Socio-environmental change in the Argentine Chaco

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ABSTRACT

The Argentine Chaco eco-region is a forest biome of unique importance due to its continuity in terms of area, and biodiversity treasures. In the last decades of the twentieth century, agricultural expansion has represented a growing threat for the ecosystem and for the people who inhabit it. Due to this process, significant ecological changes, and social and demographic transformations, are taking place, in parallel.

The aims of this paper are to analyze the socio-environmental change occurred after the expansion of soybean cultivation in the Argentine Chaco in the 1990s, and examine the consequences of such expansion in environmental and socio-demographic processes.

To perform this analysis, we examined the relative impact of changes in agrarian production in general and the introduction of soybeans in particular, on demographic, socioeconomic and environmental dynamics, through path analysis. This analysis carried out at departmental level, considering a total of 69 departments of the Argentine Chaco.

The development models of socio-environmental change and their interpretation are based on the detailed analysis of the literature, where the main theories of the issue were collected. The analysis consisted in contrast these hypotheses with empirical data to finding a general pattern explaining the process of socio-environmental change for the Argentine Chaco in the 1990s.

The model developed explained a high percentage of variation between departments in the growth of soybean and in its social and environmental effects.

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The path analysis explain a high percentage of variance of migration (62%), and in lesser extent, the rural population (39%) and poverty (13%), and in which soybean is associated with the increasing rate of deforestation (effect coefficient of 0.46).

The results suggest that soybean has had different effects on the socio-demographic conditions according to the state of maturity of the agricultural border in Chaco.

Keywords: Migration, Poverty, Argentine Chaco, Soybean, Socio-environmental Change

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1. INTRODUCTION

The Argentine Chaco eco-region is a forest biome of unique importance due to its continuity in terms of area and biodiversity. It is the second forest biome of Latin America in terms of area, after the Amazon. Its area covers 1.2 million km^2 across the territory of Argentina, Bolivia, Paraguay and a small sector of Brazil (Dinerstein *et al.*, 1995). The biome is mainly concentrated in Argentina with 650 million hectares, representing over 55% of the total area of the eco-region and 22% of the Argentine territory (Fig. 1).

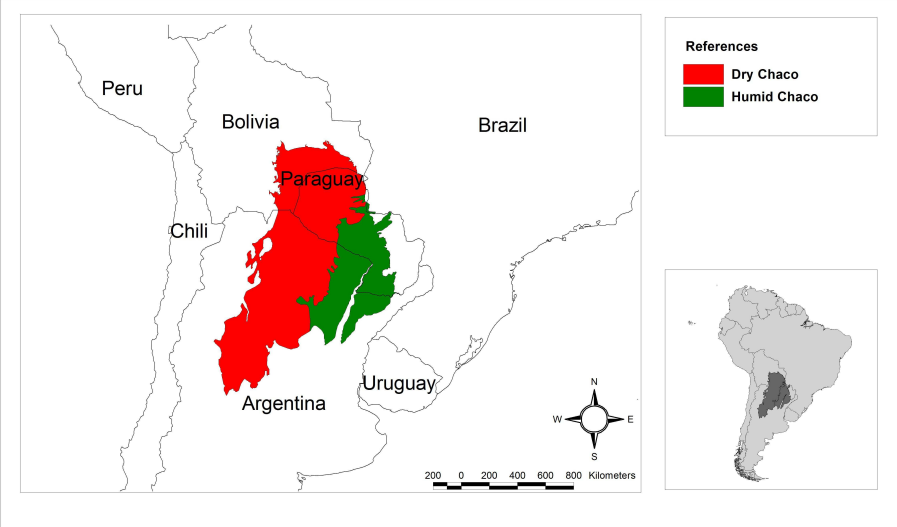

Fig. 1. Localization of Dry and Humid Chaco

In the last decades of the twentieth century, agricultural expansion has represented a growing threat for the ecosystem and for the people who inhabit it. The accelerated deforestation, mainly for soybean cultivation, is unprecedented in the history. In the 1990s, Argentine's Chaco deforestation accounted for 70% of the annual area deforested in all the country and exceeded three times the world's annual deforestation rate[3] (SAyDS, 2002).

According to some authors, rather than from better conditions for the local population, the transformation of native forest for this type of projects often involve the eviction of peasants and indigenous communities living in the forest, and whose survival depends on it (Reboratti , 2007; Lattuada and Neiman, 2005).

Many researchers were interested in the process of soybean expansion in Argentina, due to its size and implications, and the social scientists focused on the harmful effects of "soybean model" on the local population. It is therefore common to find in the literature the soybean increase as a key factor explaining the processes of emigration, depopulation, poverty, unemployment and deforestation and biodiversity loss[4].

On the other hand, the increasing deforestation rates have been traditionally as effects of population growth, migration and poverty, e.g. the Brundtland report (UN, 1987). Lambin *et al.* (2001) referred to it like the classic "myths" that are invoked to explaining the deforestation in the tropics and subtropics, and like Martínez Alier (1991) discusses these assumptions.

In this paper we attempt to test these hypotheses and, through empirical data, to develop an explanatory model of the main effects of the increased of soybean cultivation on socio-demographic variables and deforestation. That is, how far the soybean crop is responsible for the increased deforestation rates in the Chaco, and to what extent soybean is the main producer of emigration, poverty and unemployment.

The aims of this paper are to analyze the socio-environmental change occurred after the expansion of soybean cultivation in the Argentine Chaco in the 1990s, and examine the consequences of such expansion in environmental and socio-demographic processes.

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[3] In the 1990s, more than 250 000 hectares of native forests were lost per year in Argentina, of which 175 000 were in the Dry Chaco (Gasparri and Grau, 2009), meaning a deforestation rate of around -0.66%. The world's annual deforestation rate for the same decade, according Puyravaud (2003) was -0.23% (see annex, map 1).

[4] However, few have focused on the state's role in these processes and how they responded to these problems. No doubt, efficient government policies may counteract these negative effects of increased soybean.

2. THESIS ON THE EFFECTS OF SOYBEAN EXPANSION IN THE CHACO

Many authors have noted how the expansion of the agricultural border with soybean generates changes in the landscape and the agrarian morphology, linked to the progressive reduction in the number of farms and the increasing of their average size. It Is drawn, thus, the damages, produced by these changes, over an already impoverished and marginalized population, among which could be mentioned, the expulsion of rural populations to large cities (Torrella and Adamoli, 2005; Soto, 2006) and to other rural areas (Van Dam, 2002; Grau *et al.*, 2005; Reboratti, 1989; Reboratti *et al.*, 1996; Morello, 2006) and the generation of a rural landscape without peasants and with more large scale farms (Bolsi and Meichtry, 2006; Lattuada and Neiman, 2005; Madariaga, 1998). In turn, as indicated by Grau *et al.* (2005), the advance of the agricultural frontier with soybean generates the displacement of local people to non-colonised areas of the Chaco forest, which increases degradation and clearing.

The soybeans increased in the Chaco, in addition to generate changing patterns of population distribution, already cited, also would have some negative social effects, like the increase in poverty (Rulli, 2007). Van Dam (2002) argues that technological modernization linked to soybean would have effects on the level of employment in the area. Van Dam estimated that after the increase in soybean, the labor requirements have declined from 2.5 days per hectare to 0.5 days per hectare. Added to this, the profile of the workforce has changed: the soybean requires relatively skilled labor to operate the costly and complex agricultural machinery used for planting and threshing.

Given the requirement of specialists, large workforce comes from outside the region, which means no employment for local people (Van Dam, 2002). However, the increase in soybean may also generate employment, particularly for land clearing, when a large workforce is required for wiring and cleaning of the land (Leon *et al.*, 1985).

Finally, the trait most extensively worked until now, has to do with the effects of the expansion of soybean cultivation in increasing deforestation in the Argentine Chaco. Deforestation linked to other agricultural and livestock use would be minimal, although it might lead to a significant forest degradation and fragmentation (Adamoli *et al.*, 2004; Grau and Aide, 2008; Grau *et al.*, 2005, 2008; Gasparri *et al.*, 2008; Gasparri and Grau, 2009; Paruelo and Oesterheld, 2004; Torella and Adamoli, 2005; Boletta *et al.*, 2006; Morello *et al.*, 2008; Morello and Matteucci, 1999, Zak *et al.*, 2004 ; Fearnside, 2001).

3. MATERIALS AND METHODS

3.1. The study area

Our study covers most of the northern sector of the Argentine Chaco, corresponding to 69 departments in six Argentine provinces: Chaco, Formosa, Salta, Santiago del Estero, Tucuman and Jujuy (Fig. 2).

3.2. Exploration and selection of variables

Study variables are proxies of the change in forest cover, socio-demographic conditions and agricultural landscape of the departments (Table 1).

Due to the diversity of information processed, the work of collecting the information has demanded the searching over various sources. Thus, was used information from agencies, both nationals and provincials, including the *Dirección de Estadísticas e Información en Salud, Instituto Nacional de Estadística y Censos, Ministerio de Medio Ambiente y Desarrollo Sostenible,* among others. On the other hand, treatment of the information was very different for each case, precisely because of its varied nature. We worked mostly with census statistics, but also with spatially explicit information, which they have been adapted and synthesized to be incorporated into the study.

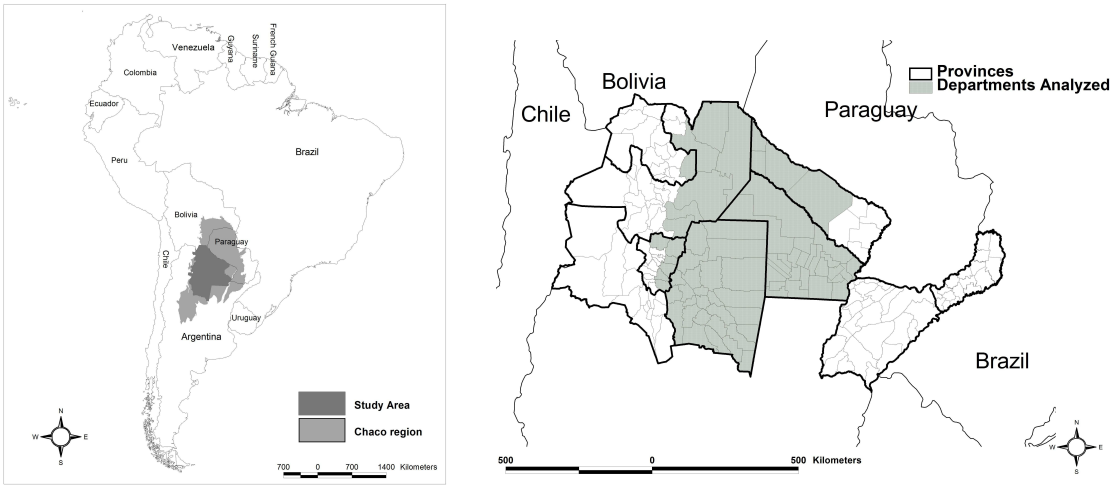

Fig. 2: Location of the study area

Deforestation Rate: The deforestation rate was obtained by using Landsat TM images with a spatial resolution of 30 m. The identification of the forest was performed by visual interpretation and on-screen digitizing. To cover the entire study area were processed a total of 19 images corresponding to two time periods: one set of images corresponds to the late 1980s and early 1990s, and the other set of images corresponds to the years 2001 / 2002.

We assumed that deforestation detected between these two sets of images corresponded to changes during the 90s. The rate of deforestation, then, was calculated as the percentage increase in area deforested in the 1990s. The data were grouped by department to be related with population statistics and agriculture.

Table 1. Description of the variables measured and used in the model (path analysis).

Name	*Description*	*Units*	*Year*
Deforestation *	Percentage increase of deforested area	ln	1985-2001
Rural_Pop *	Percentage increase of rural population	%	1991-2001
Urban_Pop	Percentage increase of urban population	%	1991-2001
Densidad_city	Percentage increase cities density	%	1991-2001
Pop.Rural.Disp	Percentage increase disperse rural population	%	1991-2001
Pop.Rural.Con	Percentage increase concentrated rural population	%	1991-2001
Priv_Employ *	Percentage increase of population with private jobs	%	1991-2001
Pub_Employ *	Percentage increase of population with public jobs	ln	1991-2001
Migration *	Average annual growth rate of migration	hab ‰	1991-2001
Poverty *	Percentage increase of population with NBI (poverty)	%	1991-2001
NBI_Households	Percentage increase of households with NBI	%	1991-2001
Soybean*	Percentage increase of soy planted area	ln	1988-2002
No_Soybean*	Percentage increase another agricultural / livestock uses	ln	1988-2002
Farms	Percentage increase of farms number	ln	1988-2002
Farms_Average.size	Percentage increase of average size of farms	ln	1988-2002
Farms_25	percentage increase of smallholdings	Ln	1988-2002
Farms_2500	percentage increase of large scale farms	Ln	1988-2002
Farms_Lim.def	Percentage increase farms with boundaries defined	ln	1988-2002
Farms-No.Lim.def	Percentage increase farms without boundaries defined	ln	1988-2002

Reference: * Variable used in path analysis, after exploration and elimination variables with high correlations.

Socio-demographic variables: The sources used for the calculation of demographic and socio-economic variables were the *Censo Nacional de Hogares, Población y Vivienda* for 1991 and 2001 (INDEC, 1991, 2001), and *Estadísticas Vitales* relating to births and deaths, according to department of residence, since 1991 to 2001 (DEIS, 1991 to 2001). From these data we calculated the following variables:_average annual rates of total population growth, average annual rates of natural growth and, indirectly, average annual growth rates of migration. In all variables we used the method of vital statistics (Ortiz y Paolasso, 2004; Reginni de Lattes and Lattes, 1969).

To evaluate the poverty levels we used the index of *Necesidades Básicas Insatisfechas* (NBI). Specifically, the indicator captures some critical needs of the population, such as overcrowding, inadequate housing, inadequate water closet, lack of school attendance by school-age children and household economic capacity. That is, the NBI measurements do not reflect household money income, but accumulated wealth or household wealth achieved in the past (INDEC, 1994).

Other variables drawn from national censuses were: increased rural and urban populations, changes in the density of cities and professional groups (public and private employees)[5].

[5] We evaluated the role of public employment (administration) as we believe that it would be linked to action by the State and act by counteracting the negative effects of agricultural

Agricultural landscape variables: We used data from *Censos Nacionales Agropecuarios* 1988 and 2002. First, we calculated, the increase in area planted with soybeans, considering its percentage increase. We also calculated changes in the average size of farms, and the proportion and area of large scale farms (greater than 2500 hectares), and smallholdings (farms under 25 hectares).

The variation between dates in the proportion of farms with and without defined limits was calculated too. The variable "No_soybean" (another agricultural and livestock uses) was calculated by subtracting from the value of total agricultural and farming area of the department, the area sown to soybeans.

Prior to the completion of statistical analysis we carried out exploratory techniques of the data and we tested the normality of the variables under study. In order to do that, we used the Shapiro-Wilk test. The results indicated that certain variables did not conform to a normal distribution, which were transformed to its natural logarithm according to the equation: ln (x - (min x) +1. The results of the Shapiro-Wilk test for the transformed variables indicated that data were normally distributed, thus parametric tests could be used to evaluate the relationships between different variables (Osborne, 2002).

The next step in the selection of variables was to explore the relationships between them, through a matrix of Pearson correlation. The matrix allowed us to select those variables that presented significant relationships and discard redundant variables.

3.3. Path analysis

The examination of the joint relationship between the social, demographic and environmental changes, and soybean expansion was carried through Structural Equation Modelling (SEM), specifically path analysis.

The path analysis is a type of multiple regression analysis which allows estimating empirically theoretically constructed models. Like any multiple regression, quantifies the correlations (partial) between independent variables and gives the percentage of variance explained of dependent variable by the independents. But what differentiates the two techniques is that a path analysis is a tool designed to examine causal models of relationships between variables (Mitchell, 1992). The technique allows test the model and sees whether it is consistent with the data. Operates with the variance and covariance to examine how well they conform to the specified structure of the model (Arbuckle, 2007). Thus, this technique appears as the most suitable for the empirical test of our theoretical foundations.

The results of the analysis are effect coefficients, which are equivalent to standardized partial regression coefficients obtained from a multiple regression

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expansion. The public employment would have important effects on social variables (poverty) and demographic (migration) and could blur the detrimental effect of increasing soy in the Chaco.

(Román Cuesta *et al.*, 2003). Thus, the model results provide an idea of the relative weight of each independent variable on the dependent. The coefficients of determination (R^2) for the dependent variables and the level of significance of the variances and covariances represented in the model also were obtained. These path analysis was carried out through the program AMOS (SPSS) version 16.

The hypothetical model is judged by a set of indexes that measure the degree to which fits the data (Jöreskog and Sörbom, 1984). In this case the agreement between the model and the original data was evaluated by chi-square (χ^2) and we also assessed the standardized residuals of the model, level of discrepancies and other indicators of goodness of fit, such as: Comparative Fit Index (CFI), Goodness Fit Index (GFI) and Adjusted Goodness Fit Index (AGFI).

Specifically, this test measures the degree to which the data are inconsistent with the hypothesis, which indicates the lack of goodness in the setting. Thus, in this case is expected that the probability of the χ^2 is not significant. A χ^2 equal to 0 represents a perfect fit to the data. However, the correlations represented in the model, and observed in the data are only estimates, which can not be expected to be identical. In fact, it is expected that differ enough to produce a χ^2 in the level degrees of freedom. Thus, a χ^2 with values close to the degrees of freedom, it is considered correct (Arbuckle, 2007).

We considered as significant variances and covariances in the path analysis those with a P of 0.15. Other works which employ these analytical techniques have also used this level of significance (Román Cuesta *et al.*, 2003).

4. RESULTS

A robust model of eight variables was achieved. Figure 3 shows the effect standardized coefficients (or estimates) obtained by estimating the theoretical model.

The path analysis was composed by eight variables, five of which are independent and three dependent.This can explain 62% of the variance in the migration rate, 39% of the variance in the rural population increase, and 13% of the variance in the increment of poverty in the Chaco. Because the model cannot explain 100% of the variance of the variables described, residual variables (U) have been included in the model, considering all the effects related to unknown causes.

The results of the χ^2 test for our model are satisfactory. The probability (0.816) shows that the evidence against the model is not significant at the 0.05 level.

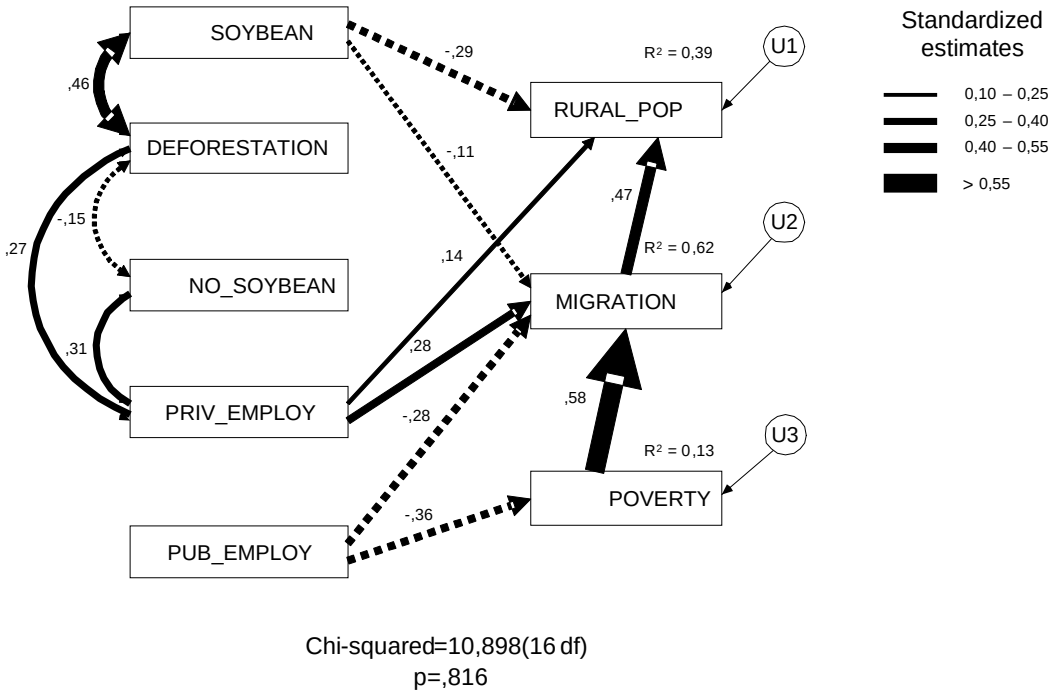

Fig 3 Model developed through path analysis. In dotted lines are shown the negative effects among variables.

The indicators of goodness of fit (CFI, GFI, AGFI) range from 0 (no adjustment) and 1 (perfect fit). The results of these also were in conformity. As shown in Table 2, all indices were excellent. The CMIN index measures the degree of discrepancy. The lower the value, the more agreement between the model and data. To get a better idea of the discrepancy to the data it has to be divided by the degrees of freedom. A CMIN / DF equal or close to 1 is optimal. In our case, the index CMIN / DF (0.681) was satisfactory. The RMSEA index summarize the standardized residuals, and is considered one of the best ways to communicate results. It is considered that the value should not exceed 0.08 (Arbuckle, 2007).

Table 2. Indicators of the causal hypothetical model: Degree of Discrepancy (CMIN), Degrees of Freedom (DF), Probability (P), Degree of discrepancy about Degrees of Freedom (CMIN / DF), Standardized Residuals (RMSEA), Comparative Fit Index (CFI), Goodness Fit Index (GFI), Adjusted Goodness Fit Index (AGFI).

Index	CMIN	DF	P	CMIN/DF	RMSEA	CFI	GFI	AGFI
Value	10,898	16	0,816	0,681	0,000	1	0,963	0,917

4.1. The effects which are explained by the model

Table 3 summarises the effects of the studied variables and their significance.

Migration, the effect best explained by the model, is caused by the increase of four variables: poverty (NBI) first, according to the standardized estimates (b = 0.58), public and private employment in the same order of importance but with opposite signs (b = 0.28 b = - 0.28), and soybeans, fourth (b = - 0.11). That is, higher rates of increase of poverty, the greater increase in immigration and higher rates of increase in private employment, the greater increase in immigration. Causes of emigration are the increase in public employment and the increase of soybean.

The variation of the rural population is explained by the migratory rate (b = 0.47), the increase in soybean (b = - 0.29) and increase in private employment (b = 0.28). The only cause with a negative effect, in this case, is soybean, indicating that a higher rate of increase of soybean, a higher rural population decline. Poverty, meanwhile, appear in the model explained only by the negative growth of public employment (b = - 0.36).

Also in the model are observed relations between the independents variables. It concludes that: a) The increase in soybean is positively related to the rate of deforestation (b = 0.46), b) other agricultural and livestock uses (NO_SOYBEAN) are related in a negative way with deforestation (b = - 0.15) and positively with increases in private employment (b = 0.31); c) deforestation is linked to increases in private employment (b = 0.27).

Table 3. Significance and effect of relationships represented in the path analysis.

Unidirectional relationships			***Effect***	***P***
Private employment	--->	Migration Rate	+	<0.001
Public employment	--->	Migration Rate	-	<0.001
Poverty	--->	Migration Rate	+	<0.001
Migration Rate	--->	Rural Population	+	<0.001
Public employment	--->	Poverty	-	0.002
Soybean	--->	Rural Population	-	0.003
Soybean	--->	Migration Rate	-	0.133
Public employment	--->	Rural Population	+	0.159
Bidirectional relationships				
Soybean	<-->	Deforestation	+	<0.001
No Soybean	<-->	Private employment	+	0.016
Deforestation	<-->	Private employment	+	0.019
Deforestation	<-->	No Soybean	-	0.169

5. DISCUSSION

The environmental and demographic change subsequent to the increase in soybean in the Chaco has been explained robustly. The path analysis performed explains a high percentage of the variance of migration (62%) and to a lesser extent, the rural population (39%) and poverty (13%), and associated soybeans extent with the increase in the deforestation rate (effect coefficient of 0.46).

This approach, in this scale of work, proved that not all hypotheses are true. Soybean appears as a powerful engine of change in the Argentine Chaco in the 1990s, with direct and indirect effects, mainly on deforestation and socio-demographic variables. On the other hand, the path analysis conducted has also highlighted the complex interactions between poverty and migration and between employment and socio-demographic variables in the Chaco.

5.1 The soybean as a cause of deforestation

The path analysis showed that the increase in soybean is strongly associated with high rates of deforestation in the departments of Argentine Chaco. The correlation between both variables, highly significant and with a high effect coefficient, shows that in those departments where the rate of increase in area planted to soybeans was high, the deforestation rates were also important. This relationship confirms the hypothesis of soybeans as the first factor of Chaco land cover change through deforestation (Adamoli *et al.*, 2004, Grau and Aide, 2008, Grau *et al.*, 2005, 2008; Gasparri et al ., 2008; Gasparri and Grau, 2009, Paruelo and Oesterheld, 2004, Morello *et al.*, 2008; Torella and Adamoli, 2005; Bolette *et al.*, 2006, Morello and Matteucci, 1999, Zak *et al.*, 2004; Fearnside , 2001).

Other agricultural and livestock uses are correlated with deforestation, but negatively. That is, in those departments with high rates of increase of other activities (no soybean), the deforestation rate was lower. However, this relationship is rather weak, not only as regards as the value of the coefficient of effect, but also as to the significance of the correlation. The latter is only in the threshold of significance that was chosen for this analysis, which was already very little conservative.

5.2. Socio-demographic effects of increased soybean

The increase of soybean in the Argentine Chaco, shows direct negative effects on demographic variables. It is a cause of emigration and is related to rural population decline, as commented in some studies (Torrella and Adamoli, 2005; Soto, 2006, Van Dam, 2002, Grau *et al.*, 2005). However, the relationship between increased soybean and emigration represents the weakest effect expressed in the path analysis, with the lowest standardized estimated and significance rather weak (0,133).

The relationship between soybean and rural population, however, is stronger, both in the effect coefficient and in the significance. Thus, the increase in soybean is strongly linked to a depletion of rural population in the departments, although its expression through the migration rate is not too strong. Thus, our results are consistent with previous studies (Bolsi and Meichtry, 2006; Lattuada and Neiman, 2005; Madariaga, 1998).

As shown in the path diagram, the soybean may have another indirect effect on the same variables, producing an increase in the rural population and generating immigration dynamics in the departments. This is because the soybean is correlated with deforestation, which, in turn, is positively correlated with the increase in private employment. Finally, private employment is linked to immigration and to a lesser extent, to increasing of rural population. The private employment, on the other hand, also correlates with other agricultural activities (coefficient effect that is stronger than the effect of soybean). That is, the rest of the agricultural activities have a higher weight, and direct, on employment generation. Instead, soybean is only linked to the employ through deforestation.

Thus, in the path diagram, we see that the increase in soybean may have a positive effect on the demographic variables, by an indirect route,. This some what represents a contradiction in the analysis. However, when interpreting the results on the light of the territory and the history of the territory in question, we approach an explanation of those relationships initially contradictory and little or no intuitive. In this case, to interpret these results we must consider the maturity of the agricultural border. Thereby, when the surface of soybean increases by land clearing (and not as a replacement of other crops), i.e., when the agricultural frontier is young, there is a large demand for labor, which leads to migration to these departments. But, when the agricultural frontier is mature, and soybeans replace to other crops (without deforestation), the demographic effects are opposite.

In this way, it is understood the dual effect of increased soybean on the population dynamics. Attract labor in the expansion phase of the agricultural frontier, when it requires large amount of manpower to land clearing and road construction (Leon *et al.*, 1985). Nevertheless, when soybeans increases replacing other crops, these tasks are no longer necessary and rural workers are not required to perform them. And indeed, planting and harvesting of soybeans, is less labor-intensive than other activities such as forestry, livestock or industrial crops (sugar cane, citrus, cotton) (Van Dam, 2002).

Furthermore, it should be noted that no direct relationship has been demonstrated in the path analysis between soybean and deforestation with the increase in poverty. However, in an indirect way, effects of increased in soybean on poverty have been observed. First, it can be interpreted as follows: if the soybean reduces the rural population and generates emigration, and that people are migrating to other rural sectors, there is a transfer of poverty. That is, on the one hand, soybean would not generate higher or lower poverty rate, but redistribution of an impoverished population. It would not be an effect on the increase in poverty, but a redistribution effect by generating migratory

movements. And that is why in path analysis we see the poverty associated with migratory movements.

There also are other possible readings. For example, one might think that soybean generates a certain dynamics that results in a mitigation of poverty, through the intervention of the State as creator of employment. Following the scheme shown in the path analysis, we see that the increased soybean and public employment, generates emigration. Public employment, meanwhile, might decrease poverty. However, we think that the growth in public employment is a response of the State to the soybean negative effects. It can even be interpreted that the State would fulfill the role of healing the inequitable conditions that the unbridled agriculture expansion produces. In any case, according to our results, we reject the hypothesis that the expansion of soybean increases poverty in the Chaco (Rulli, 2007).

5.3. The poverty-migration dynamics

Certain relationships expressed in the model appear contradictory, and the path analysis performed cannot be interpreted without knowing the complex history and the particular configuration of the study area.

Thus, certain relationships, that draw attention at first sight, must be carefully analyzed, like the cause-effect relationship between increased poverty and immigration. The strong association between increased poverty and immigration rates would indicate that the population migrated in the 1990s to the departments where poverty increased most. The sense of the relationship in the path analysis reveals that poverty determines or explains the migration.

The explanation for this association could be in the return migration to rural and poor areas, given the lack of alternatives in regional urban centers, as noted by Bolsi (2004). In his work, Bolsi notes a change in emigration trends during the 1990s in the departments of Northwest Argentina, where he observed a greater persistence of the population in the region, in parallel to a progressive deterioration of their living conditions. In the 90s, there was a high population growth throughout the North of Argentina and it is attributed to significant natural population growth and the reduction of extra-regional alternatives to emigrate (see annex map 2, 3 and 4).

The dynamics of migration undoubtedly reflected the crisis that brought about the process of economic structural adjustment, income of flexible capitalism and privatization that took place since the late '80s. Similarly, the increase in poverty in the Chaco in the nineties has to do with the same processes mentioned. Changes in employment ties and growing insecurity of workers dependent on agriculture were some of the effects that increased exclusion (Giarraca and Teubal, 2006).

On the other hand, it has to be considered the shortcomings of NBI indicator to measure poverty in rural areas. It must be kept in mind that poverty measured by the indicator, is not perfectly applicable to rural areas, because some of the

hardships in rural households are only ways of traditional habitat of the population in those areas (e.g. not having toilet inside the house, just the way is used to in the area, is a poverty indicator for the NBI). So, just because they are rural, many households are classified as poor[6].

Thus, what the path analysis shows could be simply that immigration processes occurred in departments where there was a large amount of rural population (in some cases the rural population represent 100%, see appendix, map 5).

5.4. Employment and its socio-demographic effects

Another unexpected relationship in the model developed, is that the increase in public employment is a cause of emigration in the departments of Argentine Chaco. The relationship between public employment and emigration which shows the path analysis, indicate that the increase in public employment in the decade leads to an increase in emigration. Here again the relationship can not be understood as cause and effect, but spurious. The interpretation could be found in the following presumption: in those departments where there was already heavy emigration, the State acted generating more public employment, as a way to prevent the exodus of population. However, employment generation alone could not stop the migration flow (probably because the natural growth rates remained too high and emigration continued to function as an outlet to the high total population growth), thus the effect observed is, the more public employment, the higher emigration. That is, the strategy did not work and people did not feel drawn to public service jobs as in the case of private employment -probably it pay better. However, the increase in public employment did manage to alleviate the poverty of the population, since, as shown in the path analysis, the greater increasing in public employment, the lesser increase in NBI.

[6] Forni and Neiman (1994) argue that the implementation of the NBI approach to rural areas has limitations from a conceptual and operational, partly attributed to "an urban bias that is present in most of the exercises in measurement poverty undertaken from this perspective". The authors note that the minimum needs standard used for rural and urban areas alike would not be appropriate both from an objective analysis and from the perception or evaluation of the conditions of deprivation made by the individuals themselves. It is also noted that the construction of some indicators of housing and services do not notice the ease of certain natural resources access in rural areas. Thus, most of the times are not considered the access to certain environmental goods and services free to use, such as water, building materials, housing, foods, among others. The application of the NBI may lead to an overestimation of poverty in rural areas especially the incidence of indicators of housing and sanitary conditions (Murmis, 2001). It is noted that in certain situations, lack of sanitation, presence of naked soil floors and certain types of housing are more related to cultural aspects than deprivation conditions.

6. CONCLUSIONS

The interest in the dynamics and socio-environmental effects of the agricultural border with soybeans in the Argentine Chaco is revealed through numerous studies and open discussions both in the academy, as in the media and the public. In many of those analyses, it has tended to demonize soybean production, blaming it for causing all the ills of the Chaco, such as migration, poverty and unemployment. This paper has sought to prove through empirical evidence, the veracity of such claims and yet find a general pattern explaining the border dynamics for the Argentine Chaco in the 1990s.

From the results, we can confirm and also challenge some of the assumptions often repeated, emphasizing that soybean has had different socio-environmental effects depending on the maturity of the agricultural border.

The study does highlight the main patterns of social and environmental change. Through path analysis it was obtained a map of the interactions and cause-effect relationships between variables associated with productive and environmental change and socio-demographic variables. The consistency of analysis allows us to say that the effects of increased soybean on the environment are sufficiently clear and unilateral. The increase in soybean is associated with high deforestation rates, while other agricultural activities are not so important, at least from the 1990s. At the same time, we note that deforestation is not related to demographic or social variables.

Regarding socio-demographic effects of increased soybean surface, the analysis showed a dual effect. On the one hand, directly, increased soybeans in consolidated agricultural frontiers, involves migration and rural population decline. Nevertheless, indirectly, increased soy in new agricultural borders is linked to an increased demand for labor and, therefore, immigration movements and population growth in those areas. Hence one can expect that, to the extent that current young agricultural boundaries becomes mature, migration dynamics will vary its direction, generating empty demographic in territories that now have a growing population.

The work must now be tested and compared for other different approximation scales, through case studies and qualitative methods that allow to highlighting the different realities of an environment as diverse as the Chaco.

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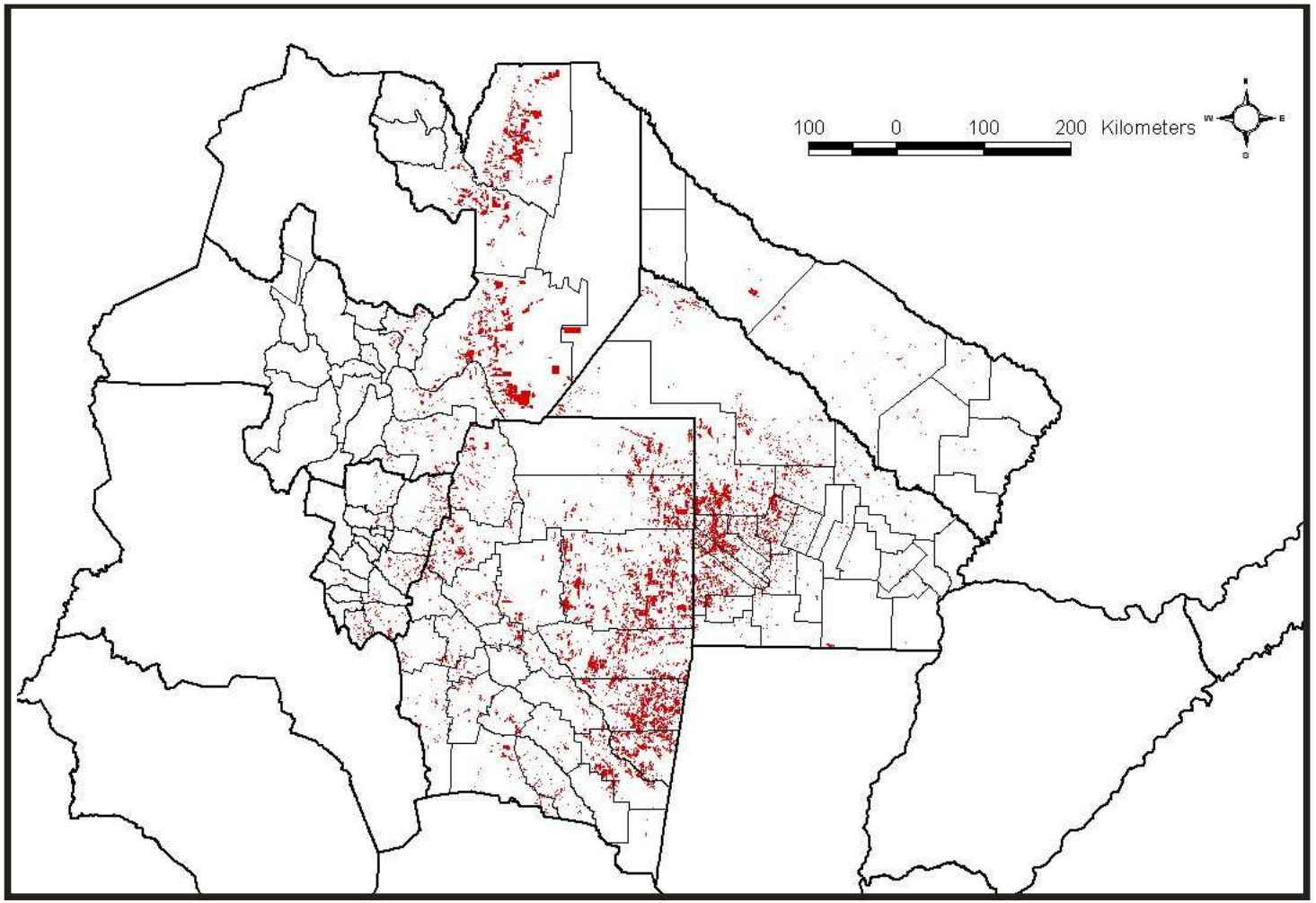
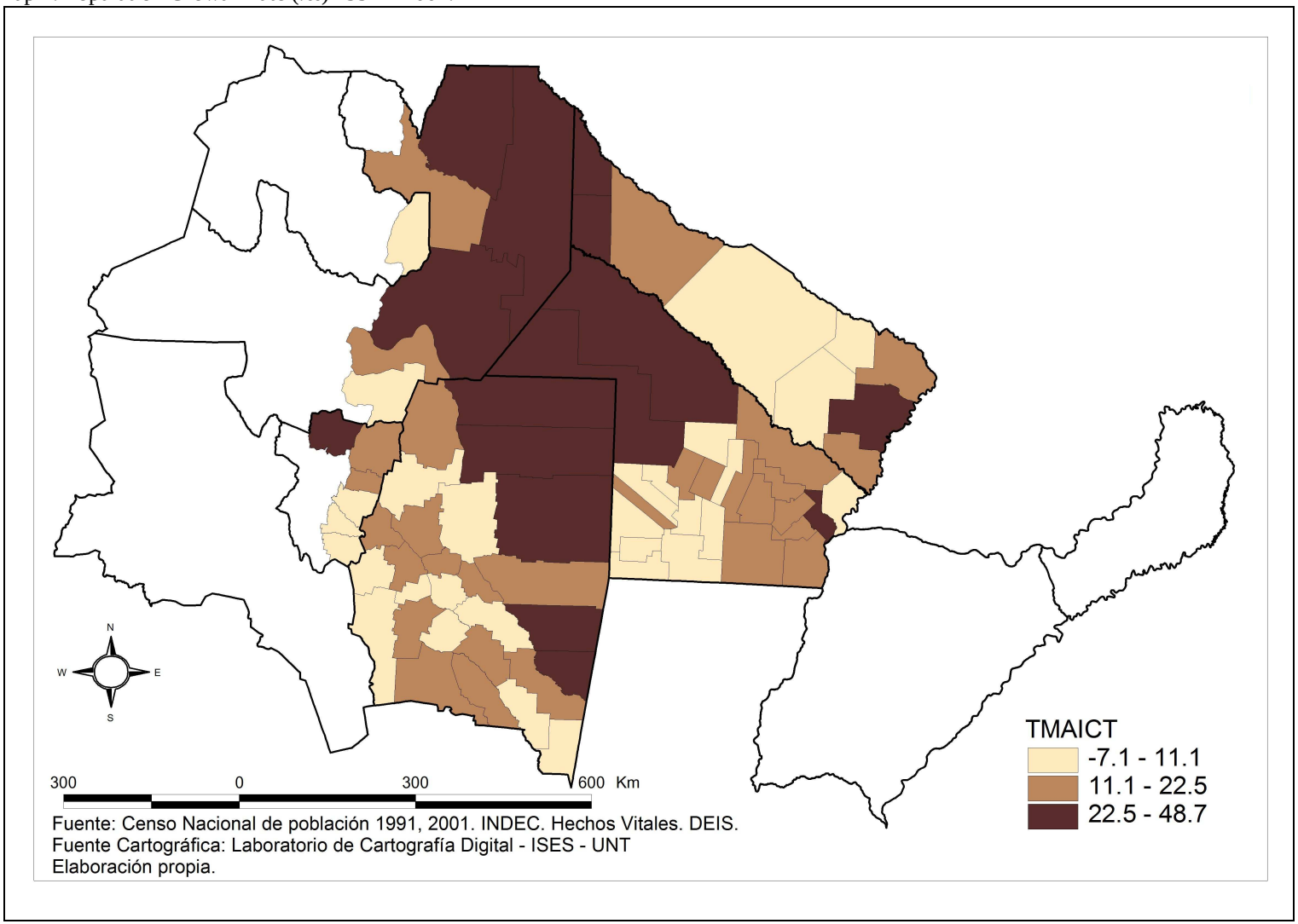
ANNEX

Map 1: Deforested area in Chaco, during 1990 decade.
Source: Gasparri, I. (2010)



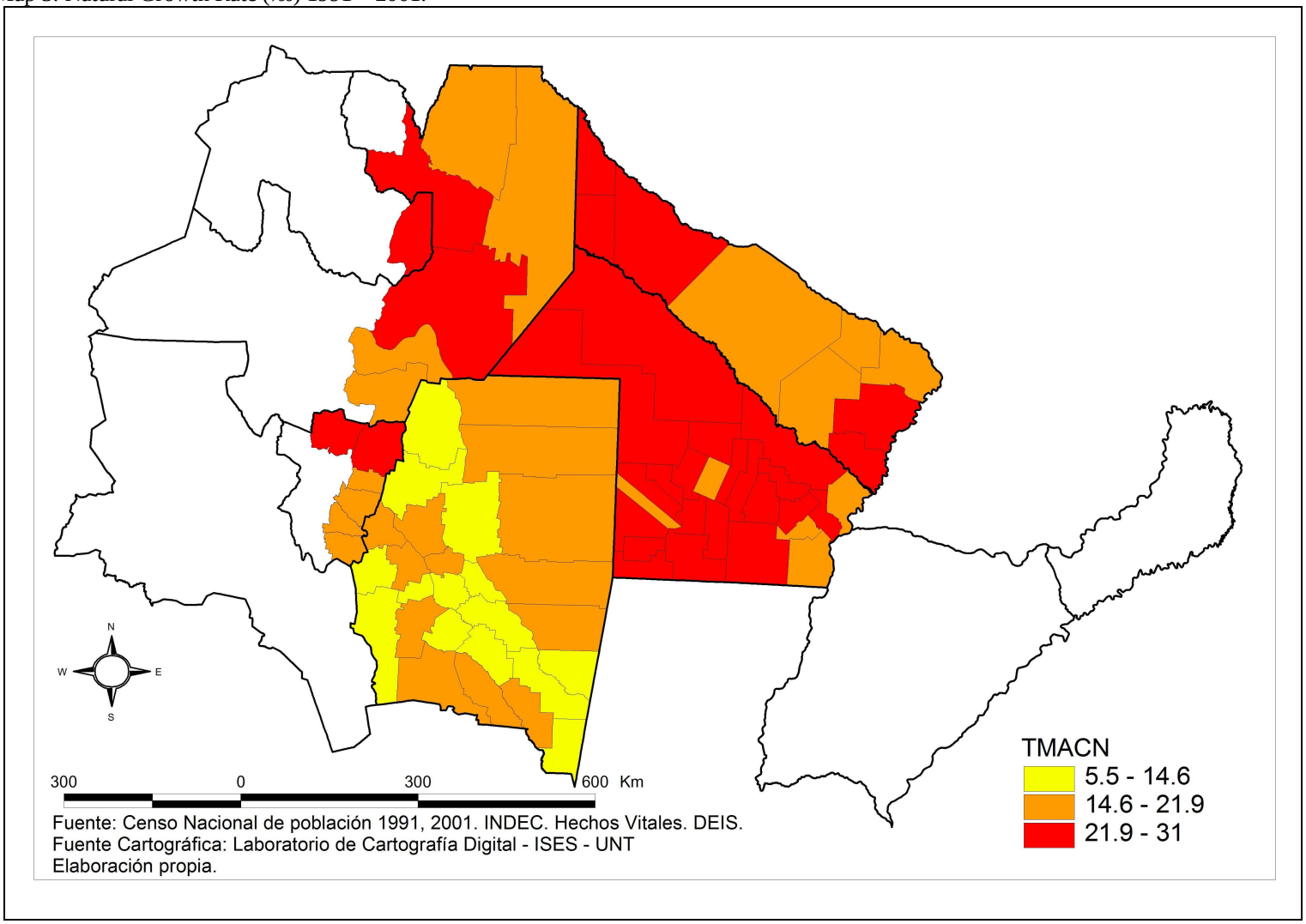
ANNEX

Map 2: Population Growth Rate (‰) 1991 – 2001.



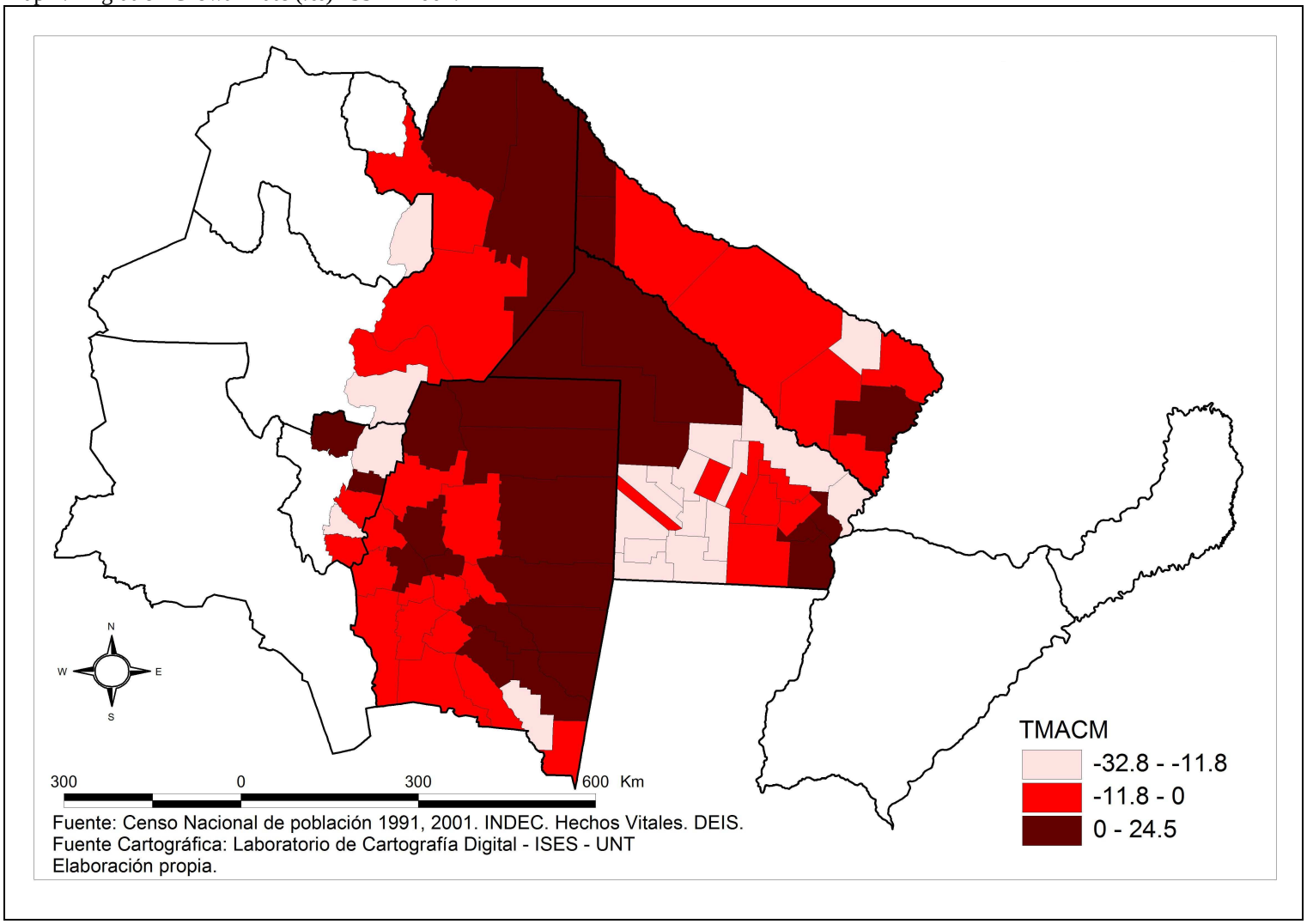
ANNEX

Map 3: Natural Growth Rate (‰) 1991 – 2001.



ANNEX

Map 4: Migration Growth Rate (‰) 1991 – 2001.



Map 5. Population distribution in Northern Argentina, 2001.