1. Introduction

Since the 1992 UN Conference on Environment and Development (UNCED) in Rio de Janeiro, sustainable development has been accepted as a general concept world wide. It was defined by the Brundtland commission as "development that meets basic human needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). There are three dimensions of sustainable development: ecological sustainability, economic feasibility and socio-political acceptability, which are in an interactive conflicting process (Barbier, 1987). The objective is to maximize these goals across the biological, economic and social systems. However, since economic growth, necessary to meet basic needs, and environmental conservation are two potentially conflicting values, tension between these values in the pursuit of sustainable development is frequent.

During the 1990s Argentina faced the implementation of neo-liberal economic policies. Government expenses were reduced and the national currency appreciated, increasing the domestic costs dramatically. In the agricultural sector the opening policy included the elimination of taxes on the importation of agricultural equipment and lower taxes on the importation of competitive products. While some agricultural enterprises increased returns, land and livestock holdings, smallholders could not benefit from this policy since they were not eligible for credits to increase productivity. Instead they were affected since they faced competition with low cost imported products; on the other hand, the facilitated capital-intensive technological change on the big farms increased the rate of rural unemployment (Manzanal, 2000). In 2003, the rate of unemployment in Argentina was higher than 20 % and poverty accounted for 50% of the population; these figures were even higher in the rural areas (INDEC, 2003). Currently antipoverty and sector investment programs are dominating rural development as in other Latin-American countries (Kammerbauer et al., 2001).

In the South Region of Río Negro province, Patagonia, where this study was located, sheep keeping, oriented toward wool production is the most important rural activity. It provides the only source of income for many families in places where the grazing land

is not suitable for cultivation, and it contributes significantly to the economy of urban areas.

Difficulties of wool commercialization, lower international prices and high production costs contributed to the decline of the wool industry, reducing the stock and consequently the wool production (Paz and Mueller, 1994; Irasola and Boggio, 2003). This reduction resulted in a direct reduction of household income, loss of capital, increased poverty and led to the migration of 42% of the rural population to urban areas within one decade (Irasola and Boggio, 2003).

Factors contributing to rural income growth, poverty alleviation and environmental conservation are of major importance and have implications for policy and public investment on the on-going rural development programs in the region. However, several studies carried out by ecologists have shown that grazing affected the structure and functioning of the ecosystems (Aguiar and Sala, 1998; Bertiller and Bisigato, 1998; Paruelo et al. 1998), and grassland degradation is blamed for the wool crisis (Aagesen, 2000). Based on these studies there is a perception that livestock keeping in Patagonia is unsustainable, which is incompatible with the observation that a high number of smallholders built their livelihood on this activity for more than a century. This contradiction is particularly due to the very reason that these studies were oriented to test only environmental changes, but social and economic dimensions of sustainability were never taken into account.

There exists evidence in the literature that diversification of the smallholders' farming systems increases sustainability (Petit and Barghouti, 1992; Bhende and Venkataram, 1994; Ellis, 1998; Bowler, 1999). In Patagonia a series of on-station studies in the last years showed that diversification of the wool-oriented production system through investment in infrastructure could be a development strategy (Giraudo et al., 1999). Modeling smallholders systems proved that investment leading to an increase in lamb production increased smallholders' net incomes (Villagra et al., 2002), and grazing by a mix of livestock species was recommended to increase animal production (Somlo et al, 1994a). However, the real contribution of diversification to sustainable development was never tested within the context of the smallholders' farming systems

in the region. Therefore, the aim of this study is to analyze the effects of diversification on sustainable development by analyzing the ecological, economic and social contribution of different livestock species in smallholdings.

2. Literature review

2.1 Introduction of sheep in Patagonia

Sheep were introduced in America by Europeans. Rodero et al. (1992) reported that in the year 1535 an expedition, which departed from Sevilla, Spain, came to Argentina carrying horses, cattle, pigs, hens and sheep. Paz and Mueller (1994) mentioned that the first Merino sheep were introduced in Argentina from Spain at the beginning of the 19th century and spread very fast across the pampas.

The introduction of sheep in Patagonia is attributed to diverse sources. Soriano and Paruelo (1990) reported that the introduction of sheep to Patagonia is generally considered to have occurred in 1876, starting from the Malvinas Islands, transported to Isla Isabel in the Strait of Magellan and then to mainland South America. Grimm (1994) mentioned that sheep entered Patagonia from southern Chile after 1881; and from Central Argentina, specifically from the provinces of Buenos Aires and La Pampa, as a result of displacement by cattle ranching and crop cultivation. Paz and Mueller (1994) reported that the first importation of the Merino breed from Australia was in 1909, and since then the Australian Merino absorbed gradually the Argentinean genotype. Today in Patagonia about 70% of the sheep stock belong to the Merino breed, raised primarily for wool, and are dominant in the more arid north.

2.2 Importance of sheep in the Patagonia settlement

The sheep industry played a major role in the settlement of non-indigenous people in Patagonia. Aagesen (2000) reported that Patagonia was one of the last temperate climate areas where Europeans settled. Gasteyer and Flora (2000) pointed out that the first Spanish colonists entered Patagonia in the 1600s, followed by the British one century later. The same authors mentioned that before being declared part of the new nation of Argentina, the Patagonia region was considered a wasteland, little more than grazing land for goats and sheep. The expansion of the Argentine frontier to Patagonia started after Argentinean independence, in 1810, when the government started to place a small and dispersed, but constantly growing number of immigrant settlers onto the grassland and steppes. The land was either purchased or ceded by the Ranqueles and Araucanians

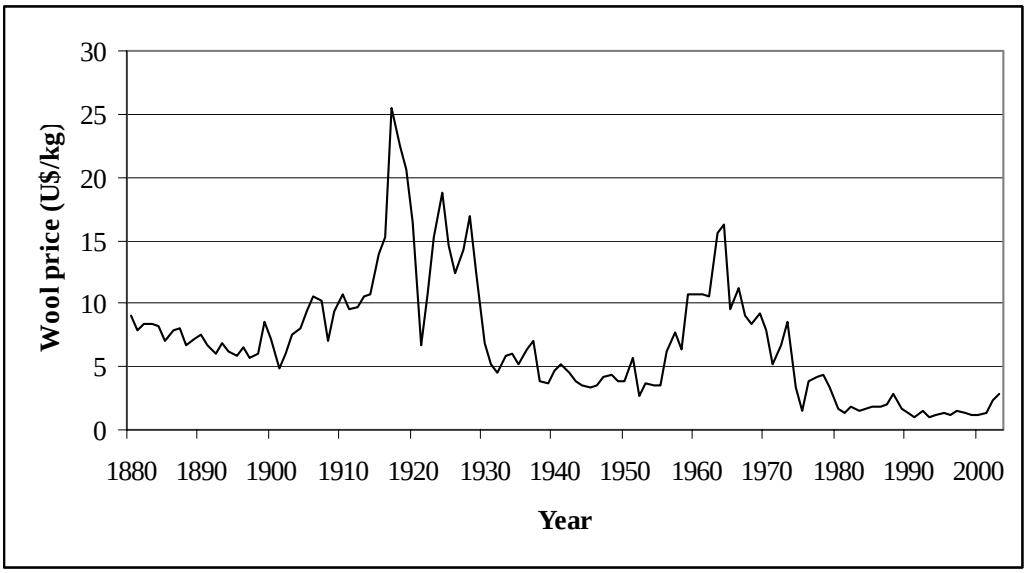
or Mapuches Indians, who occupied the region. Gasteyer and Flora (2000) reported that in 1830 the government was able to maintain the southern frontier offering salt, tobacco and horses in exchange for peace and land, until the overthrow of President Rosas by Urquiza in 1852. According to Williams (1975) in 1865 a small group of Welsh people established the first successful non-indigenous settlements in the lower Chubut valley. However, due to the chaos and civil war, the forts of the Argentine military were abandoned and the Indians began raiding the immigrants ranching communities, stealing horses, and occasionally killing people (Gasteyer and Flora, 2000).

Williams (1991) reported that since the indigenous population resisted the expansion, confronting the new settlers, British, German and Italian governments claimed that the frontier was defenseless and advised against migration to Argentina, causing a reduction in the number of European immigrants during 1873 and 1874. Williams (1991) and Gasteyer and Flora (2000) reported that in 1878 the Argentine Congress authorized the elimination of the native population. Between 1875 and 1878, General Julio Roca proceeded to decimate native inhabitants, the so-called Desert Conquest, diminishing the number of Indians from 12,000 to 2,000 people. The remaining indigenous population was relocated to reserves, which were small, contained the least fertile land and were inhospitable and isolated.

Once the indigenous population was almost eliminated, Patagonia was opened for new settlers and immigrants, resulting in a growing sheep industry. According to Gasteyer and Flora (2000) land in Patagonia was consolidated into fewer and fewer hands. Land was divided amongst those who financed or led troops to Patagonia, while settlers established ranches in those lands with more productive grasslands, adequate water supplies, and which were not already distributed after the Desert Conquest.

The principal purpose of the sheep industry in Patagonia was wool production, which was exported to Buenos Aires and Europe. Grimm (1994) reported that during its first few decades sheep ranching was the most prosperous activity in Patagonia. After 1894 the sheep industry received a new impulse with the introduction of refrigerated transport of meat. During the First World War the price of wool tripled (Figure 2.1), and the demand for meat increased. Several authors concur that this was the beginning of the ecological problems in Patagonia, since even the most marginal lands were profitable

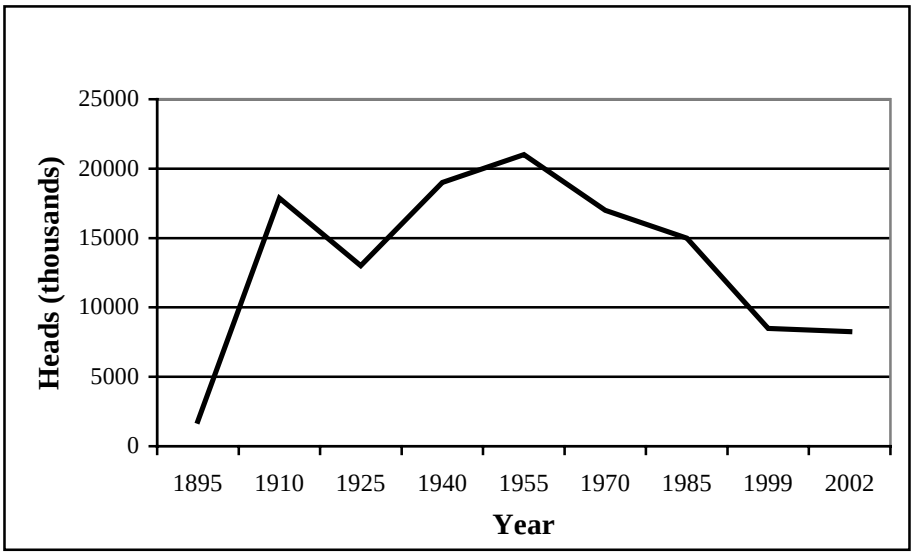
for raising livestock (Soriano, 1983; Ares et al., 1990; Aagesen, 2000). Grimm (1994) mentioned that even when production costs were generally higher on less favored land, the high price of wool justified the investments in sheep production. Once the First World War ended, wool prices decreased to their former levels and only the farms with better rangelands continued to be profitable. Most ranchers in the less favored areas responded by increasing the stocking rate on their rangelands to increase production to maintain their incomes and to pay debts.



Data source: archives of INDEC

Figure 2.1: International price of greasy wool

The number of sheep reached a peak of 22 million in 1952 (Figure 2.2), but decreased steadily thereafter. The reduction in the quantity and quality of forage in Patagonia as well as the use of synthetic materials and other economic factors were blamed for this decline (Soriano, 1983; Ares et al., 1990).



Source: INDEC (2002)

Figure 2.2: Evolution of the sheep stock in Patagonia

2.3 The smallholder livestock production system

2.3.1 Sheep production

Today the wool oriented sheep industry continues to be the principal economic activity in the South Region of Rio Negro. Investments in the infrastructure of small household systems are low and the production is very extensive (Mendez Casariego, 2000). Under these conditions lamb production is a by-product (Barrera, 1991). Lamb losses of 20% are normal in the region (Mueller, 1980). However, Villagra (2002) reported lamb losses of 50% in agreement with Giraudo et al. (2000) who reported lamb losses of 50% and ewe loses of 14% in smallholdings in the study area. Villagra (2002) observed that since factors such as predation, nutrition and cold stress, are not controlled by farmers, sheep flocks have been adjusted naturally through the survival of varying number of animals for replacement. In this context Mueller (1980) reported that there exist farms, which cannot enlarge flock size due to lack of replacement.

Apart from the study of Villagra (2002) there are no records of studies about management practices in smallholdings in the region. Lambing occurs in spring and marking three months later in summer. It was observed that weaning is an unusual management practice. In years of higher lamb survival male lambs are sold after marking at three months of age. The remaining lambs are kept together with the flock and continue suckling until ewes dry off. Lack of infrastructure is the most challenging

constraint in separating lambs from the rest of the flock. The lambing season, as well as kidding season differs by up to three months between eastern and western extremes of the region (Coronato, 1999). Sheep are sheared once a year, usually after lambing. However, there exists a trend to shear prior to lambing due to several advantages of this practice. Mueller (1980) found that pre-lambing shearing increases the lamb survival by about 10% and lambs' live weight by 200g. Also, the price of the wool increased in farms that practice pre-lambing shearing, since this practice increases wool quality. This practice is supported by the national program PROLANA (SAGPyA, 2004a).

Table 2.1 shows some productive characteristics of Merino sheep in Patagonia. The general performance is rather low in Patagonia as compared to Merino in Australia. Kelly (1992) found in a study of 18 commercial Merino flocks with extensive management in South West Australia that the average live weight was 51.6 kg, clean fleece weights 3.7 kg, mean fiber diameter of 22.9 µm, and the percentage of lambs alive respect to the number of ewe present at marking was 90.5%. That means ewes are 15% to 20% heavier, producing about 60% heavier greasy fleece weight and appreciably fewer lamb losses than in Patagonia. Kumagai and White (1995) also reported between 5.3 and 5.7 kg of greasy fleece weight in Merino sheep in Perth, Western Australia.

Table 2.1: Productive traits of sheep under extensive management in Patagonia, Argentina

Trait	n	Breed	Mean/range	source
Adult live weight (kg)	250	Merino	41-45	Giraudo et al.(2002)
	1452	Merino and Corriedale	38.7 - 39.9	Mueller et al. (1995)
Clean fleece weight (kg/head/year)	244	Merino (Farmer)	2.3	Villagra (2002)
	246	Merino (from breeder)	2.3	Mueller et al. (2005b)
Mean fiber diameter (µm)	244	Merino (Farmer)	20.6	Villagra (2002)
	246	Merino (from breeder)	17.9	Mueller et al. (2005b)