmented forest land, where increasing the land under cultivation may lead to deforestation.

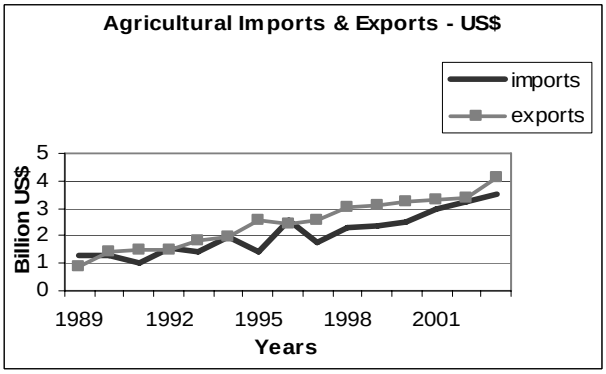
**Fertilizer consumption**

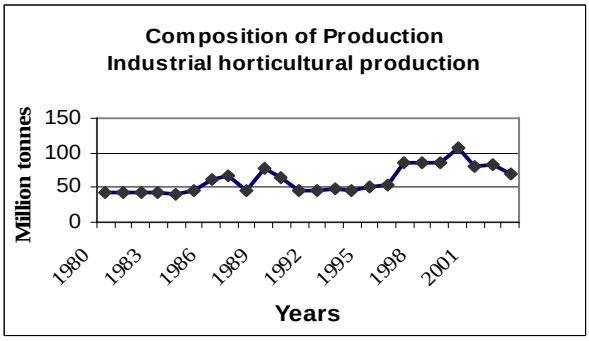
The post NAFTA period shows a significant deceleration on aggregate fertilizer consumption among both type of producers, when compared to pre NAFTA. After a relatively steep increase of 29% in tons of fertilizer consumed at a national level during the pre NAFTA period, the post NAFTA period saw a milder increase of 3.9 %. Authors estimations (as described in the Data & Trends section) point out that the post NAFTA trend was driven by an

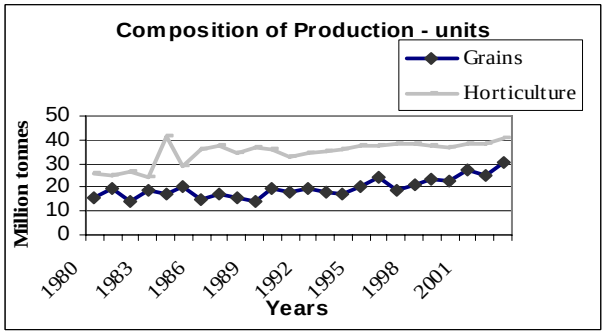
increase in the total amount of fertilizer use by Industrial producers (our estimate at 8%) and a decline in the total amount of fertilizer use by Communal farmers (-9%). If this holds true, the average fertilizer use intensity (kg/ha) during the post NAFTA period grew 24% to an average of 280 tons/ha among Industrial farmers, whilst declining 14% to 24 tons/ha among Communal farmers (total national intensity increase of 19%). These compares to pre NAFTAs fertilizer intensity growth of 11% for Industrial and 116% for Communal farmers. The growth in fertilizer use among Industrial farmers may be traced back to the pressure to compete in the input-intensive international market. The apparent drop in fertilizer use at the Communal level might be, among other things, the result of the elimination by the federal government of agricultural input subsidies which were prevalent during the pre NAFTA period, as well as the dismantling of government-owned FERTIMEX, the institution in charge of producing and distribution fertilizers throughout the country.

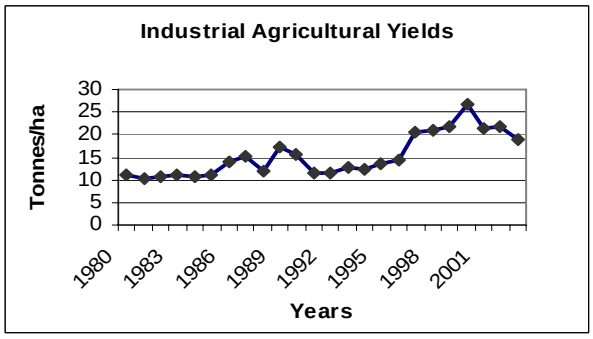


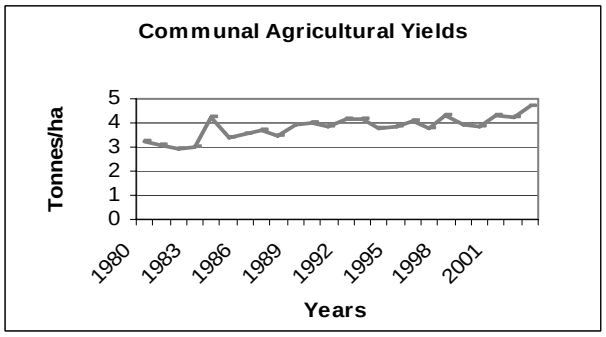



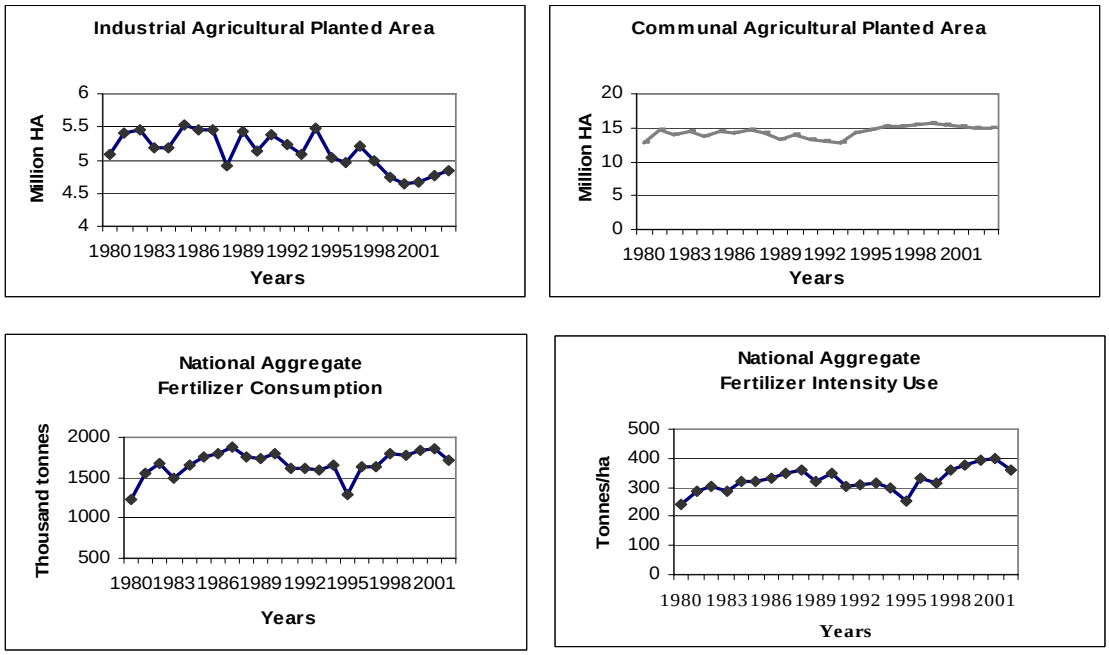




Sources: Agricultural production data (SIACON-database 2004), trade data (COMTRADE 2003)




Source: Planted area (SIACON-database 2004) and fertilizer use (FAO-stat 2003).

## 5. Scale, Technique and Composition Effect Results

To provide a context to the following results, it is useful to translate NAFTAs agricultural objectives into the Scale, Composition and Technique effect framework. It appears that NAFTA negotiators assumed that the negative environmental impacts of increased agricultural production (Scale effect), were to be offset by improved environmental legislation - specially in terms of agrochemical and water use - and increased investment in more efficient technology (Technique effect) (Nadal 2000; Sarmiento 2003). Further, it was expected that Mexico would increase the production and exports of non-traditional crops that were considered to enjoy significant comparative advantages - in terms of climate and availability of cheaper labor - such as vegetables, nuts, coffee and tropical fruits. It was thus considered desirable for Mexican producers to move from corn and grain production to cultivation of other crops. This would bring economic benefits to Mexican farmers who would switch to more profitable crops. It would also, in theory, bring environmental benefits as farmers would produce more efficiently and thereby reduce pressure on environmental resources (Composition effect) (DeJanvry, Gordillo et al. 1997; Nadal 2000). In the following paragraphs we will review in detail the result of our SCT analysis for each of these effects and will assess how reality compares to NAFTAs expected outcomes. The decomposition analysis will aid in better understanding if the post NAFTA period has resulted in a more efficient use of land and fertilizer, by showing market influences that are not evident at first sight. It will also help us identify areas of opportunity, which if properly addressed, could aid in ensuring the positive effects of trade are maximized in terms of land and fertilizer use efficiency.

Table 1 presents the aggregate and per capita results of our decomposition analysis for the period's pre NAFTA (1980-1993) and post NAFTA (1994-2003), for both land and fertilizer use. The numbers presented in the table represent changes in input use during the pre and post NAFTA periods. A 's' represents whether the mean yearly changes observed during the post NAFTA period where significant when compared to the mean changes during the pre NAFTA period. Figure 1 presents this data in a visual manner. Positive numbers tend to increase the amount of input use, whilst negative numbers tend to decrease the amount of input use.

**Land Use – SCT results and analysis**

a) Scale Effect

The Scale effect shows that at an aggregate level, national agricultural land use would have risen by 6.8M ha, or 34%, had it grown in proportion to output growth between 1994 and 2003. Per capita land use would have increased 36 ha/capita (17%), the difference being a 16% increase in the country's population. This is driven by a statistically significant Scale effect among Industrial farmers of 36% (1,972 Ha) and 15% (12 ha/capita) at an aggregate and per capita level. Pressures to increase land use are a reflection of increased output of production to supply the international demand for Mexican agricultural products, as well as of the US$ 3.8 billion in FDI that have been invested in the Mexican agricultural sector since NAFTA started, as a means to strengthen the country's international competitiveness and export capacity (Nadal and Wise 2004). Although this investment might represent only 0.3% of the total FDI the country received in the last decade, its geographical and crop concentration have made a significant impact on agricultural production (80% of agricultural FDI has been concentrated in the states of Sonora and Sinaloa, with 95% of it going to hog farming, horticulture and flower cultivation (Nadal and Wise 2004)).

At the Communal level, a steep increase in the Scale effect of land use (33% aggregate; 27% per capita) during the post NAFTA period appears not to be statistically significant as it is preceded by a similarly steep Scale increase during the pre NAFTA period (28% aggregate, 23% per capita). This may suggest that pressures to increase agricultural land under cultivation at the Communal level, trade related or not, have been, have been exacerbated rather than created during the post NAFTA period. It is important to keep in mind, however, that for Communal farmers, agricultural production growth cannot be explained by increased market access, as they do not usually participate in the international market. As explained by May and Bonilla (1997), increased production of traditional crops in poverty stricken regions is a common response to free trade adjustment pressures, as poor farmers need to counteract rising poverty and lower commodity prices through increased volume of production.

The Scale effect not only evidences the pressures to increase land use stemming from steep increases in agricultural output, but also highlights that the most useful point to start understanding the Composition and Technique changes is not the actual 2004 input use levels, but the one that would have prevailed had land use per unit of output had remained constant during the post NAFTA period.

**Table 1. Scale, Composition and Technique Effects - Results**

**LAND USE - Aggregate**

| | TOTAL | | | INDUSTRIAL | | | COMMUNAL | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1980-1993 | 1994-2003 | (s) | 1980-1993 | 1994-2003 | (s) | 1980-1993 | 1994-2003 | (s) |
| '000 ha | | | | | | | | | |
| **Actual Change** | **47.39** | **206.01** | **s** | **4.41** | **(659.53)** | **s** | **42.98** | **865.55** | |
| **Scale** | 3,865.33 | 6,799.20 | | 868.99 | 1,972.25 | s | 3,551.32 | 4,663.71 | |
| **Composition** | 830.10 | 689.95 | * | 631.16 | (848.41) | s | (930.63) | 4,471.95 | s |
| **Technique** | (4,648.04) | (7,283.10) | | (1,495.74) | (1,783.33) | | (2,577.71) | (8,270.12) | s |

**LAND USE - Per Capita**

| | TOTAL | | | INDUSTRIAL | | | COMMUNAL | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1980-1993 | 1994-2003 | (s) | 1980-1993 | 1994-2003 | (s) | 1980-1993 | 1994-2003 | (s) |
| ha per capita | | | | | | | | | |
| **Actual Change** | **(60.63)** | **(27.49)** | | **(34.61)** | **(21.11)** | | **(24.51)** | **6.12** | |
| **Scale** | (17.23) | 36.24 | s | (21.35) | 12.32 | s | 121.46 | 154.92 | |
| **Composition** | 9.44 | 6.67 | | 9.68 | (10.78) | s | (38.72) | 175.20 | s |
| **Technique** | (52.84) | (70.40) | | (22.94) | (22.65) | | (107.25) | (324.00) | s |

**FERTILIZER USE - Aggregate**

| | TOTAL | | | INDUSTRIAL | | | COMMUNAL | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1980-1993 | 1994-2003 | (s) | 1980-1993 | 1994-2003 | (s) | 1980-1993 | 1994-2003 | (s) |
| '000 tons | | | | | | | | | |
| **Actual Change** | **353.99** | **64.00** | **s** | **117.95** | **99.26** | **s** | **236.03** | **(35.26)** | **s** |
| **Scale** | 268.50 | 650.85 | * | 176.70 | 702.78 | s | 56.57 | 74.12 | |
| **Composition** | 30.48 | (117.89) | s | 92.97 | (264.61) | s | (12.36) | 65.16 | s |
| **Technique** | 55.01 | (468.95) | s | (151.71) | (338.91) | s | 191.83 | (174.54) | s |

**FERTILIZER USE - Per Capita**

| | TOTAL | | | INDUSTRIAL | | | COMMUNAL | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1980-1993 | 1994-2003 | (s) | 1980-1993 | 1994-2003 | (s) | 1980-1993 | 1994-2003 | (s) |
| tons per capita | | | | | | | | | |
| **Actual Change** | **(0.22)** | **(1.61)** | **s** | **(5.24)** | **(1.35)** | | **9.40** | **(2.12)** | **s** |
| **Scale** | (1.20) | 4.14 | s | (4.34) | 6.44 | s | 1.93 | 2.18 | |
| **Composition** | 0.35 | (1.16) | s | 1.43 | (3.42) | s | (0.51) | 2.56 | s |
| **Technique** | 0.63 | (4.60) | s | (2.33) | (4.38) | s | 7.98 | (6.86) | s |

b) Composition Effect

The Composition effect at the national level, both aggregate and per capita, appears to be small and not statistically significant when compared to the pre NAFTA period. Interestingly, however, the Composition results for Industrial and Communal producers – both aggregate and per capita – show significant changes in land use stemming from their different patterns of crop type specialization. At the Industrial level, the Composition effect tended to significantly decrease land use. By increasing their relative production of fruits and vegetables – which are less land intensive than grains – we can observe a significant trend to reduce land under cultivation as evidenced by an aggregate Composition change of -15% (-0.8 Million Ha) during the post NAFTA period. Composition changes driven by increased international demand of Mexican horticultural produce seem to have aided in partially counteracting the Scale pressure to increase land use, contributing to a more efficient use of this resource. It is important to keep in mind, however, that Industrial farmers are for the most part located in the arid northern areas, where deforestation due to agricultural land expansion is not a mayor environmental issue. The scarcest resource in this area is water, and though little data is available on environmental impacts of water overuse and pollution due to agricultural activities, the crop specialization pattern among Industrial farmers has reportedly intensified water scarcity problems in the region, as the production of fruits and vegetables is more water-intensive than that of grains. This is particularly serious given that Industrial producers are located in arid areas were water is 7 times more scarce than in the Southern tropical regions, which would be more suitable for the production of these crops (CEC 2002).

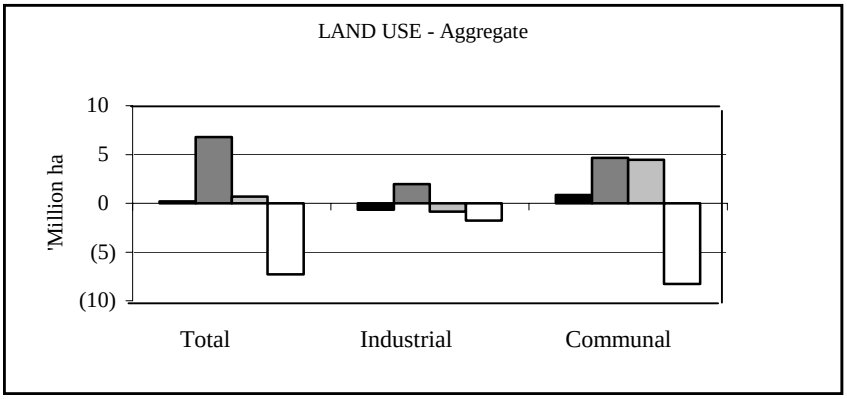
Among Communal farmers, however, the Composition effect shows a tendency to significantly increase land use in 31% (4.5 Million hectares), reflecting the higher relative importance of land-extensive grain production of Communal output. This is a particularly interesting result, as it shows that among Communal farmers, both Scale and Composition of production are contributing almost equally to land use increase patterns. The combination of Scale and pattern of crop specialization among Communal farmers, which are for the most part located near tropical forested areas, seem to have exacerbated existent problems of deforestation, soil erosion and land degradation in the tropical Southern region. Although there is no data available to correlate land use trends with deforestation, a study conducted by UNEP (2000) in Mesoamerica, considers the expansion of agricultural frontier as one of the main causes of deforestation in the region. Further, using data from FAO, Barbier (2004) estimated that between 1970-1990 the agricultural frontier expansion in Latin-America accounted for 48% of additional crop production throughout the region, contributing to the high deforestation rates of tropical forests. It is predicted that, between 1990 and 2010, 29% of the contribution to total crop production increase in the region will be derived from expansion of cultivated land.

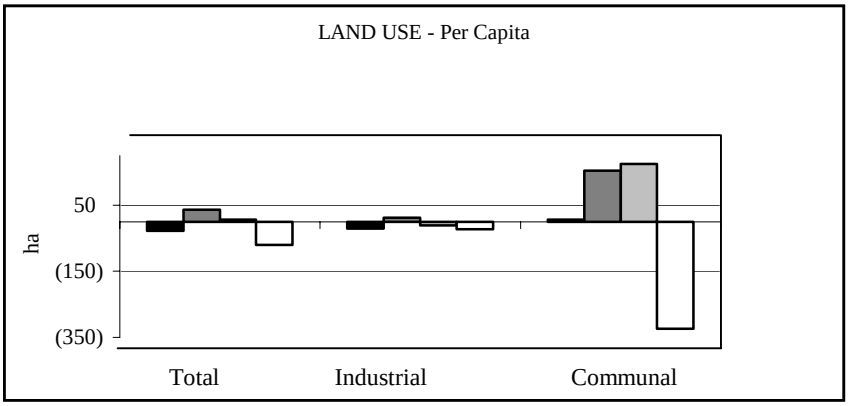
Further specialization on grain production by Communal farmers can be traced partly to rural tradition and security of food supply. However, it also seems to be deeply rooted in economic constraints. The production cost of horticultural crops is 5 to 7 times those of maize (Nadal 2000), as they require more intensive use of inputs, mainly water and agrochemicals. Increased costs coupled with lower incomes and restricted access to credits and under-funded rural development plans, have severely impaired southern farmer's capacity to convert from grain production to other more profitable crops, which may also be more suitable for Southern tropical weather.

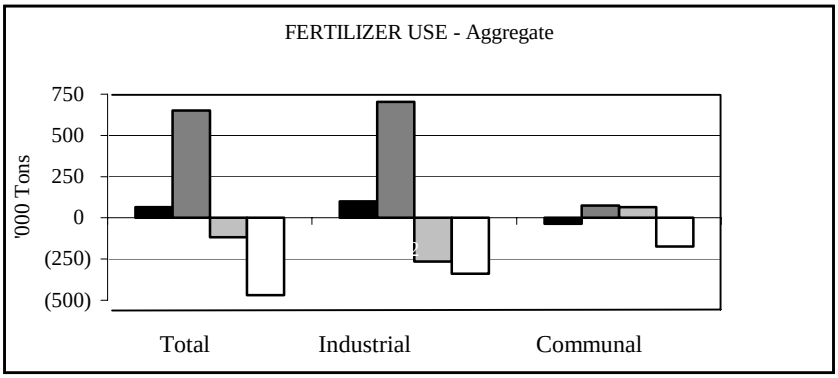
The Composition results signal not only the influence of crop specialization patterns in the environmentally efficient use of land, but also the different environmental impacts it may have according to the geographical conditions of each agricultural area. As we will see in the conclusions sections, this may have wide agricultural policy implications and highlight the important role of agricultural institutions and rural development plans, as well as of the environmental institutional framework, in aiding farmers, particularly Communal, in the uptake of crops that are more adequate for their particular geographical conditions.

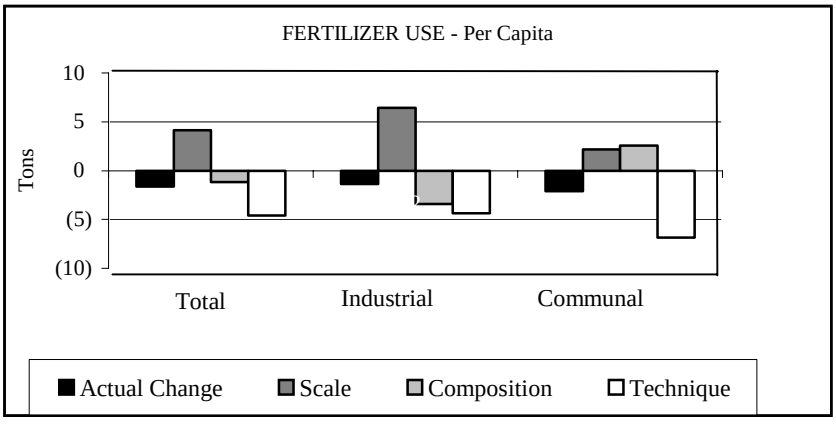
c) Technique Effect

The Technique effect tended to decrease land use across all types of producers, both aggregate and per capita. Among Industrial farmers, land use changes driven by the Technique effect are large at -32% (-1.7 Million ha) aggregate and -27% (22.6 ha) per capita, and seem to be key in counteracting the Scale effect. Technique changes among Industrial producers are also evident via the dramatic increase in yield of 54%, from 12.1 to 18.7 tons/ha. Indeed, their total production increased 36% despite a -12% decline in total planted area during the post NAFTA period. Although the average increase in yield might be partially explained by a shift from grain to horticultural production – as fruits and vegetables tend to deliver higher yields per hectare – it is also a signal of intensification of production, increased specialization of local agriculture towards export production and the creation of relatively large-Scale modern farms. Despite these improvements as well the increased FDI, the Technique effect appears not to be significant when compared to the pre NAFTA period – during when land use decreased -29% and -20% aggregate and per capita respectively. The above suggests that combined effect of technological improvements which may relate to the more efficient use of land – such as modern irrigation systems, agrochemicals and machinery – have been present before NAFTA. Possible factors influencing this outcome include the consistently low Agricultural Production Values which may have reduced the financial flexibility of the Industrial agricultural sector to invest in significantly more efficient methods of production, as well as potential weaknesses in both the environmental and rural institutional frameworks. Regarding the latter, theory suggests that the strength of the Technique effect depends on how quickly government policy is formed and adapted to new conditions (Vaughan and Block 2002; Copeland and Taylor 2003). These results suggest that policy, and perhaps more so, institutional effectiveness, might have an important role to play in terms of further increasing land-use efficiency.


LAND USE - Aggregate
'Million ha
10
5
0
(5)
(10)
Total
Industrial
Communal


LAND USE - Per Capita
ha
50
(150)
(350)
Total
Industrial
Communal


FERTILIZER USE - Aggregate
'000 Tons
750
500
250
0
(250)
(500)
Total
Industrial
Communal


FERTILIZER USE - Per Capita
Tons
10
5
0
(5)
(10)
Total
Industrial
Communal
Actual Change
Scale
Composition
Technique

Perhaps more interestingly, is that the Technique effect at the Communal level shows a significant tendency to reduce land usage, though not enough to counteract land use increases due to Scale and Composition effects. The aggregate Technique effect shows a decrease in land use of -59% (-8.3 M Ha) during the post NAFTA period. These are surprising results, especially given the relatively small improvements in yields/ha at the Communal level during the post NAFTA period, as well as the fact that these farmers do not participate in the international market (and thus any trade related effects are indirect). As seen in the data section, the average yield for Communal farmers in 2003 was of 4.7 tons/hectare – a forth of the average yield for Industrialized producers – and reflected an improvement of 'only' 25% versus 1994 (27% growth during pre NAFTA period). The observed Technique effect lead us to conclude that given the large extension of land used by these farmers; even the smallest improvement in production Techniques may positively impact aggregate land use efficiency. There is an evident area of opportunity to further improve Techniques of production in Communal areas, as according to existent case study analyses, low yields are a reflection of lack of modern technology (Wilder 2002), the loss of skilled agricultural workforce to urban migration and other off-farm activities, as well as the use of degraded land (Nadal 2000; Patel and Henriques 2003). As we will see in section 6, stronger and more adequate rural development plans and institutions could play a major role in improving the financial and social conditions of Communal farmers, as well as in maximizing the uptake of technological improvements that could lead to land use efficiency.

**Fertilizer use – SCT results and analysis**

As with the land use analysis, the following decomposition will aid us in identifying the influences that are behind fertilizer use patterns and to identify areas of opportunity to further promote its efficiency, particularly among Industrial farmers. Though data for pesticide use is not available, given the common farmers practice of using both agrochemicals alongside each other, it is fair to assume that trends in pesticide use might show similar patterns.

a) The Scale effect

The Scale effect shows that at an aggregate level, national fertilizer use would have risen by 650,850 tons, or 39% had it grown in proportion to output growth between 1994 and 2003. Per capita fertilizer use would have increased 4.14 tons/capita (23%). This trend has been driven by Industrial fertilizer use showing a significant Scale increase of 56% and 38% at an aggregate and per capita level. The fertilizer use at among Communal farmers evidences a more limited and not statistically significant Scale effect, with increases of 18% and 13% at an aggregate and per capita level respectively. Interestingly, Scale effects tending to increase the use of fertilizer, though more prominent during the post NAFTA period, are also evident before NAFTA, potentially evidencing that this pressures where exacerbated – rather than created – during the period after the treaty was signed.

b) Composition Effect

The Composition effect at the national level, both aggregate and per capita, appears to be statistically significant and driving fertilizer usage down, when compared to the pre NAFTA period. This trend is driven by Industrial farmers, where the aggregate Composition effect significantly decreases fertilizer use versus base year 1994 by 264,610 tons, -21%, partially counteracting the Scale effect. This result may seem counterintuitive at first sight, as fruits and vegetables require, in average, more fertilizer per hectare than grains. However, it probably reflects the fact that horticulture crops also tend to use less land, and more importantly, have higher yields per hectare, thus effectively requiring less fertilizer per ton produced. Despite the positive environmental effects that could be related to the Composition effect seemingly driving aggregate fertilizer usage down among industrial farmers, it is important to keep in mind several case study analysis that point out that the successful expansion of horticultural production in the northern arid region has exacerbated localized environmental problems related to water scarcity, and concomitantly increased water pollution due to highly concentrated agrochemical use (Kelly 2001; Kelly 2002b; Martinez 2003).

The opposed Composition effect is evident among Communal farmers - though in a much smaller Scale - where increased production of grains has led to a tendency to significantly increase fertilizer use. Given that grains tend to require relatively more fertilizer per tone produced, the dramatic increase in grain production, as well as its higher ratio of total output, seem to drive Communal fertilizer use upwards. This is evidenced in the Composition effect among Communal farmers increasing fertilizer use in 17% (65, 160 tons) at the aggregate level.

These results are interesting as they suggest that whilst at the aggregate national and Industrial level the Composition effect has tended to reduce fertilizer use, at the Communal level it has tended to increase fertilizer use. As with the use of land, there is an area of opportunity for rural development plans to influence the production of a more sustainable mix of crops, particularly among Communal farmers.

c) Technique effect

The Technique effect is driving fertilizer use significantly down during the post- NAFTA period among both types of producers, at the aggregate and per capita levels. Technique effect among Industrial producers show a continuing downward trend, which started during the pre NAFTA period and significantly intensified during post NAFTA, the latter evidenced by an aggregate decrease in fertilizer use of -27% (338,910 tons; -23%, 4.38 tons per capita). A more efficient use of fertilizer at the Industrial level seems to reflect a combination of technological and agricultural processes improvements, including not only the use of more advanced and imported agrochemicals, but also the use of improved and higher yielding crop varieties, as well as more modern machinery and irrigation systems. Despite these improvements, however, the combined Composition and Technique effects have not been large enough to offset the increased use of fertiliser driven by the Scale effect. In fact, despite National fertilizer use increasing at a significantly lower rate that both population (14%) and exports (73%), fertilizer use in 2002 is 4% higher than in 1994 and 38% higher than in 1980. Further, its use has been concentrated in less hectares of land – particularly among Industrial farmers, reportedly contributing to the increased environmental stress in agricultural land as well as to the pollution of nearby water sources. As we will see in section 6 of this paper, there is an area of opportunity to further promote technological improvements and the uptake of more sustainable patterns of fertilizer use

among industrial farmers through, amid other measures, the strengthening of the environmental institutions overseeing the import and use of agrochemicals.

Among Communal farmers, a Technique effect driving aggregate fertilizer use upward during the pre NAFTA period was almost offset by a negative Technique effect of -44% (174,540 tons) during post NAFTA period. A negative Technique effect – coupled with an increase in hectares of land under cultivation – does not seem to reflect increased fertilizer use efficiency, but the lack of widespread access of Communal farmers to economically accessible agricultural input packages and financial support, which seems to be curtailing the ability of these farmers to invest in more efficient technologies. Rural development plans may thus play an important role in ensuring Communal farmers have access to the financial support and training required to invest in more efficient technologies and to achieve a more balanced use of fertilizer and land resources.

## 6. The influence of the institutional framework

The neo-liberal theory that guided economic and trade liberalization policies during the 1980s and 1990s minimized the role of national and multilateral institutions. It argued that market forces helped by the "invisible hand" would guide the restructuring of previously inefficient governmental organizations into, mostly private enterprises, and would ensure the most efficient use of resources. Following a couple of decades of economic – and to some extent environmental - crises in most developing countries it is now believed that to ensure that the negative economic, social and environmental effects of liberalization remain at a minimum, institutions and policies must be robust, especially during transitional periods in which liberalization spurs changes in the extent of economic activity between sectors and countries (Rodrik 2001). Importantly, theory suggests that the strength of the Technique effect depends on how quickly government policy is formed and adapted to new conditions (Vaughan and Block 2002; Copeland and Taylor 2003). Given this, assessments of the impacts the institutional framework, environmental regulations and rural development plans have had on the rural environment are included in this section.

Surprisingly, there has been limited research into the effectiveness of national and multilateral institutions created through the NAFTA negotiations and implementation process (McKinney 2000). This section contributes to the growing literature on the topic by analysing how selected environmental and rural development institutions have been determinant factors influencing the Technique and Composition effects highlighted in the previous section. We will proceed to give a brief overview of the multilateral and national institutional development process, as well as a highlight of their general performance. We will then focus on two case studies, one analysing the institutional connections related to agrochemical use among Industrial farmers, and the other, focusing on the institutional influences on land use among Communal farmers.

### a. Institutional determinants of agrochemical use among Communal farmers

The SCT analysis evidenced that during the post NAFTA period, there has been a trend to further increase fertilizer use among Industrial farmers. Though this trend appears to be significantly weaker then during the pre NAFTA period, it does reflect that NAFTA and its

related institutional reforms have fallen short to promote a more efficient and sustainable agrochemical use among Industrial producers. In particular, we observe that the institutional framework has missed opportunities to reap the potential environmental benefits of NAFTA by not achieving a better balance between their current focus on facilitating and improving accessibility to regulated international agrochemical markets and their, so far, limited efforts to internalize the environmental impacts of agrochemical use, as well as to better regulate the quantity, frequency and way on which pesticides and fertilizers are being utilized by Industrial farmers. The following paragraphs analyze the influence of the multilateral and national environmental institutional framework in the observed Composition and Technique effects.

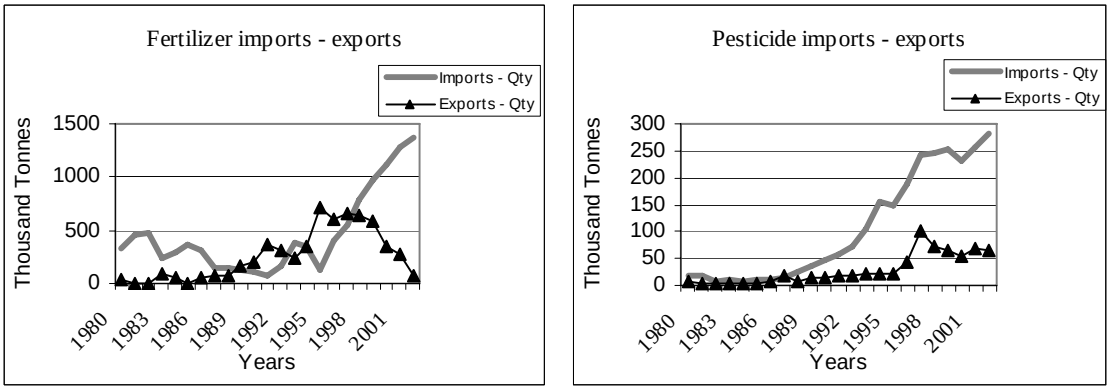
In the context of NAFTA, there have been two institutions particularly active in dealing with the regulation of chemicals in the agricultural sector in Mexico. The NAFTA Technical Working Group (TWG) on pesticides at a multilateral level and the Inter-sectorial Commission for the Control and Use of Pesticides, Fertilizers and Toxic Substances (CICOPLAFEST) at the national level. The following analysis shows that the influence of the institutional framework has been mixed. In general terms, it intended to promote more sustainable agricultural practices through the restructuring and strengthening of environmental regulations and standards, the strengthening of institutions and the increased communication and interaction among national, multilateral and international environmental institutions and conventions. However, as we will analyze in the following paragraphs, the institutional framework has shown some weaknesses in the promotion of a more sustainable agricultural industry and in some cases, seem to have even contributed to the increased reliance and overuse of agrochemicals.

The cooperative US/Canada bilateral efforts on pesticides regulatory harmonization were expanded in 1996 to include Mexico through the NAFTA Technical Working Group (TWG) on Pesticides (TWG 2003).The TWG was created under the supervision of the NAFTA Committee on Sanitary and Phytosanitary Standards (CSPS), being thus under the umbrella of the NAFTA Free Trade Commission – not under the treaty's environmental agreements. The TWG has been assessed as one of the most active multilateral institutions created by NAFTA (EPA, CICOPLAFEST et al. 2001). Its main roles have been to promote work sharing among the three governments and facilitate the physical and cost accessibility of regulated agrochemicals across NAFTA partners through the development of a "North American Market" for pesticides and fertilizers. In theory, this objective should be achieved in line with the broader environmental and sustainable development goals of NAFTA, by facilitating access to a wider range of safe and effective pest management tools. Following these principles, the TWG has been the main forum for the reduction of trade barriers to pesticides through harmonization of both, agrochemical regulation and Maximum Residue Limits (MRL) (EPA, CICOPLAFEST et al. 2001). The increased international trade in agrochemicals between the US and Mexico stemming from these policies are clearly seen in the below Fertilizer and Pesticide trade graphs. Differently from other NAFTA institutions, the TWG includes broad representation from industry and non-governmental organizations. It also works in close contact with the Pesticide Forum of the OECD and the Codex Alimentarius Commission, as well as with NAFTA's Commission for Environmental Cooperation (CEC) through the North American Working Group on the Sound Management of Chemicals (SMOC) (CEC 1997).

Despite lacking enough human and monetary resources, as well as the necessary government support, the TWG has achieved significant progress in harmonizing pesticide regulation and MRL. Specifically, the TWG has worked closely with SMOC and

CICOPLAFEST to reduce the use of persistent organic pollutants which can be harmful for human health, such as DDT and Chlordane (CEC 2001). In these cases regulatory progress have been achieved, usually meaning that agrochemical regulation in Mexico has been tightened to meet more rigorous food health standards (EPA, CICOPLAFEST et al. 2001). In terms of implementation, the objective of reducing the trade and use of these chemicals has been mixed. In the case of DDT, by 2000 Mexico has eliminated its use, surpassing the objective of 80% reduction by 2002. In the case of chlordane, despite a successful trinational cooperation, there are concerns about the potential for illicit imports and uses of this chemical due to lack of regulatory enforcement, specially in Mexico (CEC 2002).

Undoubtedly, the TWG activities are potential contributors to a positive Technique effect as they promote the better safeguarding of consumers health through the use of less persistent pesticides, the harmonization of MRL and the strengthening of regulatory processes (EPA 1997). This seems to have been a valuable first step to address what Wright (1990) and Rodriguez (2003) highlight as the main agro-environmental concerns in the region: the run-off and water pollution derived from continued and excessive use of pesticides and fertilizers, as well as farm workers unprotected exposure to agrochemicals. However, the TWG seems to have not addressed this issue in a holistic way, putting most of its efforts into reducing the toxicity of available pesticides and fertilizers, but having limited efforts to regulate the access to and quantity of agrochemicals used. TWGs focus on reducing tariff and non-tariff barriers to agrochemical trade and harmonizing pesticide regulation has resulted in increased accessibility to products that were previously prohibitive to Mexican farmers (May and Bonilla 1997).




Source: (FAO-stat 2003)

This increased supply of cheaper chemicals has been accompanied by little or no efforts to reduce reliance on pesticide and fertilizer use in any of the three NAFTA countries. Limited work has been undertaken to establish caps to the quantity of chemicals used per hectare, reduced reliance in monocultures and the employment of alternative pest management systems (Langer 2001). Moreover, environmental issues such as runoff or soil degradation are not even mentioned on the TWG five year plan (TWG 2003). Further, as we will see in our analysis of the CICOPLAFEST, these increased availability has also been accompanied with low enforcement and control from the National institutions in Mexico, thus missing the opportunity to further promote a culture of internalizing the environmental and health impacts of chemical overuse and of minimizing input overuse as an edge against risks in monoculture.

In terms of farm workers health, the TWG has funded some capacity building projects in Mexico to reduce workers exposure to harmful agrochemicals (EPA, CICOPLAFEST et al. 2001). In particular, the US and Mexico established a national train-the-trainer network for pesticide safety educators, establishing a pilot program in 2002 (TWG 2003). Although this follows the experience from previous successful projects implemented in US and Canada, 10 years after NAFTA's start of implementation, this project is still in its pilot phase. Further, the drive to reduce residue levels of persistent pesticides in export food, has resulted in the constant and excessive overuse of pesticides that have low-residuality but that are more harmful to the health of unprotected farm workers (Wright 1990; Thrupp, Bergeron et al. 1995).

Importantly to note, NGO demands on both sides of the border have been mostly focused on reducing the health risks for farm workers, increasing access to information on agrochemical risks and lobbying to take into consideration the environmental impacts of excessive pesticide and fertilizer runoff to water basins (EncuentroFronterizo 1998). At a lesser level, in the mid-nineties they lobbied against the decentralization and deregulation of agrochemicals in Mexico, cautioning that state and municipal governments were ill-prepared to regulate and control pesticide use (BorderLines 1996). However, NGOs does not seem to have actively participated – or instigated- a discussion on how the multilateral institutional framework could be better framed to address this issue.

At a national level, until the mid-eighties, the existent pesticide, fertilizer and toxic substances regulatory framework was dispersed and fell under the umbrella of four different governmental organizations - Ministry of Agriculture (SAGARPA), Ministry of Health (SSA) and Ministry of Commerce and Industry (SECOFI), and the National Institute of Ecology (INE). This translated into a regulatory framework that was often overlapping and even contradictory. Control of agrochemicals and enforcement of regulation was centralized in the federal government (BorderLines 1996) and limited resources where assigned to the adequate implementation of the different laws and regulations. Following the neoliberal trends of the early nineties, Fertimex, the government monopoly in charge of the production and distribution of fertilizers was privatized in 1991 (Smith 1992). This was followed by changes to the 1988 General Law of Ecological Balance and Environmental Protection, which decentralized and deregulated the control of "low risk" materials – including commonly used agrochemicals (BorderLines 1995; BorderLines 1996).

A few years earlier, the first wave of GATT induced liberalization brought with it the creation of The Inter-departmental Commission for the Control and Use of Pesticides, Fertilizers and Toxic Substances (CICOPLAFEST) at the national level. It was created in 1987 to coordinate the actions of the four national institutions that have competence in agrochemical regulation and enforcement in Mexico. More recently, the Ministries' of Labour (STPS) and Transport (SCT) have also joined CICOPLAFEST.

The Commission's main aim is to register and regulate chemicals for agricultural use, under the premise that complying with international requirements will ease the trading of Mexican agricultural produce with commercial partners. Similar to TWGs, CICOPLAFEST main activities have focused on the harmonization of agrochemical registration, establishment of MRL and the constant exchange of information at a national and international level to protect health and the environment. It has also contributed to the reduction, and in many cases the elimination, of import tariffs to pesticides and fertilizers (SAGARPA 2004).

CICOPLAFEST has proven useful to coordinate Mexico's position at international forums, allowing the signature of international treaties and protocols related to pesticides, fertilizers and toxic substances. This include the Montreal Protocol, Basel Convention and La Paz Agreement (CICOPLAFEST 2001), as well as the Stockholm Convention on Persistent Organic Pollutants, where Mexico has committed to phase out 12 substances that threaten human health and the environment (Guzman 2001). The Commission has also worked closely with TWG on efforts to reduce the trade and use of persistent chemicals such as DDT and Chlordane (CICOPLAFEST 2001), as well as on the harmonization of pesticides registers and MRL at the multilateral level. In this sense, increased market openness and the signature of NAFTA have positively impact the creation and strengthening of the regulation in charge of controlling chemical use in Mexico, as well as improved the country's participation in international forums.

At a national level, CICOPLAFEST has been instrumental in the creation of an extensive normative framework regulating chemical use in the agricultural sector. However, this framework, reflects the inter-institutional and dispersed nature of the commission by embracing 6 different lawsvi, 4 regulations and nine norms (Rodriguez 2003). Though it is clear that the over use of pesticides does not steam from lack of environmental legislation, lack of integration throughout the regulatory framework often generates either overlapping regulations or legal loopholes. In fact, CICOPLAFEST attributes its main institutional weaknesses to a deficient institutional design, which leads to lack of clarity regarding responsibility roles among the institutions taking part in the Commission as well as on inefficient decision making processes (CICOPLAFEST 2001). For example, lack of coordination has impeded the Commission to integrate its own manual of internal operation, so the roles and responsibilities among the different ministries it represents is unclear (SAGARPA 2004).

This was particularly evident during the period between 1994-2000, where the recent liberalization of the agricultural sector demanded stronger control of agrochemical use. Rather than addressing this need, CICOPLAFEST was fighting to improve its institutional efficiency by becoming a self-governing organ - independent from the four ministries that originally integrated the Commission. Unfortunately, lack of political will and coordination has not allowed CICOPLAFEST to become an independent organ. This has not permitted the Commission to improve its coordination capacity and better integrate and enforce the existing dispersed pesticide, fertilizer and toxic substances regulatory framework (CICOPLAFEST 2001). It has also prevented it to mirror the more efficient institutional framework of trade partners, US and Canada, which have only one institution in charge of regulating agrochemicals (CEC 1997). Further, it means that the commission still suffers from under-funding, as it receives limited support from the institutions that compose it, while its commission status does not allow it to become self-financing. The latter has contributed to CICOPLAFESTs continuous severe lack of staff, evidenced by it counting with no more than 20 technicians at a national level (SAGARPA 2004). Obvious are the implications of these institutional weaknesses on CICOPLAFESTs ability to comply with its mandate, properly develop and enforce regulation and of course, positively contribute to a sustainable use of agro-chemicals among Industrial farmers. This is evidenced by the fact that, though among its responsibilities CICOPLAFEST includes the regulation and control of the exploitation, fabrication, packaging, manipulation, transportation, storage, and final disposal of toxic substances, the bulk of its activities at a national level after the NAFTA signature have been limited to register and emit import authorizations of pesticides, fertilizers and toxic substances that comply with existent regulation (INE 2000).

Further, initial plans to broaden the Commissions scope to include the evaluation of impacts of different pesticide policies on health and the environment have not been accomplished due to the institutional design issues above mentioned (CEC, 1997). Despite CICOPLAFEST promoting the creation of state committees as a means to improve regulation enforcement and the regional understanding of agrochemical use, production and disposal (SAGARPA 2004), lack of resources have undermined these efforts. In fact, only 12 Estate Committees have been created, of which only 7 are actively operating (INE 2000). This has contributed to the Commission failing to create a national inventory of pesticide production and use in the country, which is the first step to properly understand and tackle the problem of agrochemical overuse.

In terms of farm workers health, CICOPLAFEST has collaborated with TWG in the implementation of pilot projects to reduce workers exposure to harmful chemicals. Unfortunately, these efforts have been very limited. Indeed, it is estimated that 95% of farmers in Mexico that apply pesticides of high toxicity do so without the necessary equipment for personal protection (CIEPAC 2001).

Separately, both TWG and CICOPLAFEST have worked with the pesticide industry, which is mainly dominated by multinational corporations, to promote the development and use of less residual pesticides that comply with the harmonized legislation (EPA 1997). They have, in theory, also worked with the industry to diversify pest control tools, and thus minimize pest resistance to a narrow group of pesticides. However, studies conducted by Rodriguez (2003) in the coast of Hermosillo show that 78% of the pesticide market is dominated by only eleven multinationals, and that only three pesticide products dominate the bulk of sales. This partially explains the growing resistance of some pests to chemicals and thus the need to further intensify their use (Rodriguez 2003). The lack of results on this front might be attributed to the institutional weaknesses mentioned above, as well as the significant involvement and influence of the pesticide industry in the development and implementation of agrochemical policy (2001).

Net, from a Technique Effect perspective, both CICOPLAFEST and TWG have had a positive effect in terms of strengthening regulation through harmonization of standards and establishment of MRL. However, there seems to be some indication that their same actions have contributed to weaken the Technique effect by not better regulating agrochemical input use among Industrial producers. This have resulted from their focus on facilitating and improving accessibility to agrochemical markets, coupled with their limited efforts to internalize the environmental impacts of pesticide and fertilizer use, as well as to control the quantity, frequency and way on which pesticides are being utilized.

Similar institutional impacts in the northern agriculture have been evident in other inputs, mainly water. It has been widely discussed that given the limited role and reduced budget of the National Water Commission, as well as the reliance of national water legislation on a decentralized management structure, it is unlikely that substantial efficiency increases will be experienced in the near future (Kelly 2001; Wilder 2002). Further, the inability of the National Water Commission, as well as of the municipal level governments to adequately charge for water use for irrigation exacerbated the incentive for overexploitation (Kelly 2001; Kelly 2002a; Kelly 2002b).

### b. Institutional influences on land use among Communal farmers

The SCT analysis evidenced that during the post NAFTA period, there has been a trend to further increase land use among Communal farmers. Though this trend appears not to be significant (when compared to the pre NAFTA period), it does reflect that NAFTA and its related reforms and transition plans have fallen short to promote more sustainable agricultural practices among impoverished farmers. In particular, we observe that there have been missed opportunities to reap the potential environmental benefits of NAFTA in two areas: a) the promotion of Communal farmers transition to higher premium, higher yield horticultural crops that are more suitable for tropical weather, and b) the adoption of more efficient, higher yield/ha technologies that could reduce Communal farmers reliance on expansive agricultural methods.

The following paragraphs present an analysis of the influence of rural development plans in the observed Composition and Technique effects[vii].

Several authors have thoroughly written on the socio-economic impacts of neoliberal policies in Mexico– including trade liberalization - on Communal farmers, as well as on the positive and negative influences of existent rural development plans (DeJanvry, Sadoulet et al. 1995; Yunez-Naude and Edward Taylor 2001; Sarmiento 2003). Some have even included the environmental impacts in the analysis (Nadal 2000; Vaughan and Block 2002; Patel and Henriques 2003). Taking advantage of this previous research, and not intending to thoroughly cover all the aspects of these programmes, we focus our analysis on drawing links between the implementation of the rural development plans and the Technique and Composition effects.

As mentioned in the background section, following the neoliberal reforms to the agricultural sector in the early 1990's. the Ministry of Agriculture (SAGARPA) established two basic policy instruments to substitute for the previous government support schemes. Both Procampo and The Alliance for the Countryside were aimed to assist producers, especially low income farmers, during the transition period to an open economy (Yunez-Naude, 2003; Nadal, 2000).

PROCAMPO was established in 1994 as an income support mechanism –decoupled from production - to compensate for loss of income expected as a result of lower corn prices after trade liberalization (PROCAMPO, 2003). The Alliance was conceived in 1995 and is intended to promote farming productivity and crop substitution in line with NAFTA objectives (Yunez-Naude, 2003; SAGARPA, 2003).

In order to better achieve their objective to help farmers adapt to trade liberalization during the transition period, the programs' payments were to remain constant for the first ten years of NAFTA, to then be phased out over the following five years (DeJanvry and Sadoulet 2001). However, several studies indicate that inadequate funding and implementation of both programmes have failed to provide the required support needed by Communal producers during the transition period (Nadal 2000; FAO and SAGARPA 2002; Patel and Henriques 2003; Rodriguez 2003).

In terms of funding, the combined budgets of the two programs dropped nearly 50% after the 1995 crises and had recovered to only about 70% by 2002 (Nadal and Wise 2004). Lack of adequate funding has limited the coverage of both programs, PROCAMPO covering 60% of the target producers, while Alliance covering only 18% (Nadal 2000; FAO and SAGARPA 2002). Contrary to the objective of helping less well-off producers, both programmes have had an

increasing focus to incentive modern export-oriented production. Small-Scale corn producers have thus experienced even more dramatic declines in government support (DeJanvry and Sadoulet 2001; Nadal and Wise 2004). This is evidenced by a study conducted by FAO and SAGARPA (2002) on Alliance for the Countryside. It shows that the programme support have been concentrated in the hands of fewer, larger private producers, being these the ones that receive more funding, with actions that are more consistent and of greater value. Given that most of Alliance technical and equipment support schemes require farmers to commit to paying up-front a significant proportion of the investment costs, the beneficiaries from this programme are mostly private farmers with resources to invest (SHCP 1995). Alliance have had little impact with poorer producers, as they receive less money in a more dispersed manner. Indeed, the study shows that the distribution of resources has been unequal, with poor and very poor farmers receiving only 5% of the total budget, while accounting for 19% of the total population (FAO & SAGARPA REF). In the case of Procampo, given that payments are proportionate to the area planted, the 45% of impoverished Communal producers with areas smaller than five hectares receive only 10% of Procampo transfers (DeJanvry and Sadoulet 2001).

For impoverished Communal farmers that do receive the support, Procampo's direct cash transfer represents an increase of 8.7% over 1994 income (DeJanvry and Sadoulet 2001). Although this means that households were made better off than without the transfer, it is not enough to counteract the drop in income from reduced corn prices, and, as seen through the SCT analysis, have not been sufficient to induce changes in cropping patterns.

It is fair to say that the rural development plans are not to blame for the impoverishment of the Communal rural areas. However, their significant under funding and bias towards supporting the better-off producers have impeded them to adequately support Communal producers on their struggle with the liberalized market. Had the programmes been adequately implemented during the past ten years, the Composition and Technique effect may have been more positive.

In terms of Procampo and Alliance's influence in the adoption of new productive Techniques among those farmers that do receive the support, empirical research shows that this has been limited, and in some cases negative. It has been assessed that Alliance for the Country Side has failed to provide access to Communal farmers to the institutional infrastructure required by modern production Techniques, such as credit, marketing channels and technical assistance (SAGARPA & FAO). DeJanvry and Saudolet (2001), highlight that rural development interventions that enhance access to technical assistance, lower the need to participate in the agricultural labour market and thus, could help retain more skilled labour on the farm. This can aid in the process of modernizing production processes and undertaking of more sustainable agricultural practices. It can also increase the flexibility and adaptability of smallholders while facilitating their engagement with alternative productive strategies appropriate to their capacities and the biophysical constraints of smallholder production (Eakin 2002). Unfortunately, Procampo and Alliance seem to have had limited contributions to such outcomes.

It has also been argued that the funds from both Procampo and Alliance have been in many cases limited to providing predetermined inputs "or technological packages" –consisting of improved seeds and agrochemicals - instead of providing the technical assistance and guidance required to develop the countryside in a sustainable way (CIEPAC 2001; PANNA 2003). In the case of Procampo, qualification certificates for the programme can be used as collateral against which to borrow from input retailers (DeJanvry and Sadoulet 2001). It is estimated that 70% of

households use Procampo money to purchase agrochemical inputs. Of the latter, 44% have used this support to increase the amount of inputs purchased, while 17% claim they use it to start using purchased inputs. Farmers participation in Procampo's input purchasing programme is voluntary, but is encouraged as a means to influence farmers' technology choices and improve rates of chemical and fertilizer adoption (Nadal 1999). Despite the fact that PROCAMPO has been broadly used as an "input subsidy", the Technique effect among Communal producers evidence that these efforts have not been enough to maintain a level of agrochemical use that can significantly improve yields/ha and thus counterbalance the pressure to further increase land under cultivation.

The programme objectives of Alliance for the Countryside, include support for irrigation improvements, pasture establishment, phytosanitary education and mechanization, as well as available funds for small-Scale rural development project (SHCP 1995). However, a significant proportion of Alliance's budget has gone to the Kilo for Kilo programme, which is intended to facilitate the adoption of hybrid maize, sorghum, barley or oats by heavily subsidizing the cost of the seeds (SAGAR-Puebla 1999).

The effect that the above have had in the production Techniques of Communal farmers is summarized by (DeJanvry, Gordillo et al. 1997) as follows "Traditional peasant production practices based on native seeds, biological control, organic fertilizers, animal traction and intercropping were degraded by a truncated process of technological modernization that was initiated by government organizations for the research and development of agriculture".

Regarding the Composition Effect, Alliance for the Countryside has not been capable of achieving its objective and provide Communal farmers with the support to afford the higher capital investment required by non-traditional crops, as well as the necessary training to successfully switch to new produce (FAO and SAGARPA 2002). Even among the group that received Alliance's support, only 1/3 of the producers saw a change in production, productivity or quality this proportion dropping only between 10-24% among the poorer producers (FAO and SAGARPA 2002). The institutional, funding and implementation weaknesses of the programme have contributed to the inability of producers to diversify to more efficient and premium priced crops, and achieve the expected Composition effect.

Separately, the combined effect of trade liberalization, reduction of public subsidies, the decentralization of governance, the elimination of governmental services to agriculture, and the under funding of rural development plans have put an unbearable pressure to social institutions at the Communal level (Nadal 2000; DeJanvry and Sadoulet 2001) . Declining incomes caused by all these factors set damaging patterns that weaken social institutions. The need to compensate low incomes through non-farm activities and migration results in deterioration of social institutions that play a key role in resource management. This results in less qualified labour working the fields and embarking in planning, transportation and commercialization of crop production. It also reduced the communities' ability to benefit from technical support (DeJanvry, Sadoulet et al. 1995). For example Nadal (1998) explains how migration negatively affects the ability of communities to take important collective action that is frequently required at times of planting or harvesting. This often translates into adverse environmental impacts, including deforestation, soil erosion and lower capacity to manage genetic resources.

In summary, the institutional analysis of land use in Communal areas indicate that the rural development programmes have missed opportunities to encourage larger and more positive Technique and Composition effects, failing to compensate lower producers incomes, not contributing to their investment in more sustainable technologies, not counteracting the pressure to increase land under cultivation by using higher yielding technologies and by not providing Communal farmers with the support to switch to more efficient and valuable crops.

## Conclusions and Recommendations

This paper explores trends in land and fertilizer use in the agricultural sector in Mexico during the post NAFTA period, among both Industrialized and Communal farmers, as well as the influence of the national and multilateral institutional framework on these outcomes.

The decomposition of post NAFTA agricultural data into Scale, Technique and Composition effects has proven useful to better understand land and fertilizer use patterns and to give us an indication of the source and direction of environmental impacts in the agricultural sector. Our analysis also offers insights into the areas of opportunity that need to be addressed if the Mexican agricultural sector is to reap the environmental benefits of international agricultural trade.

It should be kept in mind that limited data points to conduct this analysis mean that the results should be assessed as being more exploratory than conclusive. Further, the use of national indicators to assess aggregate impacts during the post NAFTA period imply that more localized impacts, which may be more variable than the aggregate results, will not be evident.

The principal contribution of this paper is to show which factors have either not been large enough or not been directionally adequate to counteract overall Scale increases, as well as to highlight how the institutional framework has contributed to these outcomes, particularly the Composition and Technique effects.

Among industrial farmers, although both the Composition and Technique effects tend to drive fertilizer usage down they have not been large enough to offset the Scale effect. Two interesting conclusions stem from these results: a) it seems that industrial farmers increased reliance on horticultural production to supply the export market tends to decrease, rather than increase, fertilizer use; and b) contrary to predictions, and despite increased FDI and significant yield-increasing technological improvements, the Technique effect among industrial producers is far from able to counteract fertilizer use increase due to agricultural production growth.

Regarding the latter conclusion, there is a clear area of opportunity to further promote technological improvements and the uptake of more sustainable patterns of fertilizer use among industrial farmers through, amid other measures, the strengthening of the environmental institutions overseeing the import and use of agrochemicals. Specifically, our institutional analysis shows that the Multilateral and National environmental institutional framework has missed opportunities to reap the potential environmental benefits of NAFTA by being too focused on facilitating and improving producer's accessibility to the international agrochemical markets, whilst having limited capacity to regulate and oversee the quantity, frequency and way in which pesticides and fertilizers are utilized. In general terms, the areas of opportunity for these

institutions do not rely necessarily on improving their mandates and objectives, but on the need to develop their coordination capacity and ability to better integrate and enforce the existing dispersed pesticide, fertilizer and toxic substances regulatory framework. More adequate funding would also ameliorate current issues related to lack of human and monetary resources.

Regarding land use among communal farmers, it is interesting to see how both Scale and Composition of production are contributing almost equally to land use increase patterns, thus seemingly exacerbating existing problems of deforestation, soil erosion and land degradation in the tropical Southern region. It is also of interest that the Technique effect at the Communal level shows a significant tendency to reduce land usage, though not enough to counteract land use increases due to Scale and Composition effects. These are surprising results, especially given the relatively small improvements in yields per hectare at the Communal level during the post NAFTA period, as well as the fact that these farmers do not participate in the international market. Through our institutional analysis, we have observed that rural development plans created to aid farmers in the transition to an open economy have not successfully supported communal farmers in: a) the transition to higher premium, higher yielding horticultural crops that are more suitable for southern tropical weather; and b) the adoption of more efficient, higher yielding technologies that could reduce Communal farmers reliance on expansive agricultural methods. Adequate funding of rural development plans and allocation of funds to aid impoverished farmers in need of technical assistance should contribute to strengthening the positive Composition and Technique land use effects among Communal farmers.

## REFERENCES

2001. Pesticide differences spark debate. Associated Press.

2001. Reformas al Articulo 73 de la Constitucion Politica de los Estados Unidos Mexicanos (para facultar al congreso a establecer un impuesto especial sobre sustancias toxicas persistentes y/o bioacumulables).

Antweiler, W., et al. 2001. Is Free Trade Good for the Environment? American Economic Review, 91: 877.

Appendini, K. 1998. Changing Agrarian Institutions: Interpreting the Contradictions. The Transformation of Rural Mexico: Reforming the Ejido Sector. San Diego, Center for U.S.-Mexican Studies, University of California San Diego.

Barbier, E. B. 2004. Agricultural Expansion, Resource Booms and Growth in Latin America: Implications for Long-Run Economic Development. World Development, 32 (1): 137-157.

BorderLines. 1995. SEMARNAP Scuttles Key Environmental Regulation. 19-3(11).

BorderLines. 1996. Proposed Changes to Mexican Law Worry Environmentalists. 29-4(10).

Cáceres, F. C., et al. 2002. Evolución y características de la pobreza en México en la última década del siglo XX. Documentos de investigación, SEDESOL.

Carpentier, C. L. 2001. Trade Liberalization Impacts on Agriculture: Predicted vs. Realized, Commission for Environmental Cooperation.

CEC. 1997. NAFTA's Institutions. The Environmental Potential and Preformance of the NAFTA Free Trade Comission and Related Bodies. Montreal, North American Commission for Environmental Cooperation.

CEC. 2001. Informe final sobre los Avances en la Instrumentacion del Plan de Accion Regional de America del Norte sobre Clordano, Comision para la Cooperacion Ambiental de America del Norte (CEC).

CEC. 2002. Relatoria. Taller de expertos en Agua dulce en América del Norte. Albuquerque, Commission for Environmental Cooperation.

CEC. 2002. Sound Management of Chemicals, North American Agenda for Action: 2003-2005, Pollutants and Health, North American Comission for Environmental Cooperation.

CICOPLAFEST. 2001. Informe Sexenal de la CICOPLAFEST 1994-2000 - Memoria. Mexico City.

CIEPAC. 2001. El Maiz Transnacional Contra la Soberania Alimentaria de los Pueblos Indigenas. Boletin "Chiapas al Dia" No. 258. Chiapas.

CNA. 2001. Programa Nacional Hidraulico, 2001-2006. Mexico D.F., Comision Nacional de Agua.

COMTRADE. 2003. United Nations Statistics Database. www.unstats.un.org.

Cooper, J., et al. 2003. Some Domestic Environmental Effects of U.S. Agricultural Adjustments under Liberalized Trade; a Preliminary Analysis. The Second North American Symposium on Assessing the Environmental Effects of Trade, North American Commission for Environmental Cooperation, Mexico City.

Copeland, B. R., et al. 1994. North - South Trade and the Environment. Quarterly Journal of Economics, 109: 755-87.

Copeland, B. R., et al. 2003. Trade and the Environment: Theory and Evidence. Princeton, Princeton University Press.

David, B. D. A., et al. 2000. The Impact of the New Economic Model on Latin America's Agriculture. World Development, 28 (9): 1673 - 1688.

DeJanvry, A., et al. 1997. Mexico's Second Agrarian Reform: Household and Community Responses. La Jolla, Center for US-Mexican Studies, University of San Diego.

DeJanvry, A., et al. 2001. Income Strategies Among Rural Households in Mexico: The Role of Off-farm Activities. World Development, 29 (3): 467-480.

DeJanvry, A., et al. 1995. NAFTA and Mexico's Maize Producers. World Development, 23 (8): 1349-1362.

Eakin, H. C. 2002. Rural Households' Vulnerability and Adaptation to Climatic Variability and Institutional Change: Three Cases from Central Mexico. Department of Geography and Regional Development, University of Arizona: 507.

EncuentroFronterizo. 1998. Pesticide Risks Panel Discussion; Conference Summary. First Meeting on the Border Environment, Ciudad Juárez, Mexico.

EPA. 1997. Report of the Second North American Free Trade Technical Working Group on Pesticides. Ottawa, US Environmental Protection Agency.

EPA, et al. 2001. Milestone Report. The North American Initiative. A Report of the North American Free Trade Agreement Technical Working Group on Pesticides, Joint Report, EPA, CICOPLAFEST and PMRA.

FAO-stat. 2003. Food and Agriculture Organization Statistics Database. www.fao.org.

FAO, et al. 2002. Evaluacion de la Alianza para el Campo 2001: Informe de Evaluacion Nacional Apoyo al Desarrollo Rural. Mexico, United Nations Food and Agriculture Organization & Secretary of Agriculture, Ranching, Rural Development, Fisheries and Nutrition.

Grossman, G. M., et al. 1991. Environmental Impacts of a North American Free Trade Agreement. National Bureau of Economic Research, Working Paper Series. 3914.

Guzman, S. 2001. Mexico to sign POPs treaty, completing NAFTA compliance. Environment News Service.

Husted, B. W., et al. 1996. Mexico - Impact of Environmental Policy Instruments on International Investors. Private Capital Flows and the Environment. Lessons from Latin America. B. S. Gentry. Northampton, Massachusetts, Edward Elgar Publishing.

IISD. 2000. Environment and Trade: A Handbook. Canada, International Institute for Sustainable Development and United Nations Environment Programme.

INE. 2000. Características de Peligrosidad Ambiental de Plaguicidas. Capitulo 9. Mecanismos de Coordinación Intra e Intersectorial. México City, Instituto Nacional de Ecologia.

Kelly, M. E. 2001. El Rio Conchos: Un Informe Preliminar, Texas Center for Policy Studies.

Kelly, M. E. 2002a. Water Management in the Binational Texas/Mexico Rio Grande/Rio Bravo Basin, Texas Center for Policy Studies, Bulletin 107.

Kelly, M. E. 2002b. Lessons from a Free Trade Era in Mexico: Environmental and Social Impacts in Sonora, Aguascalientes, Tabasco and Oaxaca., Red Fronteriza de Salud y Ambiente A.C. P.E.C.E.

Khan, M. E., et al. 2004. Testing for Pollution Havens Inside and Outside of Regional Trading Blocks. B.E. Journals in Economic Analysis and Policy, 4(2): 4.

Langer, J. 2001. NAFTA Technical Working Group on Pesticides, Annual Full Meeting, Mexico City.

Martinez, J. M. 2003. Acuiferos y Agroquimicos en una Region Fronteriza: Retos y Oportunidades del TLCAN para la Agricultura Mexicana, Red Fronteriza de Salud y Ambiente, A.C. & Universidad de Sonora, Segundo Simposium de Analisis Sobre los Efectos del Comercio en el Medio Ambiente, Comision de Cooperacion Ambiental.

May, P. H., et al. 1997. The environmental effects of agricultural trade liberalization in Latin America: an interpretation. Ecological Economics, 22: 5 - 18.

McKinney, J. A. 2000. Created From NAFTA: The Structure, Function, and Significance of the Treaty's Related Institutions. United States of America, M.E. Sharpe.

Mumme, S. 1999. NAFTA's Environmental Side Agreements: Almost Green? Despite shortcomings, promising potential for improved protection. Borderlines, 60(7): 9.

Nadal, A. 1998. Maize in Mexico: Some Environmetnal Implications of the North American Free Trade Agreement (NAFTA), Commission for Environmental Cooperation.

Nadal, A. 1999. Maize in Mexico: Some Environmental implications of the North American Free Trade Agreement (NAFTA), Comission on Environmental Cooperation, Environment and Trade Series No 6, Issue Study I.

Nadal, A. 2000. The Environmental & Social Impacts of Economic Liberalization on Corn Production in Mexico, Oxfam GB and WWF International.

Nadal, A., et al. 2004. The Environmental Costs of Agricultural Trade Liberalization: Mexico-U.S. Maize Trade Under NAFTA, Working Group on Development and Environment in the Americas. Discussion Paper Number 4.

OECD. 1994. The Environmental Effects of Trade. Paris, Organisation for Economic Cooperation and Development.

OECD. 2000. Domestic and International Environmental Impacts of Agricultural Trade Liberalisation. Paris, Organisation for Economic Cooperation and Development.

OECD. 2003. Environmental Performance Reviews - Mexico. Paris, Organisation for Economic Co-operation and Development.

Oxfam. 2002. Rigged Rules and Double Standards: trade, globalisation, and the fight against poverty. Oxford, Oxfam International; Make Trade Fair.

PANNA. 2003. World Bank Accountability Project Report, Pesticide Action Network North America.

Patel, R., et al. 2003. Agricultural Trade Liberalization and Mexico. Food First: Institute for Food and Development Policy. California. Policy Brief No. 7.

Rodriguez, J. M. M. 2003. Acuiferos y Agroquimicos en una Region Fronteriza: Retos y Oportunidades del TLCAN para la Agricultura Mexicana, Red Fronteriza de Salud y Ambiente, A.C. & Universidad de Sonora, Segundo Simposium de Analisis Sobre los Efectos del Comercio en el Medio Ambiente, Comision de Cooperacion Ambiental.

Rodrik. 2001. The Global Governance of Trade: As if Development Really Mattered. New York, United Nations Development Programme (UNDP).

SAGAR-Puebla. 1999. Alianza para el Campo: Puebla Apoyos 1999. Puebla, Gobierno del Estado de Puebla.

SAGARPA. 2004. Secretary of Agriculture, Ranching, Rural Development, Fisheries and Nutrition, web page, www.sagarpa.gob.mx. Access date: August 2004.

Sarmiento, S. 2003. Mexico Alert: NAFTA and Mexico's Agriculture. Hemisphere Focus, Center for Strategic and International Studies, XI(7).

Selden, T. M., et al. 1999. Analyzing the reductions in US air pollution emissions: 1970-1990. Land Economics, 75(1): 1-21.

SHCP. 1995. Plan Nacional de Desarrollo 1995-2000. Mexico DF, Secretaria de Hacienda y Credito Publico, Gobierno de Mexico.

SIACON-database. 2004. Sistema de Informacion Agropecuaria de Consulta (Agriculture Database). Mexico, Centro de Estadistica Agropecuaria.

SIMBAD. 2002. Sistema Municipal de Base de Datos, VII Censo Ejidal 1991, Instituto Nacional de Estadistica, Geografia e Informatica.

Smith, W. R. 1992. Salinas Prepares Mexican Agriculture for Free Trade. The Heritage Foundation, Backgrounder #914.

Thrupp, L. A., et al. 1995. Bittersweet Harvests for Global Supermarkets: Challenges in Latin America's Agricultural Export Boom., World Resource Institute.

Torres, B. 1999. Environmental Cooperation Before and After NAFTA. Economic Integration in NAFTA and the EU. K. A. a. S. Bislev. Great Britain, MacMillian Press LTD: 106-121.

TWG. 2003. The North American Initiative: The Next Five Years, NAFTA Technical Working Group on Pesticides.

UNEP. 2000. Global Environment Outlook: GEO 2000, United Nations Enviornment Programme.

Unisfera. 2003. The Economic and Environmental Impacts of Agricultural Subsidies: An Assessment of the 2002 US Farm Bill & Doha Round. Quebec, Unisfera International Centre.

USDA. 2002. Effects of North American Free Trade Agreement on Agriculture and the Rural Economy, S. Zahniser and J. Link, Economic Research Service, US Department of Agriculture. Agriculture and Trade: Report No. WRS0201: 134.

Vaughan, S., et al. 2002. Free Trade and the Environment: The Picture Becomes Clearer, Commission for Environmental Cooperation.

Wheeler, D. 2001. Racing to the Bottom? Foreign Investment and Air Pollution in Developing Countries. Journal of Environment and Development, 10 (3): 225-245.

Wilder, M. O. 2002. In Name Only: Water Policy, the State and Ejidatario Producers in Northern Mexico. Department of Geography and Regional Development, University of Arizona.

WorldBank. 2003. Lessons from NAFTA for Latin American and Caribbean(LAC) Countries: A Summary of Research Findings. Washington.

Wright, A. 1990. The Death of Ramon Gonzalez: the Modern Agricultural Dilemma.

Yunez-Naude, A., et al. 2001. The Determinants of Nonfarm Activities and Incomes of Rural Households in Mexico, with Emphasis on Education. World Development, 29(3): 561-572.

## END NOTES

[i] This is not to say that all northern producers are Industrialized and all southern farmers are Communal, as this would be an oversimplification. In the states of Chiapas and Guerrero, for example, there are areas where input intensity is comparable to internationally competitive agricultural production. Likewise, in the northwestern states of Sinaloa and Sonora, there are regions where subsistence production prevails under very difficult conditions.

[ii] NAFTA's two environmental side agreements are: The North American Agreement on Environmental Cooperation (NAAEC) and the US-Mexico Border Environment Cooperation Agreement (BECA). NAAEC addresses party's failure to enforce environmental laws and cooperation agenda contains the dispute settlement process, while BECA aims to identify mechanisms for financing border environmental projects and promote clean-up (USDS, 2000).

[iii] As will be explained in the methodology section, due to limitations in the availability of data, the outcome of this SCT analysis will be changes in input use, rather than pollution levels (as is the case in most SCT analysis).

[iv] See (Cooper, Johansson et al. 2003) for the use of this method in the US.

[v] Agricultural Production Value (APV) refers to the monetary quantification of production volume, at the prices paid to the producers (SIACON-database 2004).

[vi] Metrology and Normalization Law, General Health Law, Ley de Sanidad Fitopecuaria, Environmental Protection Law and Federal Vegetal Sanitation law, Federal Employment Law (INE 2000).

[vii] The environmental impacts of NAFTA on the Southern region seem to be mostly a reflection of exacerbated socio-economic problems. The latter, together with the fact that environmental policies and institutions have had little involvement in Communal agriculture, makes it more sensible to analyse the influence of rural development plans, rather than of environmental institutions, on the Technique and Composition effects.