Towards a Sustainable Pampa Agriculture: Past Performance and Prospective Analysis

By Otto T. Solbrig

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1. Introduction

In 1538, Pedro de Mendoza founded the city of Buenos Aires hoping that its hinterland would furnish gold and other metallic riches. He and his followers were highly disappointed as there was no gold or other precious minerals in the pampa, and after enormous suffering, the city was abandoned and the remaining inhabitants moved to the city of Asunción (Mujica Lainez 1988). Yet the pampa had in store another type of gold for those with the will and the resources to obtain it: the golden ears of wheat and maize, and the riches of the fertile grazing lands feeding herds of cattle and flocks of sheep.

Although the colonial economic history of what was to become Argentina was connected more with silver from the mines of Potosí, and the supplying of these mines with mules, clothing and food, than with the products of the pampa (Socolow 1978), slowly over the next two centuries the pampa grew in importance, and after 1810 and independence, the pampa and its cattle became the mainstay of the economy of the nascent republic.

The agriculture and the grazing lands of the pampa were the basis of the economic development and well-being of the Argentine population in the 1880-1910 period, which is the time when Argentina surged ahead in relation to other South American countries (Scobie, 1968; Giberti 1970; Ortiz 1978; Adelman 1994). Agriculture and livestock husbandry have remained important and dynamic economic sectors ever since, in spite of some periods of depression.

The alternation of cattle raising on native grasses or rich alfalfa land with agriculture based on a wheat and maize rotation used by Argentine farmers and ranchers turned out to be a very sustainable technology. With time, agriculture slowly became more profitable than cattle raising, and the grazing-agriculture rotation was abandoned in those soils that were most apt for agriculture, where very recently a system of double cropping of wheat and soybeans was established. However, this new system has proven to be ecologically fragile and pampa soils are now suffering a process of erosion that is quite severe in certain areas (Kugler 1983; Morello *et al*. 1991; INTA 1991; Hall *et al*. 1992; SAGyP-CFA 1995; Ghersa *et al*. 1995).

The degradation of natural resources, particularly soil properties and water quality, is very worrisome because it endangers the comparative advantage and the competitive capacity of the Argentine rural sector. This is a problem that plagues modern high-input agriculture all over the world (NRC 1989; Norse et al.1992; Cassman and Harwood 1995). Although some modern techniques, most notably minimum and no tillage agriculture, can reduce soil erosion, no known technique has yet been devised to reduce erosion to ecologically or economically acceptable levels. Biodiversity loss and genetic erosion is of general importance to sustainable agriculture, but in Argentina, not as acute a problem as soil erosion. Another problem of modern agriculture is chemical contamination of streams and underground aquifers with residues of agrochemical products that can also be present in the foodstuff. So far, no such contamination has been recorded for the pampas, but research on this subject in the pampas is almost non-existent. The increased use of agrochemical products in the last few years merits more investigation into this matter.

In general, resource degradation is the result of inadequate land use combined with deficient agronomic practices taking place in social and economic environments that provide few alternatives since most farmers, given a choice, try not to degrade their land. Therefore, the solution to this problem must be to provide more alternatives. These can best be provided by an interdisciplinary approach including inputs from ecological and agronomic science, economics and political science.

The last two years, spurred by the doubling or near doubling of grain prices, have seen a remarkable increase in the pampa's surface area devoted to crops, in its yields, and in the amount of inputs used. Helped by favorable weather conditions, the wheat harvest in 1996 reached 15.2 million metric tons, a record, and the total grain harvest is estimated to be 58 million metric tons, another record. Yet although production was up, earnings in 1996 were down in comparison with 1995, due to a lowering of world prices. Will farmers continue to invest in machinery and inputs (fertilizer, herbicides, and pesticides) if prices continue to soften as is predicted? What policies should Argentina pursue to keep production up? And how will this impact the environment? These are some of the questions I address in this paper.

Another problem is the structure of production and land tenure in the pampas. Argentina started its agrarian development with a very high concentration of land ownership. Over time, large estates were broken up: owners frequently subdivided and sold lots as land prices rose; without a primogeniture inheritance pattern, estates fragmented among heirs; and profligate lives by owners, or incompetent management, broke up others. Between the beginning of the century and the early 1960s, the average farm size diminished steadily. However, since then, there has been a new concentration of land (Barsky and Pucciarelli. 1991). We do not know exactly what brought this about, but economies of scale associated with modern high-input agriculture could have been a contributing factor.

I here present a brief review of the ecological, agronomic and economic background of agriculture in the Argentine pampa and its problems, and some policy options as a contribution to the development of a stronger and more sustainable Argentine agriculture. I have benefited in writing it from the advice of numerous colleagues from Argentina and the United States[1]. I take, however, full responsibility for any errors that may have crept into the text.

2. The pampa region: Geography and Extent

The Argentine pampa is one of the richest agricultural areas of the world. Covering a total of about fifty-two million hectares, its flat level plain of productive organic soils was originally covered with grasses. It is part of the vast Argentine plain named *Pampasia* by Frenguelli (1946) which extends from the *Sierras Pampeanas* in the west and the border with Bolivia and Paraguay in the north, to the southern part of Buenos Aires province. This plain is an extension of a still bigger plain wedged between the Andes in the west and the Guyana-Brazilian shield in the east, which includes the Venezuelan llanos, the Amazonian lowlands, and the Chaco-Pampa region. The *Pampasia* formation stretches over an extensive area, with very low and smooth undulations and a

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slight slope inclined towards the east and the south. It is covered mostly by loessic sediments, except in its western border, where we find a discontinuous ring of sandy sediments with fixed and moving dunes. According to Frenguelli, *Pampasia* is a plain in formation, i.e. an immense tectonic basin (*Graben*) that has been (and is being) filled with sediments from the Andes brought by wind and water. The fine texture of these sediments makes them very vulnerable to wind and water erosion.

Fig. 1. The pampa region (thick line), isohyetes, provincial borders (dashed line) and main divisions (dotted line). 1. Undulating pampa; 2. Sandy pampa; 3. Depressed pampa; 4. Southern pampa (after León *et al.* 1980).

The humid pampa is found in the central and southern part of this plain. The northern boundary corresponds approximately with the Carcaraña River in the province of Santa Fé, and the southern limit coincides with the 35th parallel S in the province of Buenos Aires (Parodi 1947; Cabrera 1971; Soriano et al. 1992). The humid pampa presents a very low relief interrupted by

low mountains that do not surpass 1500 m (Sierras de La Ventana and de Tandil). Within this region, four sub-regions can be identified from a geomorphological viewpoint (although as with all classifications there are different opinions regarding the number, limits and nomenclature of the various subdivisions) (fig.1): (1) the undulating or rolling pampa (*pampa ondulada sensu* Parodi 1947*; pampa ondulada sensu* León et al. 1980; *rolling pampa sensu* Soriano *et al.* 1992 in part), (2) the sandy pampa or inland pampa (*pampa arenosa sensu Parodi 1947; inland pampa sensu* Soriano *et al*. 1992), (3) the depressed or flooding pampa (*pampa deprimida sensu* Parodi 1947*; flooding pampa sensu* Soriano *et al.* 1992), and (4) the southern pampa and mountain area, formed by two mountain systems separated by a large plain (*pampa austral sensu* León et al. 1980; *southern pampa sensu* Soriano *et al.* 1992). Soriano et al. (1992) also recognize a fifth division, the *Mesopotamic pampa*, for that portion of the pampa situated in the province of Entre Rios. We will follow the criterion of León *et al.* 1984 that considers the Mesopotamic Pampa part of the undulating pampa.

2.1. The undulating or rolling pampa

The undulating or rolling pampa (*pampa ondulada*, fig.1) rests on a crystalline block slightly raised in relation to the depressed basin to the south. Here, the combination of good soils, sufficient rainfall (from slightly over 1000 mm in the east to 800 mm in the west) and a large aquifer at 30 m depth create one of the two best-endowed agricultural areas of Argentina.

The undulating pampa is morphogenetically active, and the rivers that drain into the Paraná or the La Plata have carved broad valleys in past periods of higher rainfall. The fine texture of the soils makes them very vulnerable to physical degradation when subjected to inadequate agricultural practices. Furthermore, the long slopes with a gradient between 2 and 5%, make the soils particularly vulnerable to water erosion (SAGyP 1995). Of the 4.4 million hectares of the undulating pampa, 36% (1.6 million Ha) are subjected to some kind of water erosion.

Grain agriculture dominates the farming activities of this region, especially wheat, corn and soybeans. Temperature and rainfall regimes allow planting two crops a year, usually winter wheat

and summer soybeans, though this practice is very recent. The area is close to the Paraná river, which is accessible to sea-going vessels and is where the most important cereal ports of Argentina are situated, as well as a large part of agro-industry that uses cereals or oil-seeds as inputs. The undulating pampa has the longest history of occupation by European people and is home to some of the largest and oldest cities of Argentina, including Buenos Aires.

2.2. The sandy or inland pampa

The sandy or inland pampa is a strip that extends from the provinces of Córdoba, Santa Fé, and La Pampa into that of Buenos Aires, to the west of the undulating and the depressed pampa (fig. 1). It is an area, especially on its western edge, of sandy materials of up to 10 m in thickness that have been sculpted by the wind into well-defined hills and dunes, stabilized by vegetation but with the potential of becoming active. Some of its closed drainage basins to the east are transformed into swamps or lakes, such as the *lagunas* of Melincué in Santa Fé and Potrerillo and la Chilca in Buenos Aires (Tricart 1972; Parodi 1947; Cabrera 1971; Soriano *et al*. 1992).

The soils are deep, of good permeability, moderate to low porosity, and in some areas with a calcareous horizon (Glave 1988). In the west, 50% of the land is primarily used for cattle raising, the other 50% primarily for agriculture. Among annual crops, soybeans, corn, rye, sunflowers and sorghum are the most frequently planted; the most important forage plant is alfalfa. The sandy pampa is the sub-region of the pampa where the traditional cattle-agriculture rotation is most popular, with several years of continuous agriculture followed by years of grazing cattle on alfalfa. Rotations in which the agricultural cycle is too long in relation to pastures (i.e. 5-8 years of agriculture, 3-4 pasture) are non sustainable. A recommended cycle that has proven to be sustainable is 3 years of agriculture followed by five of pastures.

2.3. The depressed or flooding pampa

The depressed or flooding pampa is a broad depression in the form of a triangle (fig. 1), with slopes that oscillate between 0.5 and 0.25 % at the border between the mountains (*Sierras*) and

the pampa, and slopes that are barely 0.025% in the vicinity of the Río Salado, the principal axis of the depression (Tricart, 1973). These slight slopes delay drainage and, consequently, from a farming perspective handling water in this region is as important as soil management. There exists also a very interesting ecological interplay between native and introduced plants, grazing effects, and the consequences of flooding (León 1975; Sala *et al.* 1981, 1986; Durán 1996). The great difficulties in natural removal of water after prolonged rains result in a large number of very shallow lagoons that dry up during periods of drought and overflow after extended rains, leading to extensive floods. The many water surfaces act as giant evaporators concentrating the salts contained in the soil minerals (that origined in past marine incursions into the region). This creates a problem of salinization and alcalinization that constrains agricultural development in the depressed pampa. Only in slightly elevated areas with a positive slope do we find good agricultural soils, which show up as islands in a sea of natural grasses or planted forages (Cahuepé *et al.* 1982; Berasategui and Barberis 1982). This region played an important role in the expansion of cattle raising in the early and middle 19th century and is still used mostly for that purpose.

2.4. The mountain system (Sistema de Sierras) and intervening plain (southern pampa)

There are two old mountain systems in the pampa: the Sierra de Tandil and the Sierra de la Ventana, with a very fertile plain in between dedicated mostly to the raising of cereals (fig. 1). These mountain systems do not surpass 1500 m in height, but they have affected significantly the morphogenetic development of the depressed pampa (Tricart 1973; Parodi 1947; Cabrera 1971; León *et al.* 1984; Soriano *et al.* 1992; Hall *et al.* 1992). Two types of mountains exist: those formed by igneous rocks (granites and gneiss) and those formed by sedimentary rocks (sandstones and quartzites) as well as limestones. The erosion and partial solution of the limestone explains the high concentration of calcium carbonate in the southern piedmont area of the depressed pampa.

Soils resulting from these types of rocks are of limited agricultural use but have a potential for forest plantations that has not been sufficiently exploited, especially given the demand for wood from the beach tourism industry nearby. Where the slope becomes slight at the foot of the

mountains (5 to 10 degrees according to Tricart 1973), a thick layer of loess appears that gives rise to high-quality brunizen soils with a thick organic layer. Here, highly-technological agriculture and horticulture with supplemental irrigation have sprung up with potatoes, vegetables, some cereals, and some dairy farming as main activities.

The plain that extends between these two mountain systems is a major cereal growing area of Argentina (called the *corazón triguero de la pampa húmeda).* The brunizen soils overlay a layer of 2 m of loess lying in turn over limestone rocks. Most of this area is mixed-use (agriculture and cattle raising) with only some small interior basins unfit for agriculture because of salty soils, used exclusively for cattle raising.

Since 1970, agricultural activities on the best soils of the region with high organic content have intensified, with the cattle-wheat rotation replaced in many farming establishments by continuous agriculture. Traditionally, the most commonly cultivated crops have been wheat, barley, sunflowers, corn, and potatoes.

2.5. Climate

The climate of the pampa is warm temperate with adequate to less than adequate rainfall. Summers are warm, and winters are cool, with very few days of frost. It snows only occasionally. Rainfall is greater in spring and fall, than in summer and winter, with intermittent periods of water shortage in the summer months, especially January and February.

Average temperatures vary between 15^{o} C. in the south and 18^{o} C. in the north of the pampa. Absolute maximum temperatures surpass 40^{o} C., while maximum minimum temperatures oscillate around -10^{o} C. Temperatures fluctuate a fair amount, and in summer months the temperature can descend to 10^{o} C. or lower after a period when the temperature has been above 40^{o} C. These oscillation can be very damaging to crops.

Rainfall decreases from NE to SW, from about 1100 mm to about 600mm. (fig. 1). Monthly rainfall averages between 50 and 90 mm in the late spring and summer months, and only 20-30 mm in the winter months. Although winter precipitation is low, because of the low

temperatures, it is usually adequate for maintaining the range, although it can be limiting when double-cropping. In summer months, there is often a period of drought that can last from two to six weeks and can be devastating to summer crops.

In the last twenty years, there has been an increase in precipitation in the humid pampa of about 100 mm on average (Hoffmann 1970; Sierra et al. 1993/94, 1995). There has also been a decrease in temperature fluctuations due mainly to higher winter minima and lower summer maxima. These changes have been one of the major reasons that double cropping could be introduced in the undulating pampa.

Global climatic changes taking place as a result of anthropogenic activities are likely to be felt in the pampas. In the last few years, a pattern of climatic changes similar to those taking place in the northern hemisphere has been observed: excessively hot summers, and above normal wet winters, with an intensification of both flooding during wet periods and drought during dry spells. Although not enough is known to make any certain predictions, climatic change could be a destabilizing factor of pampa agriculture.

2.6. Soil types and regional use

The soils of the pampa have been mapped, classified, and described by the soil institute of INTA in the various sheets of the Soil Map of Argentina (scale 1:50,000 to 1:500,000). These soils have been formed over loessic sediments and are approximately 3500 years old (Fidalgo and Tonni 1978). Most, specially in the eastern half, have an A surface horizon of 30 cm thickness, loam or clay-loam in texture (21-32% clay; 57-68% silt; 4-19% sand), followed by a textural B horizon, silty-clay to loam-clay in texture (30-57% clay), that varies in thickness from 40 to 90 cm according to the series (Senigagliesi *et al*. 1996). The development of the B horizon and the content of clay are greater in the east and gradually diminish towards the west and south of the pampa. The high content of clay in the B horizon reduces water percolation; while under conditions of drought, the clay increases soil resistance, thereby reducing root growth (Pecorari and Balcaza, 1988). Not all soils have a textural B horizon, specially in the sandy pampa. On the other

hand, the fine texture of the surface soils and the low rate of water percolation make these soils poor absorbers of rainfall and prone to water erosion.

Table 1. Distribution of soil types (in Ha) with different appropriate uses in the three land use zones (after Gomez et al. 1991)

Zones	Agriculture	Agriculture-Livestock	Livestock-Agriculture	Livestock
I. Agriculture	2,910,000 (41.7%)	1,753,600 (25.1%)	574,900 (8.2 %)	1,746,200 (25.2%)
II. Livestock	27,000 (0.3 %)	924,800 (10.9%)	2,909,000 (34.2 %)	4,636,100 (54.6%)
III. Mixed	3,444,200 (9.6 %)	10,086,100 (28 %)	15,984,600 (44.5 %)	6,441,900 (17.9%)
Total pampa	6,381,200 (12.4%)	12,754,500 (24.8 %)	19,468,500 (37.9 %)	12,824,200 (24.9%)

Any land use classification is technology dependent, and probably no land in the pampas can be cultivated continuously without some degradation. The reader should have this in mind as we discussed land use, especially in relation to “continuous” agriculture. The characteristics of the soils of the pampa region allow their classification into four agronomic categories: (1) most appropriate for regular agriculture; (2) suitable for agriculture if rotated with cattle grazing; (3) apt for cattle grazing with some occasional agriculture, and (4) well-suited only for cattle raising. The physical, chemical, and climatic limitations for establishing agriculture on these soils increase from type 1 to type 4, especially their susceptibility to erosion. Soils best suited for agriculture (with or without grazing rotation) cover only 37% of the area; of the rest, a quarter (25%) are apt only for cattle grazing (table 1).

The pampa can be divided into three zones from the point of view of optimal potential use (fig. 2, table 1): (I) the primarily agricultural area covering the core area of the undulating pampa; (II) the primarily livestock raising area that corresponds mainly with the depressed pampa and adjacent areas; and (III) the "mixed" agricultural-livestock area making up the rest of the region. In this last zone only 9.6% of the soils have no limitations and can be used for continuous agriculture, 28.1% are classed as appropriate for agriculture if rotated with cattle grazing; 44.4% are apt for cattle raising with some agriculture and 17.9% are good only for livestock raising. The proportion of these types of soil allow this mixed region to be further classified into nine different sub-zones (table 2).

Fig. 2. The three major land use zones according to Pizarro and Cascardo (1991).

The distribution of soil and environmental conditions explains why the pampa region has been primarily a livestock-raising area, and why the rotation of agriculture and livestock (the wheat-alfalfa alternation) is so relevant as a land-use technology. Although those soils primarily well-suited for continuous or near continuous agriculture are very fertile, they cover only six million hectares (19 if the agricultural-livestock raising soils are added), barely 0.425% of the world's arable land (1.2% if the agricultural-livestock soils are added).

Table 2. Extent (in Ha) of soils with different appropriate uses in the sub-regions of the mixed zone (after Gomez et al. 1991)

	Agriculture	**Agriculture-Livestock**	**Livestock-Agriculture**	**Livestock**
1	32,400	503,600	2,750,000	379,200
2	439,200	667,900	606,100	116,500
3	1,151,600	698,200	1,022,900	1,734,500
4	536,700	525,000	389,200	238,800

5	42,000	2,951,300	4,809,200	1,817,300
6	232,100	1,429,800	1,477,900	419,200
7	107,700	468,900	791,200	501,400
8	---	920,200	2,835,000	826,100
9	902,500	1,921,200	1,303,100	408,900
Total	**3,444,200**	**10,086,100**	**15,984,600**	**6,441,900**

The actual cropped area of Argentina (mostly from the pampa region) in 1991 was 27.2 million hectares[2] (which includes land with a mixed livestock-agricultural classification and land outside the pampa region). In contrast the total cropped area of the United States in 1991 was 185.7 million hectares, that of Canada 45.9 million Ha., and Australia 46.7 million Ha. (table 3). Actual cultivated surface is lower than potential, but has been increasing steadily in the last five years. In 1996/97 the surface in wheat alone was 6.716 million Ha. and the total cultivated surface in the last year is estimated at 22.509 million Ha (SAGPyA 1997).

Table 3. Arable land (million Ha), Rural labor force (millions) and % of labor force that is rural (source WRI 1995)

Country	Arable land	Rural labor Force	% rural labor force
Former USSR	224.400	17.954	12.43
USA	185.742	2.780	2.24
Europe	124.097	20.805	8.90
Australia	46.703	0.400	4.83
Canada	45.850	0.420	3.11
Argentina	27.200	1.185	10.12

Since land use classifications are technology dependent, a change to more intensive technology and greater inputs can overcome some of the soil limitations. But even if those areas of the pampa classified as best for livestock raising with some agriculture are added, the pampa region comprises potentially only 36 million hectares of agricultural land out of about 52 million total.

3. Human settlement

Argentina along with Uruguay has the lowest demographic growth of any Latin American country. It also shares with Uruguay the highest level of literacy and urbanization in South

[2] Good statistics and time series regarding cropland in Argentina are not available, and there are large discrepancies between sources. The figure of 27.2 is that of WRI 1995.

America. Both countries were subjected to large waves of European immigration during the second half of the 19th century extending until the beginning of W.W.I that have shaped their cultural identities and left their imprint on economic activity.

At the beginning of the 19th century only a narrow strip of the undulating pampa, extending from the border of the depressed pampa to the city of Santa Fé, and not much more than 100 miles wide to the west of the Paraná river, was settled by Europeans. The typical estancia at that time was dedicated to extensive cattle raising in open ranges with very unimproved herds. All through the 19th century these herds expanded, and with them the need to gain new land from the Indians. The limiting factor during the first half of the 19th century was access to water. This explains why the undulating pampa with its well developed drainage system was the first to be settled, followed by the depressed pampa. Only after the middle of the century when bore holes and wind mills were introduced was it possible to occupy the rest of the pampa.

The expansion of the frontier was principally the result of an excess of cattle and not a hunger for land by landless peasants, and this would shape the economic structure and cultural characteristics of the area. Labor was chronically short until W.W.I, and cattle raising and equestrian prowess (the *gaucho* tradition) acquired a special prestige which they still hold. Ranching interests dominated the political scene from the time of Rosas (middle 1820's) to the accession of Yrigoyen (1916), and continued to have a strong influence up to the first government of Perón (1946-1955). This in spite of the fact that agriculture played a very important role in the economic development of Argentina (Scobie 1968, Giberti 1970, Solberg 1987, Adelman 1994).

3.1. Rural and urban population of the pampa area.

The humid pampa region is home to the majority of the population of Argentina, most of it concentrated in megacities. The strip on the western margin of the Paraná-La Plata rivers, from Rosario to La Plata (340 km length) is the largest urban concentration of the country (and occupies some of the best agricultural soils). In 1991, 68.9 % of the Argentine population was concentrated

in the pampa region, and 33.6% of it occupied the good soils of the undulating pampa (Sanchez 1993). Between 1970 and 1991 all the cities that form the industrial axis Rosario-La Plata (Greater Buenos Aires, Greater La Plata, Greater Rosario, Zárate) increased their population by more than 31% , and in those cities of the strip where the petroleum and steel industries are located, demographic growth was even greater: Campana 98.3% and San Nicolás 77.3%.

Argentina is a highly urbanized country. In 1988, 86% of the population was urban (and only 14% was rural), up from 76% in 1956. In 1988, 54% of all Argentineans lived in cities of over half a million people, 45% of them in greater Buenos Aires (World Bank 1990). There are no data (disaggregated) for the pampa region, but given the concentration of large cities in this area and the highly mechanized agriculture in use it is very unlikely that the percentage of the rural population in the pampa is greater than in the rest of the country. In 1991, in the province of Buenos Aires that comprises most of the pampa region, the population living in towns of less than 2000 inhabitants was 608,000 persons, of which 30.15% (193,600) worked in rural establishments. In absolute terms the rural population of the pampa can be estimated at one million persons or less (the combined rural population of the states of Buenos Aires, Santa Fé, Córdoba, La Pampa and Entre Rios in 1991 was 1,290,400. Not all this area lies within the humid pampa).

From the early days of the Republic and throughout the 19th century, Argentina has had a serious labor shortage problem in the pampa, that prompted the governments of the middle and second half of the century to implement a policy of encouraging European immigration. The labor shortage also encouraged the use of labor saving machinery. After 1910 the labor situation eased some, but the pattern of capital investment to reduce labor costs has continued to this day, encouraged no doubt by the labor legislation (*estatuto del peón*) passed during the government of Perón (1946-1955).

According to the World Resources Institute (WRI 1995) the Argentine rural labor force in 1993 was 1,166,000 persons, down from 1,656,000 in 1961. Since the population of Argentina has grown from 20,951,000 in 1961 to 32,712,000 in 1991, the rural labor force as a percentage of the

total population of Argentina has decreased from 7.9 to 3.56%, and as a percentage of the labor force from 20.16 % in 1961 to 10.12 % in 1991. Compared to the other major cereal and grain producers of the world (table 3), Argentina ranks behind the former USSR in the proportion of the population employed by the rural sector but ahead of Europe, Australia, Canada, and the United States in that order. I have no data for the pampa itself but the percentages there are probably much lower since agriculture in the pampa area is much more mechanized than in the rest of the country. This is indicated by a number of studies that show an increase in labor productivity between 1960 and 1980 of roughly 2% a year (Bocco 1991).

3.2. The structure of pampean agricultural and livestock establishments

Argentine historical and sociological writings on the pampa have been dominated by the role of the large land holding (*estancia*) dedicated mostly to cattle raising. At the beginning of pampa settlement, land was the factor of production in greatest supply, and it was labor and capital that were in greatest demand. It should therefore not be surprising that cattle ranching was very extensive for some 200 years. When the frontier closed in 1879 and agriculture increased in extent, almost all of the land was in the hands of large and politically powerful ranchers (*estancieros*). European immigrant farmers became therefore sharecroppers (*arrendatarios*) rather than small holders as in Canada and the United States. Exceptions to this are the agricultural colonies in the state of Santa Fé and Entre Rios (Gallo 1983). Barsky (1992) and Adelman (1994) have shown that the sharecropper system was a rational economic arrangement that favored both sides and that there was no collusion on the part of large landholders to bar access to land by the newly arrived European farmers. All writers agree, however, that this arrangement had negative social consequences.

A characteristic of present day rural establishments in the humid pampa is their heterogeneity. There are at least five major types of farming enterprises (Solá 1991) based on the type of labor used, the type of landholding, and the degree of outside-the-farm interests of the operators. These are:

The combined family farm. This is the kind of agricultural establishment based on the work of the family, that usually combines agriculture on land owned by the farmer (usually small) with some sharecropping. The social actor in this model is a farmer (*chacarero*), that also normally works for third parties (*contratista de labores*).

The capitalist agrarian firm. This type of unit is the most common one in the pampa. It is defined as one that employs outside labor to do the farming while the management is usually performed by the owner, who may or may not live on the farm. It is larger in extent than the family farm, and derives all of its income from rural enterprises.

The large diversified firm. This type is separated from the previous type in its being part of a conglomerate of which the rural enterprise is one more activity. Such firms have a high level of capitalization, resulting from a large period of accumulation, and are self-sufficient in terms of machinery. The number of these firms is low, but in certain areas they are relevant on account of the large surface they own and farm.

The small service firm (*contratista agrícola*). These are farmers with machinery that work the land of third parties, either on a fee basis or as sharecroppers. This type of firm is common throughout the pampa.

The specialized agricultural firm. This is a new form of land use. The social actors are a varying combination of service firms (including banks), agricultural professionals, urban investors, and agrarian producers. These firms employ very modern technology and are of a size that allows them to reap benefits of scale. This combination of factors provides them with a strong bargaining position when negotiating with land owners.

The small family farmer often lacks sufficient capital and has a tendency to overwork his land. Consequently small family farms sometimes show a high degree of land degradation. Contrary to common belief, the record of specialized service firms (*contratista agrícola*) believed to engage in land degrading practices (Morello et al. 1991), is as good or better than average (Gallacher *et al.* 1994; Gallacher 1995). More systematic research on the relation between farm structure and sustainable agriculture in the pampas is badly needed.

Solá (1991) has analyzed the economics of these various enterprises (table 4). He finds that in spite of low prices for grains (he analyzed production in 1987) all types of exploitation showed on average a net profit. This is in contrast to more marginal areas of Argentina where many firms showed losses during the decade of the 80's.

The most common type of farming enterprise in the pampa, the capitalist agrarian firm, in spite of a greater income than the family farm due to its better yield, is also the least profitable. As a matter of fact, once the return on investment in production factors has been taken into account, the capitalist firm often is unprofitable. But the family farm and the diversified firm are themselves

barely profitable. On the other hand, the small service firm and the specialized firm show net benefits two to three times higher than the enterprises based on land ownership. It therefore is not surprising that these are expanding forms of land use. Of course, profits depend on prices. In the last two years all types of enterprises have had great benefits, and in the 80's, when on top of low border prices farmers had to contend with export taxes, everybody's income was depressed.

Table 4. Economic results by type of firm (in index numbers) (after Solá 1991)

	Family	**Capitalist**	**Diversified**	**Small service**	**Specialized**
Gross income	100	111.7	153.9	114.1	160.9
Direct expenses	100	163.9	180.4	235.9	368.4
Depreciation	100	105.4	127.7	73.7	84.8
Net income	100	87.8	147.6	63.9	76.9
Gas, infrastructure	100	111.9	97.9	188.8	179.0
Fixed taxes	100	115.2	157.6	29.8	43.5
Net margin	100	73.5	156.2	45.1	63.4
Return on investment	100	107.1	175.1	19.7	19.7
Final net benefit	100		46.1	193.3	318.0

A serious problem that has hampered farm development has been the high rate of inflation in Argentina and high export taxes. Inflation during the 50 year period between the late 1940's and the early 1990's was always in the two or three digit range, hitting a high of 4223 % in 1989 and of 1343 % in 1990. Since then it has decreased dramatically and in the last two years has been among the lowest in the world (1995 = 1.6%; 1996 = 2.0%). Although it is premature to declare that inflation is no longer a problem in Argentina, since it is strongly engraved in the consciousness of every citizen in the country, its dramatic reduction has increased rural profitability. One negative consequence of lingering doubts regarding inflation is the high cost of capital and its near unavailability at reasonable interest rates. The elimination of inflation has also been very hard on debtors as is always the case in these situations, and many small rural enterprises have had to declare bankruptcy. A new problem derived in part from the effort to stabilize the currency and eliminate inflation is the overvaluation of the Argentine peso that obstructs exports and reduces profit margins.

The high export taxes have also been very damaging. Argentine governments have relied since colonial times on customs receipts to finance government operations. Inflation and the

government's inability to collect ordinary taxes over the last twenty years led to an increase in export tax rates that reached confiscatory rates in 1989 of 33% for cereals (wheat, maize, and sorghum) and 43% for oil seeds (soy-beans, sunflowers). Such rates made agricultural production only marginally profitable and led producers to reduce expenditures as much as possible. Most of these export taxes have now been eliminated, or have been reduced to levels of 3% or below.

4. Agriculture and Livestock raising

The agricultural potential of the pampa was the basis of the economic development and well-being of the Argentine population in the 1880-1910 period, which is the time when Argentina surged ahead in relation to other South American countries (Gallo and Cortés Conde 1987; Adelman 1994), and agriculture and cattle raising has remained an important and dynamic economic sector, in spite of some periods of depression. Consequently the degradation of natural resources, particularly soil properties and water quality, is very worrisome, because it endangers the comparative advantage and the competitive capacity of Argentina.

4.1. Principal crops, total production, yields, where grown

Argentine (mostly pampean) agricultural production has been increasing since the early 1960's (table 5). Yet pampean agriculture is little diversified. Considering the agricultural potential of the regions it is surprising that only six crops --wheat, corn (maize), soybeans, sorghum, sunflowers (for oil) and flax (also for oil)-- account for most of the production and planted surface (Hall *et al.* 1992). Other crops with some significance are rye and barley in the southern inter-mountain plain, potatoes (in the good soils at the foot of the Sierra de Tandil), and rice (mainly in Entre-Rios province). Alfalfa and oats for forage are also important crops. Nevertheless the first six crops accounted for 97.7% of production and 82.5% of the cultivated surface in the five year period between 1982 and 1987 up from 82.5% and 68.7% respectively in the 1960-65 period (Pizarro and Cascardo 1991). The tendency of farmers has been to increase their concentration on these crops, especially four of them: wheat, soybeans, sorghum, and sunflowers. Of these soybeans

have had the most spectacular performance, with production almost doubling in the last ten years and increasing by a factor of nine since 1970 (table 6-7).

Table 5. Index of the volume of Argentine production (Base 1981/82-1986/87 = 100) (source SAGyP 1996)

Year	Total Production	Cereals	Oil seeds
1970/71	58.13	67.25	23.04
1975/76	66.60	73.68	27.28
1980/81	84.92	99.15	61.37
1985/86	103.57	90.10	125.67
1990/91	116.97	80.33	163.60
1995/96	125.86	81.13	193.64

The pampa contributed 82.5% of the country's surface planted in cereals and oil-seeds and 86% of its production in the 1982-89 period. Of this, the undulating pampa contributed 25% of the surface and 29% of production, the southern plain 53.3 and 52.2% respectively, and the depressed pampa only 4.5 and 3.9%. The undulating pampa is the center of the most productive agriculture in the region, while the southern plain contributed most in terms of overall production, especially wheat.

Table 6. Cultivated surface (in Ha) of three major grain crops in the provinces of Buenos Aires, Cordoba, Entre Rios, La Pampa and Santa Fé (source SAGyP 1996)

Year	Wheat	Maize	Soybeans	Total
1980/81	4,964,000	2,979,000	1,703,400	9,646,400
1982/83	7,237,000	2,569,130	2,321,800	12,127,930
1984/85	5,824,600	2,955,200	3,060,000	11,839,800
1986/87	4,836,900	2,601,700	3,276,000	10,714,600
1988/89	4,598,000	1,515,050	3,656,150	9,769,200
1990/91	5,706,600	1,680,700	4,384,200	11,771,500
1992/93	4,173,300	2,143,000	4,525,120	10,841,420
1995/96	5,698,000	2,657,000	6,697,000	15,052,000
1996/97	6,716,000	3,253,000	6,327,000	16,296.000

Wheat and corn have been the principal crops for the last 100 years. Both of these are major export crops (tables 6-7); soybeans and sorghum are more recent crops. While wheat and to some extent corn are food crops, soybeans and sorghum are used primarily for animal feed. While wheat and corn have a large domestic market, soybeans and sorghum are mainly export crops. This indicates that there has been a shift in production towards more exclusive export crops, which is one

of the objectives of structural adjustment policies pursued by Argentina since the middle 1980's but especially since the accession of the Menem government in 1989. These trends were interrupted in the 1995/96 and 1996/97 seasons due to an increase in the price of wheat and corn, which produced increases in the surface dedicated to these crops and in their yields.

Table 7. Production (in Tm) and yield (Kg/Ha) of three major grain crops in the provinces of Buenos Aires, Córdoba, Entre Rios, La Pampa and Santa Fé (source SAGyP 1996)

Year	Wheat	Yield	Maize	Yield	Soybeans	Yield
1980/81	7,719,000	1,555	11,938,000	4,007	3,450,000	2,025
1982/83	14,895,000	2,058	8,273,500	3,220	3,700,000	1,593
1984/85	12,478,000	2,143	11,067,000	3,745	6,100,000	1,993
1986/87	7,621,000	1,576	8,549,000	3,286	6,316,000	1,928
1988/89	7,479,000	1,627	4,589,100	3,029	6,050,000	1,655
1990/91	10,860,200	1,903	7,021,000	4,177	10,085,100	2,300
1992/93	9,726,500	2,331	9,532,400	4,448	9,923,200	2,193
1994/95	11,108,760	2,184	9,966,900	4,682	10,874,100	2,066
1996/97	15,178,000	2,260	14,639,000	4,500	13,666,000	2,160

In 1995/96 harvested surface of sunflowers was 3,546,000 Ha, and of sorghum 296,000 Ha (Trucco, per.com.) and in 1996/97, sunflowers, 2,944,000 Ha, and sorghum 686,000 Ha. (SAGPyA 1997). Cultivated surface is up more than 50% over the area cropped 15 years ago (table 6) and so is production, but yields have increased only moderately (table 7). Argentine farming, including pampa agriculture, is still very extensive, with land the principal production factor, even though there is no more unused land left in the pampa region (Hall *et al.* 1992). Some increases in cultivated surface are possible by double cropping, which was introduced in the early 1970's and has augmented some since, but most of the increase in cultivated surface in the last years has come from cultivating land used previously for livestock husbandry, some of which is marginal for agriculture. If proper care is not taken, this could create serious problems of land degradation in the near future.

Nevertheless, there is evidence of an intensification of farming in the last five years, as can be seen by some increases in yields (table 7, fig. 3), most probably the result of an increase in the use of fertilizers, little used before 1980. In 1984 overall use of fertilizers of all kinds was 88,000 Tm, used mostly outside the pampas region. Consumption in 1996 is estimated at over 450,000 Tm --a five fold increase-- most of it used in the pampa region (Trucco and Salvador 1997; table 14).

Tractors were introduced in the 1950s and their power increased from 34 HP in 1950 to 104 HP in 1985 (Huici 1986, Hall *et al.* 1992). Wheat yields in 1996 varied between a low of about 10 q/ha and a high of 50-60 q/ha. Still, yields are quite low, both in comparison with other countries, and with results in experimental farms.

Supplemental irrigation using deep wells is being advertised as a way of counteracting the effect of summer and spring drought, and some producers are adopting it. This technique is already well established in the potato growing area of Balcarce-Mar del Plata where 45-50 thousand Ha are irrigated and is now spreading to other crops. In the northern region of the pampa it is estimated that some sixty thousand Ha of corn, soy-beans and wheat are provided with supplemental irrigation (Senigagliesi per. com). There is little information regarding the quality, size and extent of aquifers but some studies (Santa Cruz 1987) indicate a high content of alkaline salts in some of them. In the Mar del Plata area, the combined needs of agriculture and city use, have resulted in seepage of salty sea water into underground aquifers along coastal areas. More research on aquifers is badly needed before supplemental irrigation is widely adopted.

Fig. 3. Argentine pampas: surface and production 1900-1984.

Intensification of production involves more than increasing the use of inputs and energy. The genetic makeup of the crop must be able to use the increased inputs, especially fertilizers, and must be able to support increased applications of herbicides and pesticides. Furthermore, inputs, especially fertilizers, interact in complex ways with soil microorganisms, and the soil nutrients available to the crop are a complex function of soil physical and chemical characteristics, soil humidity, and nutrient concentration. Modern methods (precision agriculture) try to increase the efficiency of input applications through the use of sophisticated sensors and application machinery.

Yet, there is some question as to whether the necessary basic knowledge exists for the pampa system to use high input methods efficiently (Hall *et al.* 1992). This is an area in need of much more research.

4.3. Comparison with other areas, both national and international.

In the last century Argentina was a major wheat, corn, and linseed exporting country. Although still an important player in the cereal trade, it no longer holds the position it had in the last century. Europe and the United States are much greater producers and exporters than Argentina (table 8). Yet, because the Argentine and Australian harvest is shifted six months with respect to its major competitors, Argentina's crop is important to replenish needed world stocks at that time of year.

Table 8. Total cereal production and export of cereals in 1991 (source WRI 1995)

Country	Area planted (thousand Ha)	Production (thousand Tm)	Exports (thousand Tm) (% production)
Argentina	8,180	21,385	11,101 (52%)
Australia	14,139	18,735	15,098 (81%)
Canada	20,205	50,968	28,962 (57%)
Europe	63,813	303,808	64,221 (21%)
USA	65,928	280,257	86,863 (31%)
former USSR	103,087	155,924	588 (4%)

The cultivated area of the pampa is significantly less than that of its competitors, and as we saw there is not much of a chance of increasing the planted surface. Yields of wheat and maize still lag significantly behind those of its principal competitors (tables 9 and 10). On the other hand, soybean yields of 2014 Kg/Ha (1979-81) and 2141 Kg/Ha (1990) are competitive with those of the USA (1979-81=1980 Kg/Ha; 1990= 2287 Kg/Ha.) and Brazil. The reason for this discrepancy is no doubt related to the fact that soybeans are a late entry into the pampa and from the time of their introduction they were cultivated with more advanced technology (Sábato 1980), while wheat and corn are traditional crops in the pampa, still cultivated by some farmers in a more traditional way, which points to the importance of increasing the speed of technology diffusion. What is also disturbing is that yield growth in the pampa has not been as fast as it should be (fig. 4). The most likely explanation is the reluctance of the Argentine farmer to use adequate amounts of fertilizer,

although that has changed in the last two years (and so have the yields). Another factor has to do with the genetic stocks employed.

Table 9. Wheat: cultivated area (thousand Ha), production (thousand Tm) and yield Kg/Ha) for six countries (source FAO Yearbook 1995)

	1979-81			1990		
	Area	**Production**	**Yield**	**Area**	**Production**	**Yield**
Former USSR	59,463	89,859	1,511	48,214	108,000	2 240
USA	28,896	66,227	2,291	28,066	74,534	2 656
Europe	25,492	91,881	3,600	27,190	113,090	4 159
Australia	11,440	14,468	1,263	9,851	15,712	1 595
Canada	11,386	20,430	1,784	14,050	31,798	2 263
Argentina	5,245	8,060	1,547	5,800	10,800	1 862

Fig 4. Wheat yields selected countries.

Table 10. Maize: cultivated area (thousand Ha), production (thousand Tm) and yield Kg/Ha) for four countries (source FAO Yearbook 1995)

	1979-81			1990		
	Area	**Production**	**Yield**	**Area**	**Production**	**Yield**
USA	29,661	192,084	6,474	27,094	201,509	7,437
Europe	11,738	54,791	4,668	10,254	43,375	4,230
Canada	1,039	5,901	5,672	1,040	7,033	6,765
Argentina	2,895	9,333	3,159	1,626	5,049	3,105

4.4. Livestock, kinds, numbers, distribution

Ranching was, and still largely is, the most important rural activity in the pampa, in spite of the steady growth of agriculture. A fourth of the pampa (the *pampa deprimida*) is not appropriate for agriculture, and, on account of its soils, a good part of the rest of the pampa is best employed in a grazing/agriculture rotation. In 1986 it was estimated (Peretti & Gomez 1991) that 13.2 million Ha were planted in crops (of which 990,000 Ha were double-cropped for a total of 14.2 million Ha), while 36.2 million Ha were dedicated to grazing livestock, a ratio of 2.7 Ha of grazing land for each Ha of agriculture (table 11). However, this ratio has decreased sensibly since 1960 when it was 5 to 1. Cultivated surface has increased significantly in 1995 and 1996.

Cattle raising for beef is the most important ranching activity, sheep having been displaced mostly to more marginal zones outside the pampa. Horse breeding is an important, but limited activity. Cattle raising is extensive and very little supplemental feed is provided. Carrying capacity of the range varies with the region and soils, being lowest in the depressed pampa (0.7-0.8 animals/Ha) and highest in the agricultural zone (1.39 animals/Ha). The average for the pampa is 0.95 animals/Ha. The improvement of the range through the use of forage plants is the principal investment, although less than a third of the grazing lands are so improved. Hoof and mouth disease have been endemic in the pampa, but a serious campaign of vaccination has earned the pampa region the designation of "free of hoof and mouth disease through vaccination" and it is hoped that soon the region will be designated totally free of the disease. This should increase the potential markets and price for Argentine beef.

Table 11. Agricultural and Grazing surface (thousand Ha) of the pampa (source Peretti & Gomez 1991)

Zone	**Activity**	**1960**	**1974**	**1977**	**1982**	**1986**
I. Agriculture	Agriculture	2,914	2,884	3,258	4,419	4,745
	Grazing	3,792	3,978	3,783	3,270	2,787
II. Livestock	Agriculture	462	599	777	837	733
	Grazing	7,695	7,558	7,380	7,320	7,424
III. Mixed	Agriculture	4,798	6,786	8,196	9,025	8,698

	Grazing	29,721	27,742	26,352	25,583	25,985
Total pampa	Agriculture	8,174	10,269	12,231	14,281	14,176
	Grazing	41,208	39,278	37,515	36,173	36,196

Cattle stocks increase and decrease according to the international price and internal demand and their relation to the earning margins of agriculture (table 12; fig. 5). The cattle herd of Argentina grew until the early 1970's and has been static ever since (fig. 6). However the herd in the pampa has diminished some in relation to other areas of the country, from 71% of the total in 1960/62 to 66% in 1984/86. Although the quality of the beef animals is very high, other indicators, such as percent of live births, are not.

Fig. 5. Changes in the Argentine cattle herd, 1961-1988 according to Peretti &Gomez 1991.

Fig. 6. Size of the Argentine Cattle herd 1875-1993 according to Peretti & Gomez 1991.

4.5. Dairy farming

Another very important rural activity in the pampa is dairy farming, pursued to some extent throughout the area, especially around cities, but with a concentration in southeastern Entre Rios (south of Paraná), central Santa Fé, west of Buenos Aires, and around Tandil. The opening of the Brazilian market after the Mercosur treaty has helped develop this sector.

Table 12. Kilograms of meat needed to obtain the average per hectare income from farming in the different use zones (1960-1985)

Year	Agriculture	Livestock	Mixed
1960/61-65/65	426.0	325.3	308.6
1964/65-69/70	451.2	300.6	284.5
1970/71-74/75	347.5	230.4	222.3
1974/75-79/80	578.4	339.8	347.8
1980/81-84/85	541.5	412.1	413.2

Most dairy farming is done in small establishments by resident owners although the size of the average herd is increasing. Often dairy farming is combined with some crop farming or with raising of beef cattle. Production in these establishments tends to be low, with less than 40 Kg milk/day due to low technology. In some establishments manual milking is still practiced, and only limited supplemental feed is provided although this is changing rapidly. Larger establishments in the major dairy farming areas, on the other hand, use modern mechanical techniques to process the milk, provide supplemental feed, graze their animals on pastures planted with alfalfa or other forage plants, and keep a strict control of the herd. Production in such establishments seldom reaches 60 Kg milk/cow/day, being mostly in the 40-50 Kg milk/cow/day. The dairy cows in Argentina belong to the "Holando-Argentino" breed, a larger type of Holstein developed in Argentina.

5. Land tenure

One of the most contentious social, political, and historical issues about the pampa is land tenure. Ever since a rural strike in 1912, known as the *grito de Alcorta* (the name taken from a small rural locality in southern Santa Fé province), this issue has been hotly debated in Argentina. Given the historical settlement pattern in Argentina --a frontier driven by the land needs of a very extensive cattle industry-- it is not surprising that there is a high concentration of land. Only after the military campaign in 1879 that conquered the nomadic Indians in the western part of Buenos Aires Province, south of Santa Fé and Córdoba, and all of La Pampa province, was the federal government in possession of a large land surface that it could have used to foster a land-settlement scheme. Although such a program was discussed in the legislature of the province of Buenos Aires at the time, budgetary constraints and political considerations forced the state to sell its lands. Much state land was also given away for political reasons.

The early colonial pattern of large land holdings (10,000 Ha being a small holding, some extending up to 500,000 Ha!) dictated the system of sharecropping agriculture with immigrant farmers that developed after 1860. This pattern was aided by the immigrant farmer himself, who did not come to Argentina with the object of settling, but with the aim of earning a small capital with which to return to Europe. Although many Europeans eventually settled in Argentina, the unavailability of land was not necessarily seen as an impediment (Adelman 1994). Eventually through inheritance or sale of poorly managed large estates, the very large *estancias* were broken up. Of course, small-holdings existed throughout and there also existed a small but effective system of farmer colonization (Gallo 1983), particularly in the province of Santa Fé. From the beginning of the century until the 1960s,the average size of a holding kept grew steadily smaller (table 13).

From table 13 several general conclusions can be drawn. There appears to have been a steady reduction of the average farm size between 1914 and 1969, from 355 Ha to 277 Ha. This trend seems to have reversed itself, since the average farm size in 1988 was 370 Ha, greater than in 1914. The distribution of the number of farms of different sizes also seems to have changed. In

1914 there were a total of 189,271 farms, and in 1969 there were 269,817. Of these, 1,927 farms (1%) were over 5000 Ha in 1914 while in 1969 there were only 1,454 (0.5%) of that size. Likewise, in 1914 there were 10,066 farms over 1,000 Ha (5.3%), and in 1969, 13,503 (5%) occupying 61.3% and 51.7% of the total surface area, respectively. While this still constitutes a great land concentration (more than half of the land is in farms of over 1,000 Ha), the situation has become somewhat more balanced. Furthermore, if one considers that extensive ranching still constitutes the principal farming activity, it is not surprising to find that most of the land (70%) is in the hands of farmers with more than 500 Ha.

Table 13. Evolution of the number, surface and average size of pampa farms (after Barsky and Pucciarelli 1991)

Year	Number	Total Surface	Average
1914	189,271	67,242,813	355.3
1937	248,415	67,232,900	270.7
1947	282,003	71,031,885	251.9
1960	248,220	67,710,787	272.8
1969	269,817	74,927,177	277.7

Finally, it must be mentioned that the number of farms below 25 Ha has shown a great increase between 1914 and 1969, constituting about a quarter of all establishments. This could be interpreted as the classical minifundio-latifundio situation of other areas of Latin America. A more likely interpretation is that these small farms represent the truck farming segment around the major cities and along the coast of the Paraná River (Baradero and adjacent areas).

6. Environmental problems

In the humid pampa there are a number of environmental problems, most of them having to do with industrial pollution and urban contamination. We will not deal with these here, other than to mention that water contamination appears to be a serious problem. There is very little reliable data on the extent of water contamination, and its source is more likely to be industrial rather than rural, given the low use (until recently) of fertilizers, herbicides, and pesticides. This situation may be changing with the increase in use of agrochemical products in the last five years. But there is

essentially no monitoring of ground water contamination and consequently very limited reliable information. Soil erosion brought about by continuous farming is the most evident rural environmental problem. Another problem is an increase in weeds and concomitant use of chemical herbicides.

6.1. Soil degradation

Erosion --the destruction and removal of the upper layer of the soil surface-- is a natural process that inevitably takes place in every ecosystem. Climatic conditions (especially heavy precipitation and the action of wind), geological features (principally slope), and the granulometry of the soil control the rate of natural erosion. Human activity, in particular agriculture and livestock grazing, increase the rates of erosion by an order of magnitude or more. Soil erosion is detrimental to agricultural production because it removes the upper layers of the soil, which tend to be the ones that contain most of the nutrients that the plant needs, and that, because of their higher content of organic matter (due to the accumulation of decomposing litter), increase the soil's capacity to retain water and nutrients. Yet the rate of erosion of agricultural fields can be controlled with appropriate practices, even though it cannot be eliminated completely.

The increase in agricultural activities in the pampa has led to a serious problem of soil erosion, especially in the undulating pampa where these activities are more intense (Michelena *et al.* 1989; Senigagliesi 1991; Ghersa and Martinez de Ghersa 1991; Panigatti and Viglizzo, 1995; SAGyP 1995; Senigagliesi *et al.* 1996). It is estimated that in over approximately 1.6 million Ha -- 36% of the Argentine pampa-- the soil is degraded on account of water and wind erosion. Just for the agricultural area of the undulating pampa (*núcleo maicero*) the yearly losses in production are calculated at 250 million dollars (SAGyP 1995). For the entire of the pampa the losses are estimated to be one billion a year (Casas, com. per.).

Michelena *et al.* (1989) compared soils that had been continuously farmed with those that had not and found losses of 37 to 53% in organic matter, 40 to 53% in nitrogen, and 77 to 83% in available phosphorous. Among physical properties the structural index showed a decrease of 64 to

78%, and the index of water percolation decreased by 56 to 80%. The rates of erosion of soils under continuous agriculture have been calculated at between 18 and 27 tons/Ha/year, and they can be as high as 40-60 tons/Ha/year. Where agriculture-livestock grazing rotation is practiced these numbers are reduced significantly. A factor contributing to soil degradation is the high silt content (60-65%) in the cultivated layer of the soil, that gives it a high degree of instability and makes it susceptible to erosion by wind and water.

In the region of the depressed pampa (fig. 1) dedicated primarily to cattle grazing on natural or little modified grasslands, the principal problem is overgrazing, and the loss of the proper physical surface properties as a result of trampling as well as the effect of periodic floods. It is calculated that in this region, out of 13 million hectares, 3 million have been affected by erosion and another two and a half million are susceptible.

Studies by Sala *et al.* (1981, 1986) in this region have shown that the native flora is negatively affected by grazing, but that many alien plant species cannot withstand the periodic flooding. Consequently, flooding acts like a cleansing process, returning the grassland back to a more original floristic composition.

The increase in precipitation in the humid pampa in the last twenty years (Hoffmann 1970; Sierra *et al.* 1993/94, 1995) and the decrease in temperature amplitude has encouraged an increase in double cropping in the undulating pampa and has expanded the cultivated area in the sandy pampa by 94% between 1970/71 and 1983/84 from 560,000 Ha to over 1,100,000 Ha (SAGyP 1995). Since these soils are more fragile still than those in the undulating pampa, this increase in agriculture in the sandy pampa has been particularly damaging from an edaphological point of view.

Another problem is soil compaction due to the effect of plowing (*plow sole, piso de arado*) and the use of heavy equipment. This is a particularly serious problem in the pampa on account of the very fine soils. Soil compaction reduces the capacity of the soil to absorb and retain water, reduces soil aeration and root growth, with the consequent loss of productivity. This is another

reason to practice rotation with cattle grazing, as the *plow sole* tends to disappear after a number of years of grazing. Soil crusting is another negative effect related to soil erosion.

6.2. Economic losses due to soil deterioration.

A number of studies have evaluated the effects of soil erosion on agricultural productivity (Berón and Lemos 1982, Berón and Irurtia 1992, Rivero de Galetto *et al*. 1984). These studies found that eroded soils reduced production significantly for the three major crops studied: wheat, maize, and soybeans. So, for example, in maize in the period 1970/71 to 1986/87, yields that were increasing at a rate of 229 Kg/Ha/year on uneroded soils during the first years of the period only increased by 85 Kg/Ha/year in the second half of the study on eroded soils in spite of increases in agricultural technology. The negative effects of soil erosion are often underestimated due to the incorporation of new and more productive agricultural methods (new varieties, herbicides, Labbate 1996).

Soil erosion also affects the local economy on account of the downstream effects of flooding, damage to roads and other communications, and accumulation of sediments in drainage basins. Furthermore, the degradation of the quality of the soils increases production costs, since corrective measures need to be implemented, and the amount of work increases. Finally soil erosion can increase transportation costs if roads are affected.

6.3. Increase in weediness and changes in biodiversity

The agriculturalization of the pampa has increased the abundance of a number of weedy species of foreign origin that are very difficult to eradicate. About a quarter of all species of plants growing wild today in the pampa were introduced, probably by humans, in the last 400 years (Solbrig unpublished based on Cabrera 1968) . A study in the county of Pergamino (Lewis and Pires 1997) indicates that since 1930, fifty-one new species have been found growing in the county

(in addition to most of the original 488 species). Some of these new species have become very invasive and difficult to eradicate.

When farmers prepare their fields for a particular crop, they create conditions that also favor the growth of undesirable wild growing plants that emerge with the crop and compete with it for soil nutrients and water. The traditional method to combat weeds has been mechanical destruction, either by hand or through the use of harrows and similar equipment. Hand weeding is preferable to mechanical weeding from a conservationist point of view, but is much more costly. Mechanical weeding loosens the soil and increases erosion. A third method, introduced in the last fifty years is chemical weeding through the use of herbicides, that can be applied before sowing to keep weeds from emerging, or after the crop has been planted. It has the advantage of not disturbing the soil and therefore reducing soil erosion, but can have harmful effects on underground and water supplies off the farm. Once the crop reaches a given size it shades the ground and effectively controls weed emergence and also protects the soil from the harmful effects of wind and water.

Weed control and soil erosion are therefore connected when traditional cropping methods are employed. Conservationist tillage is based on the notion that the ground should be kept covered at all times with live or dead vegetation to reduce erosion, and chemical herbicides should be used to control weeds. Sowing takes place together with plowing, or in no-tillage methods, plowing is avoided altogether, and the seeds are planted directly into the ground over existing vegetation that has been killed through the application of herbicides.

Table 14. Increase in herbicide, pesticide (Million U$S) and fertilizer use (1,000s Tm) and number of new tractors (source: Ing. Agr. Carlos Salvador, after CASAFE)

Year	Herbicides and Pesticides	Fertilizer	Tractors
1988	246	358	--
1989	242	316	--
1990	253	303	--
1991	286	325	3790
1992	336	516	4871
1993	406	594	4550

1994	521	922	6393
1995	626	1200	4329
1996	720	1500	7380

Chemical control of weeds is well known by pampa farmers. The high cost of capital inputs has led pampa farmers at times to use lower herbicide doses than recommended for total weed control. Consequently weed control has been incomplete and some weeds, such as *Sorghum halepense* (*sorgo de Alepo*), may have developed partial resistance to the herbicide (on this subject there are varying opinions); those weeds now constitute formidable agronomic problems (Ghersa and Martinez de Ghersa 1991). This situation was particularly true in the past. The lowering of prices for weed killers, their greater specificity, and the better economic situation of farmers in the last few years has increased the use of weed killers (table 14). On the other hand, increase use of weed killers can have negative effects on aquifers and can reduce biodiversity. These costs are borne by society at large and not by the farmers (economic externalities) and need to be evaluated carefully.

6.4. Necessary conditions to reverse the process of soil degradation

To halt soil erosion in the pampa, changes in the present production system are probably needed to use the soil more rationally, bearing in mind the specific characteristics of local soils. Those lands with the greatest susceptibility to water erosion should be used for grazing, or a mixture of agriculture and grazing, with use of conservationist tillage techniques during the agricultural phase of the cycle and planted forage resources during the grazing phase. It must, however, be pointed out that this recommendation can only be implemented if the opportunity costs are not too high, which in turn will depend on relative agricultural and livestock prices, the cost of credit, etc., as well as the availability of technical advice.

A technique that should be used universally is the systematic rotation of crops belonging to the grass and the legume family. These rotations favor the accumulation of nutrients and organic matter with good carbon/nitrogen ratios. Examples of this are the alternation of soybeans with wheat in the same year; or corn and soybeans in alternate years. Rotation can also help control

weeds. Such rotations have been practiced with very good results in the pampa for a long time. There is a universal tendency in high-input agriculture towards monocropping, but less so in the pampa than in other areas of intensive farming such as the United States. Concurrently, there has been an increase in the use of fertilizers to make up for crop rotation.

There is an increasing uneasiness among pampa farmers about the adverse consequences of the process of agricultural intensification. In general the concern of producers translates into a growing adoption of techniques of minimum tillage. The benefits of these techniques from the point of view of soil conservation are well known, while other aspects of this technology are more controversial, especially the increased use of chemicals (Moyer *et al*. 1994). Also, because these technologies are management and knowledge intensive and present economies of scale, they can put small and medium producers at a disadvantage favoring the large, vertically integrated enterprise (Barsky, 1991). Above all, they require a high degree of sophistication in terms of technical and managerial skills with continuous access to updated information. This has promoted the growth of specialized firms, including those that provide technical advice, as well as a new mechanism to pool machinery and knowledge. The intensification of pampa agriculture, also referred to as "modernization," must therefore be seen principally and essentially as an upgrading and updating of managerial skills and human capital (Barsky 1991; Viglizzo *et al.* 1991; Torres Zorilla 1994), rather than just the replacement of existing technologies. It also points to the importance of agronomic education and the need to strengthen and modernize it.

It is important, in order to conserve the soil, to encourage the use of these minimum or no-tillage technologies in order to maintain the fields covered by vegetation at all times. This not only reduces soil erosion but also reduces soil evaporation and creates a favorable humid climate for the crop. Because these techniques require more management as well as capital inputs, they represent a change in the present mix of production factors and are another aspect of intensification. Minimum tillage techniques are being used with increased frequency in the pampa region having increased from 9% of cultivated surface in 1992/94 to 13 % in 1994/95 (Trucco 1997). They are

concentrated in soy-bean production, although lately there has been an increase of the use of conservation agriculture in other crops (table 15). This subject requires more research.

Table 15. Surface (thousand Ha) planted with no-or minimum-tillage (1989-1996) (Source: Trucco and Salvador, 1997)

Year	Soybeans	Total	% in Soybeans
1989-90	80	92	87
1990-91	280	300	93
1991-92	445	500	89
1992-93	775	970	80
1993-94	1350	1800	75
1994-96	1670	2440	68
1995-96	2150	2970	72

A very important change that would help conserve the productive capacity of pampa soils is the use of fertilizers and soil additives in adequate amounts. Such has been the tendency in the last few years when fertilizer use increased dramatically (table 14). Until the last two years, the use of fertilizers had been limited, and due to cost considerations, the quantities applied have been insufficient. Nitrogen and phosphorous have been the two most limiting elements and the use of fertilizers that contain these nutrients is strongly recommended together with the use of crop varieties that can make use of the higher soil nutrient levels. The use of lime to correct soil acidity where it exists due to the accumulation of herbicides and pesticides residues, is also recommended. Another practice is to manage the fields so as to control the action of water or wind by using contour plowing, micro terracing, and building windbreaks. These are, however, seldom used.

Finally, more attention should be paid to the introduction of integrated pest management (IPM) techniques for a better control of weeds, insect pests and plant diseases. IPM has shown to provide better control at a lower cost, with consequent environmental benefit. It requires, however, as do all these techniques, much more and better management.

6.5. Socio-economic obstacles to the adoption of conservation agriculture

The reduction of soil erosion and natural resource degradation in the present context of pampa agriculture will inevitably require the intensification of agriculture via the use of more fertilizers, weed killers, crop varieties adapted to the new soil environment and minimum tillage techniques

(Cetrangolo and Amador 1995). The alternative –-returning to a system of low input agriculture and cattle raising-- is no longer economically viable, and could not produce the necessary surpluses required by the economy at large. Intensification implies an increase in the use of agro-chemical products and it is feared that this will create a problem of soil and water contamination. It is often argued that such increases are inevitably associated with inefficiencies in the use of these products, especially when they are used intensively with associated scale inefficiencies (law of Mitscherlich). The relevance of this generalization has been questioned by de Wit (1992) who maintains it does not apply when changes in various factors (such as nutrients, improved varieties, and machinery) are happening simultaneously. This author produced evidence from Holland of constant returns when the totality of techniques change simultaneously in a harmonic way. Zoebl (1996) maintains that it is not the levels of inputs that restrict efficiency, but the availability of knowledge and information on which decisions are made. This same point, namely that management capacity in making decisions is the principal bottleneck for a rational intensification has been argued for Argentina by Viglizzo *et al.* (1991). It is therefore not necessarily true that a reduction in soil erosion through the use of minimum tillage techniques will increase chemical contamination, provided the proper management is available, nor is it necessarily true that an increase of agricultural inputs will increase the level of contamination. Given the present level of knowledge and training of management, it is very unlikely that intensification will not result in an increase in chemical contamination of streams and aquifers, as has been the case in Europe and the United States (NRC 1989; Logan 1990).

Inefficiencies in the use of inputs affect farm production, farmer's profit margins, and society at large. Underuse of inputs, which has been the case until recently in the pampa, results in less than optimal productivity. Overuse of inputs leads to contamination of soil and water (economic externalities). In either case, profit margins are affected, either because production is below optimal, or because expensive inputs are wasted. It is often argued that farmers, as rational economic actors, will use inputs efficiently in order to maximize profits. This assumption is probably invalid. Although farmers try to maximize profits, in addition to the fact that to do so requires perfect knowledge as alluded to above, a variety of human foibles and external factors always present, from

neglect, laziness, lack of proper timing, uncontrollable weather conditions, and unplanned shortages, conspire to produce management imperfections even in the best of situations. Furthermore, unless farmers are made responsible for externalities, society at large will pay for a larger part of the costs of input inefficiency thereby reducing the incentives to be efficient.

The deterioration of natural resources in the pampa has not yet provoked a debate within Argentine society regarding the social costs of these changes. Consequently there is no evidence of a systematic consideration by society at large of the externalities associated with soil erosion and chemical contamination, although some studies exist that show possible areas of danger. For example, Viglizzo (1994) has pointed out possible losses of wildlife, Alvarez *et al*. (1995), Rosell *et al*. (1995) and Viglizzo (1994) have estimated the balances of carbon and nitrogen, usually negative, in the new land use systems, and Michelena and Irurtia (1995) have mapped the wind erosion susceptibility of the semi-arid regions of the pampa.

It must be pointed out that intensification does not imply inputs that are especially different of what is already in use. In principle, what is required is:

- new genetic materials obtained using classical genetic techniques or the newer biotechnological approaches (for example, incorporating insect pest resistance, disease immunity, or resistance to herbicides);
- a different mix of agrochemical products, with an increase in the use of fertilizers (herbicide use has increased with the introduction of soybean culture); and
- specialized machinery for use in conservation tillage (with a higher purchase cost).

The greatest difference of the new technologies is a greater use of knowledge and management and an increase in agronomic consultants. Inevitably, it also involves a change in production factors with a greater use of capital.

These approaches are being implemented, and they have been especially notable during the last two years when farmers reaped windfall profits as a result of a price spike. The surface planted in soybeans using minimum tillage has increased; new varieties with shorter cycles are being used, more fertilization, especially with phosphorous, is being practiced, and the planting density has

increased thereby decreasing the area of naked soil (Palermo 1997). It is an open question whether these trends will continue now that prices are tending to resume their secular downward tendency.

7. Agricultural intensification, trade liberalization and environment

Argentina has again adopted an export-led development strategy that was so successfully pursued in the last century. Forgetting for the time being the social problems that this policy generated, it was undoubtedly very beneficial from an economic standpoint (Bulmer-Thomas 1994). The theory behind this strategy is that of comparative advantage, according to which the combination of production factors --natural resources, labor, and capital-- present in each country give it distinct advantages in the production of certain products that allow its firms to compete through trade in foreign markets and thereby earn the foreign reserves to buy other products that are not available locally or which can be obtained through trade at lower prices than what it would cost to produce them locally[3]. The growth of Argentina during its heyday (as well as the rest of Latin America) was based on the export of natural products and the importation of industrial goods. Although the percentage of industrial products exported today has increased sensibly in comparison with last century, Argentine foreign trade is still largely based on the export of agricultural products and oil.

7.1. Economic development strategies

In order for an economic activity to be competitive in today's globalized world economy, firms have to be highly efficient and competitive. The local factors of production --natural resources, capital, and labor-- have ceased to provide as great a comparative advantage as they did a century ago due to modern communication and the ease with which capital, knowledge and to some extent labor, can be moved from one place to another. Today it is the economic efficiency of a firm that allows it to conquer markets (Porter 1990). Therefore, in order for Argentine agriculture and livestock grazing to become the dynamic sector it once was, modern management systems have to

[3] The theory assumes that there is no free movement of capital and labor, conditions that were more or less true in the last century, but that are not true today (Daly and Goodland 1994).

be introduced. Given the close relationship between natural resource use and the environment, rural work must also pay attention to environmental integrity (Young 1992; Young and Solbrig 1992; Solbrig 1993; Solbrig and Solbrig 1994), else the renewable resources on which agricultural activity is based will degrade. The Argentine government is apparently very aware of these requirements and has established the "Cambio Rural" program (SAGyP, 1995) to improve the competitive ability of small and medium sized rural establishments in a context of sustainable agriculture.

The official name of this program, begun in 1993, is *Programa Federal de Reconversión Productiva - Cambio Rural*, and it aims at improving living conditions of the rural population and the reactivation of the process of investment and economic growth in the rural sector within a framework of sustainable agriculture. It is targeted to the small and medium producers, and it is a national program not restricted to the pampa area (SAGyP, 1995). The program, administered by the Secretary of Agriculture, Fisheries and Food of the Ministry of Economics, in partnership with the provinces, is based on organizing pools of producers that will be the recipients of technical information and credit.

Usually the degradation of natural resources takes place at a slower temporal scale than economic activity. Consequently, although the producer is aware of the losses in production capacity that are taking place and their long term consequences, immediate economic necessities often lead the firm to underestimate the medium and long term consequences of soil erosion and water contamination, particularly when, as is the case in the pampa, the farmer is seeing an increase in yields due to the use of better technology (Labbate 1997). This is a classical case of "market failure." The basic problem is that at present (and very likely always), there is no substitute for land or water and it is very difficult or impossible to calculate a real discount rate. Once these resources are lost, their production capacity is gone forever.

National and international policies --especially the existence or lack of transportation, information, and trade infrastructure (Solberg 1987)-- are another important factor that changes the competitive ability of producers and often leads them to neglect the conservation of natural

resources in order to remain competitive. The deterioration (or conservation) of natural resources is therefore not a simple matter, but is the result of many factors --technical, managerial, economic, and political. Hence, conservation farming is not just a question of possessing the proper technical knowledge, but requires also a favorable socio-economic and political environment. It may require novel forms of acquiring and owning chemical inputs, machinery, and the entire panoply of post-harvest activities.

7.2. Intensification of the rural sector activities and their impact on natural resources

It is generally believed that the increase in international trade, together with the low level of prices for Latin American agricultural products in international commerce, as well as the slow incorporation of conservation farming techniques, has increased the pressure for agricultural intensification and that this will result in the deterioration of the natural resources of the region (Morello *et al.* 1991; Di Pace 1992; Viglizzo 1994; Gligo 1995; Panigatti and Viglizzo 1995; Gallopin 1995). What is the evidence that this is will happen in the Argentine pampa?

Although not as high as in other parts of Latin America, a high percentage of the agricultural production of the pampa consists of wage goods. Therefore the increase in yields and in efficiency should have a direct effect on inflation and poverty reduction, especially urban poverty (Trigo 1995). This interpretation is consistent with the re-analysis of the role of agriculture in economic development, described among others by Timmer (1992, 1995), that maintains that the linkages between agriculture and industry are more complex than has usually been assumed in the past. Timmer (1992) postulates that there is a contribution of agriculture to overall development that cannot be measured exclusively by market forces. This contribution operates through a number of mechanisms that include the effect of stable food prices on overall investment (not just in agriculturel), the increase in productivity of economic factors, the effect of the learning process, the role of agriculture in poverty reduction, the management and use of natural resources, and the non-economic value of the latter (existence value, quality of life, etc.).

A second aspect of agricultural modernization and intensification that is taking place throughout Latin America, but particularly in the pampa region, is the increasing contribution of agriculture to the improving of the trade balance (Trigo, 1995). In effect, in 1990 Latin American agriculture contributed 40% of exports, and 55% if oil and minerals are excluded. For the 1972-1987 period, agricultural exports constituted 60-68% of Argentine exports (Obschatko, 1990). These positive contributions must be considered when assessing the intensification of agriculture (Solbrig and Vera 1997).

Another aspect that also needs to be considered is the increasing role of agro-industry *vis-a-vis* the primary sector. Investigations in several countries of the region have shown that these linkages are very important and of a greater magnitude than overall linkages in the economy (19.5% greater than the total of the economy in Brazil; 5.5% greater in Chile and 12.4% in Mexico; Schejtman, 1994). An indirect measure of the importance of the Argentine primary sector in relation to agro-industry can be obtained if we consider that in the last decade the contribution of the primary sector to GDP oscillated around 15%, but it is 36% if the agro-industrial complex and related services are included (Obschatko, 1990). If these results can be generalized, they imply, among other things, that increases in agricultural production and productivity will be strategically important to the overall Argentine economy and very specially to the generation of jobs outside the farm, a conclusion that coincides with the analysis of Timmer (1992) mentioned before. This scenario can of course be upset by market imperfections that could impede the incorporation of medium and small producer into export agriculture (von Hesse, 1994; Obschatko, 1990).

Like the agricultural sector, the cattle sector is also in search of new markets. The struggle of many years to control hoof and mouth disease is finally paying off, the pampa area having been certified as "free of hoof and moth disease through vaccination." This development as well as marketing strategies ("organic" meat; special "Hilton" cuts, etc.) should enhance the value of native and planted pastures and help maintain their biodiversity.

Consequently, although intensification has the clear and present danger of creating natural resource degradation if no technological adjustments are made, especially soil erosion, there are also very clear and tangible benefits for farmers, rural workers, and society at large. Whether intensification produces significant resource deterioration will depend on the economic and institutional environment in which the rural sector operates, and this in turn will be closely connected to national macroeconomic, political and trade policies.

7.3. The Mercosur and its effect.

Mercosur is the incipient common market created by Argentina, Brazil, Paraguay and Uruguay in 1990. It is basically a customs union in which all four countries agree on a common exterior tariff and abolish all interior tariffs. Since January 1, 1995, tariffs on most products within the common market have been dropped, and a common exterior tariff has existed for most products. Mercosur differs from the European Common Market in some significant ways. To start with, Mercosur does not imply free movement of people. Secondly and more importantly, the Mercosur countries do not aim at economic or political integration, nor do they aim to establish a common monetary policy. Finally, Mercosur has not established any supranational institutions to resolve disputes. There is no Mercosur bureaucracy, and any disputes must be resolved by a consensus of the governments (or their representatives).

Yet Mercosur has already had an impact that goes beyond the trade objectives. Bolivia and Chile applied for membership and have been incorporated as of January 1997. Brazil has become the most important market for Argentine producers, and trade between the two countries has tripled in five years. The distrust between Argentina and Brazil that has been the principal feature of their respective foreign policies and military strategies has been replaced by a policy of collaboration.

Mercosur has been very important for the rural sector. Brazil, especially southern Brazil, has become the most important foreign market for Argentine cereals and dairy products, as well as fruits and vegetables (not necessarily from the pampa region). Given the comparative advantages of the Argentine and Brazilian rural sectors, it is likely that there will be a readjustment of the mix of

agricultural products in the two countries with Argentina specializing in cereals, oil-seeds (including soy-beans), temperate fruits and vegetables, and dairy products, and Brazil concentrating on tropical products (tropical fruits, citrus, coffee), as well as soybeans. From an environmental point of view, Mercosur is a spur to the intensification of rural production that should bring with it better farming techniques, but as discussed above, whether it occurs will depend on a variety of other factors. Yet in the long run, an open trade policy with all countries is probably more favorable to Argentine agriculture than a regional policy, especially if the creation of the World Trade Organization (WTO) eliminates subsidies and other subventions by the large agricultural producers.

8. Policy options

The major problems of pampa agriculture on the productive side can be summarized as follows: (1) low but increasing productivity, (2) low but increasing use of inputs, (3) low but perhaps increasing capitalization, and (4) medium but increasing soil erosion. The region has also suffered from discrimination in government policies that resulted in high export taxes and other charges which have now mostly ended. To this list must be added the fact that infrastructure (roads, harbors, transportation networks), although improved significantly in the past few years, still needs to be modernized substantially. Furthermore, electricity, paved feeder roads, and telephone services are still not universally available to rural households. Rural housing, especially for labor, is sub-par in many establishments. Credit is expensive and hard to obtain. Future markets and rural insurance is not well established, increasing costs and financial risks.

From the demand side, the increases in both the world's population and the living standards of many third world countries, particularly the Asiatic Tigers, assure the existence of an expanding market for basic agricultural commodities. However, after the price hikes of the last two years created by a series of unusual circumstances, prices are likely to resume their downward secular trend, at least in the foreseeable future. The overvalued Argentine currency is likely to exacerbate the problem and cut into Argentine farmers' profits.

Low prices combined with high export taxes and other charges during the decade of the 1980s, with expensive credit and high inflation led to a decapitalization of the pampa. This seems to be now changing. Prices in the last two years have increased substantially (especially in 1995 when they doubled for certain commodities), demand is up, inflation is almost gone, and export taxes have been eliminated. However, prices are likely to resume their downward trend and Argentine farmers will have to be very efficient to remain competitive in a world where farmers in Europe and North America are the beneficiaries of overt and covert subsidies (that Argentina cannot afford) in spite of international agreements that are supposed to eliminate them. What are some of the policies that can help Argentine farmers in the present situation?

8.1. Some suggestions

It is obvious that the Argentine pampa is an enormous resource that is being threatened by soil erosion and resource degradation and which is not used to its full capacity. In order to implement any recommendation, a number of combined and complementary actions are necessary, as follow:

- First, an effort must be made to increase the collective awareness among both rural and urban producers, politicians, bureaucrats, and other social actors regarding the crucial importance of improving pampa agricultural productivity and of conserving natural resources.
- Increasing efforts must be made to accumulate and elaborate the available evidence on resource degradation in order to evaluate and quantify the process of erosion and loss of natural resources, both in their physical and economic aspects. Combined with it, a program of monitoring and publicizing resource degradation should be implemented.
- The training and updating of technical personnel, producers, community leaders, etc. in modern production techniques must be greatly accelerated, so as to increase production with less degradation of natural resources. This will require an increase in public expenditures in agricultural education and in research.
- Agronomic education must be thoroughly overhauled. A more flexible and less encyclopedic curriculum must be adopted, with an emphasis on problem solving. A closer connection between agricultural research in experiment stations and agronomic training must be developed.
- More efficient and cheaper mechanisms to finance the rural sector and reduce risks should be explored. The high cost of credit, insurance, and a less than perfect future market constitutes a great handicap to pampa farmers.
- A stronger organization of the rural sector must be promoted in order to allow producers, social and political leaders, and rural inhabitants, to search for opportunities to implement appropriate conservation actions and to increase their wealth and well being.

- Political, legal and economic measures that favor conservation practices in the rural sector must be implemented. Where needed, new ones must be created. Tax breaks and other incentives for conservation farming should be explored.
- The role of the private and state sector must be re-evaluated and clearly defined.
- Finally, at the macroeconomic level, the effects of an overvalued currency on the rural sector and on the overall economy must be seriously investigated. If commodity prices go back to their 1980s level, the export sectors of the economy could be seriously hurt.

9. Conclusions

In the coming years, the combination of the inevitable population growth and the increase in living standards in countries that until recently were poor, particularly in South-East Asia and China (with a third of the world's population), will create a big demand for agricultural products, especially cereals, oil-seeds, and animal proteins. The challenge faced by farmers the world over is to increase overall production without compromising the productive capacity of the land and without contaminating the water supply. Another challenge is to do it without increasing in prices for agricultural commodities; increases that would inevitably augment malnutrition, which is already a serious problem worldwide (Solbrig 1996).

The insertion of Argentina into the world trading system was one of the factors that pushed the development of Argentine agriculture and cattle raising in the past. The alternation of extensive agriculture with cattle grazing that was practiced was a sustainable system both from an ecological and a socio-economic viewpoint, although opinions differ in relation to this last point. If the forecasted demand for agricultural products develops, the pampa could see another period of high growth. But an intensive agriculture is ecologically more delicate than an extensive agriculture and to be viable, it will demand greater capital, more technical knowledge, and a much greater investment in education and research.

At this moment, changes that have some of the characteristics associated with the evolution of an agricultural frontier are taking place. These processes are characterized by a search for quick gains ("imediatismo" in the Brazilian sense, Schneider *et al.* 1993), that is, the preference for immediate income over future gains, with the corresponding exploitation and mining of natural resources. The past experiences of Argentine farmers with inflation and anti-rural government

policies no doubt reinforce the tendency towards maximizing present gains. A climate must be created to reverse that perception so that farmers can adopt a long range perspective. Only when the financial and economic time scale in which the farmer operates approximates the time scale at which land degradation is taking place, will we see serious efforts to reduce resource degradation.

Furthermore, the privatization of state resources that is taking place has the clear risk of eliminating precisely the public investments in common goods that is necessary for the private market economy to be profitable, among which we list agronomic research, registry and quality control of inputs, the provision of information and research on markets, and other services (Obschatko 1990; Timmer 1992). We totally agree with the words of Ing. Agr. Felix Cirio (1984): "Daría la impresión que dejar todo librado al efecto de 'las fuerzas del mercado' no parece una estrategia adecuada a estas circunstancias sino que por el contrario, podría llevar a retardar la concreción del potencial productivo actual." (The impression exists that leaving everything to the "forces of the market" is not a policy suited to these circumstances, rather, on the contrary, it could lead to a delay in realizing the productive potential).

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