Determinants of the restriction of pastoral areas in Senegal

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Abstract

In this article, we identify and analyse the determinants of the restriction of pastoral areas in Senegal. The analysis is based on an econometric approach with the Vector Autoregressive (VAR) model as the estimation technique. The estimation period is from 1990 to 2015. It is estimated that population growth, expansion of cultivation areas and temperature increases are leading to a decrease in pastoral areas, while increases in forest areas and rainfall can contribute to the expansion of pastoral areas in Senegal.

Keywords: determinants; restriction of pastoral areas; VAR, Senegal.

Introduction

Senegal has long been a country where the majority of the population lived from agriculture. This agriculture is the main activity of the primary sector. It employs nearly 60% of the country's working population and contributes between 10% and 11% to the formation of GDP (ANSD, 2016). The importance of the agricultural sector in the development of poor countries has been recognized for years. According to the 2008 World Bank report, the poor are mainly found in rural areas and are mostly dependent on agriculture. Livestock provides more than half of the value of global agricultural production and one-third of that of developing countries. Livestock is the second primary sub-sector after agriculture with 25% of the wealth of the primary sector and 4% of GDP (ANSD, 2017). This important place of livestock in the national economy and family economies contrasts with the low level of support allocated to it in terms of public investment, which ranges from 0.7% to 1.1% of the budget, for an average contribution of 30% to the constitution of primary sector GDP according to the National Livestock Development Plan (2011).

Yet the sector is undergoing profound changes and transformations that have emerged from decentralization and regionalization. These, combined with the policy of disengagement of the State, productive and market activities and the increasing involvement of producer organizations in the development of the sector, have profoundly changed the nature and quality of interventions in favour of the economic and social development of livestock.

Population growth and the phenomenon of climate change have also put increasing pressure on increasingly scarce pastoral resources. The strong competition and tensions that are developing between the various

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users of the rural space are evolving, often in conflict and eventually, and may call into question the peaceful coexistence that has always characterized social relations in rural areas.

Pastoral livestock is threatened in Senegal because ecological dynamics, land clearing, and public policies compromise access to resources, on which its essential mobility is based Magrin et al. (2011). However, pastoralists in Senegal constitute a relatively large group (nearly 13% of the country's population), whose activities and way of life are severely affected by the degradation of natural resources (Touré, 1997). The current biodiversity in pastoral areas leads to a shortage of resources that makes competition for space between agriculture and livestock increasingly acute. As a result, there is an increase in antagonisms and conflicts between groups that claim the same rights to resources on which they depend for their survival (Touré, 1997). In the field of land, some measures have been taken to narrow the pastoral area in favour of agriculture. This development of infrastructure control to the detriment of rangelands has all the more detrimental consequences as pastoral systems are mainly extensive and currently face the need for larger areas to maintain livestock. Indeed, according to DIOP et al. (2009), among the factors causing herd movements, it has been reported that grazing areas are insufficient because the confinement of space and uncontrolled land management increasingly reduce grazing areas; there has been a tendency to reduce grazing areas and access roads (not renewed since 1988) and to encircle villages. Pastoral activities are thus gradually marginalized in several areas in Senegal, sometimes even excluding pastoralists from the territories they have traditionally exploited. Institutional and agro-ecological changes such as population growth, climate change, market globalization, changing demand for animal products, decentralization and state disengagement, as well as security issues, are changing the contexts in which pastoral societies have traditionally operated. All these factors combined have led to profound changes in the management of livestock farming. This situation, which has characterized the country for decades, deserves particular attention from all actors, but above all a synergy in the search for solutions and action.

The objective of this work is to identify the key determinants of this reduction in livestock areas in Senegal.

1. Factors leading to the restriction of pastoral areas

1.1 Demographic pressure

Population issues are crucial to a country's development and future. Increasingly, the demographic variable occupies a prominent place in the development policies of all countries, especially those of the Third World. There are interrelationships between population dynamics, economic development and the environment. To assess the effects and impacts of population dynamics on natural resources and economic growth, it is necessary to know the state and structure of the population.

In Africa and particularly in Senegal, population issues, the capitalisation of the demographic dividend, are a major challenge for achieving development objectives. Despite the significant progress made towards achieving the MDG[4], Senegal's population dynamics are characterized by relatively high fertility, declining mortality, especially among children, and an age structure characterized by a young population.

[4] The MDG aim to improve human well-being by reducing poverty, world hunger, child and maternal mortality, ensuring access to education for all (education for all), controlling and managing epidemics and diseases, abolishing gender discrimination, ensuring sustainable development and building global partnerships

We also know that livestock farming has a very close relationship with agriculture. The performance of livestock farming is closely linked to that of agriculture. In view of all these facts, there can be no doubt at all that demographic pressure can have an impact on livestock farming, at least through its influence on agriculture.

In general, population growth in pastoral areas is estimated at 2.5 to 3.5% per year, equivalent to a doubling of the population every 25 to 35 years.

According to Diop et al. (2012), over the past fifty years, occupation in the Sahel area has intensified. From 1960 to 2010, the human population increased by a factor of 3.6, leading to the creation of urban centres that promoted the marketing of meat, milk, hides and skins... but limited livestock access to rangelands, water points... According to Touré et al.(2017), not only has the population of West Africa grown rapidly, with an average annual rate of 2.75 per cent, but it has also urbanized a few major cities with an average annual growth rate of almost 9 per cent. The majority of West Africans still live in rural areas, but the urban population has increased from 8.3 per cent in 1950 to nearly 44 per cent in 2015. Rindfuss et al. (2004) argue that the changes in lifestyles and consumption associated with this increasing urbanization have changed land use and occupation, well beyond the direct and obvious increase in inhabited areas

In the agro-sylvo-pastoralzone, the population is estimated at 657,768 inhabitants in 1988, 1,000,224 inhabitants in 2002 and 1,235,872 inhabitants in 2013. In terms of population density, the density of the agro-sylvo-pastoral area was 12 inhabitants per km² in 1988, 17 inhabitants per km² in 2002 and 27 inhabitants per km² in 2013 according to CSE (2016).

The food demands of the urban population are reflected in land demands on the outskirts of cities, particularly for the cultivation of perishable foodstuffs, such as fruits and vegetables. A portion of the wages earned in the city by new urban dwellers is transferred to rural areas in their home villages and stimulates economic investment in activities that have the potential to change land use, such as abandoning or intensifying agriculture. These are just a few examples of the possible interactions between population and land use (Lambin et al., 2001).

1.2 Extension of agricultural areas

The extension of cultivated areas, to the detriment of rangelands, is a key parameter in the interactions between livestock and the environment in arid zones according to Carriere (1996). The cultivated areas are expanding in line with population growth. The quality of the grazing lands decreases, because it is the best land that is cultivated and, as a result, livestock farming loses its mobility. This is more confirmed by Diop et al. (2012) who argue that in ISPS's countries (Information System on Pastoralism in the Sahel): Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and Senegal, the needs of a growing population and the development of export crops have increased the area under cultivation by a factor of 2.5, to the detriment of protected areas, whose area has declined by 13%. In addition to these dynamics, livestock activities have been strengthened with an increase of 2.5 in livestock numbers (expressed in UBT) between 1961 and 2009. In Senegal, according to CSE (2015), the expansion of cultivated land in Senegal is relatively modest, increasing from 32,600 km2 in 1975 to 32,900 km2 in 2000 and 41,000 km2 in 2013, an increase of only 26 per cent between 1975 and 2013. However, the distribution and expansion of agricultural land within the territory have significantly altered the landscape. The development of agriculture has led to the fragmentation of savannahs and open forests, resulting in the loss of natural habitats and a decline in the quality of remaining natural ecosystems. In addition, agricultural expansion accelerated between 2000 and 2013 compared to the previous 25 years. While the average annual increase in cultivated areas was rather small between 1975 and 2000 (about 10 km2 per year), it increased dramatically between 2000 and 2013, reaching an average of 630 km2 per year (CSE, 2015). However, this trend masks disparities within the Senegalese territory. According to a study carried out by the CSE in 2015, land use statistics for 1975 and 2010 provided information on the agricultural domain for these two years. According to CSE (2015), to better analyse the evolution of the agricultural domain, an indicator based on the ratio of the areas of agricultural zones and the areas of municipalities has been developed to judge the intensity of activity for the two years and make the comparison. The comparison of the two maps shows a decline in agricultural activity in the northern part of the groundnut basin and its extension to the communes located to the south of the groundnut basin. This increase also extends to the contiguous areas of the southern forest zone of Casamance and the agro-sylvo-pastoral zone.

Land use statistics revealed a larger increase in cropping areas in the southern forest area of Casamance (2480 km2) followed by the agro-sylvo-pastoral area (1576 km2), the groundnut basin (1056 km2), the Ferlo sylvo-pastoral area (816 km2) and the Senegal River valley area (616 km2). In the Niayes area, cultivated areas have decreased by 132 km2 (CSE, 2015).

According to Touré et al. (2017), changes in land tenure in West Africa reveal similar trends. With so many new inhabitants to feed, the area under cultivation doubled between 1975 and 2013. Large expanses of savannah, open forests and forests have been replaced or fragmented by crops. At the same time, villages, towns and cities expanded over an area 140 per cent larger than in 1975. In Senegal, the pastoral and agro-pastoral systems occupy more than 90 per cent of the land. They have vast territories that make up the cattle's grazing areas. In the agro-pastoral system, the coexistence of agriculture means that they occupy the same land, which sometimes leads to conflicts. Semi-intensive and intensive systems, located around major cities, occupy about ten per cent of the land (FAO, 2017).

1.3 Evolution of forest areas

Land use statistics make it possible to assess the evolution of the landscape between 1975 and 2010 according to the CSE report (2015). While cultivation areas increased by 6412 km2, savannah areas decreased by 8708 km2. A large part of the clearing for agriculture has gone to areas where rainfed agriculture is more prevalent.

To make way for crops and houses, more than a third of the forest cover in 1975 has disappeared. Within savannah and steppe landscapes, droughts, compounded in some cases by unsustainable land-use practices, have degraded vegetation cover, resulting in a 47 percent increase in sandy surfaces. According to CSE (2015), the reduction of savannah areas in favor of steppes and cultivation areas of the threat to forest formations.

Between 2005 and 2013, 2655 ha of forests were downgraded from the forests of Pout, Diass, Mbao, Malika and Ndiael. However, the classified estate of Senegal amounts to 7135,618 ha or 36% of the national territory.
The boundaries of the country are most often closed, and sometimes they are illegally occupied, due to insufficient monitoring, fraudulent exploitation and land clearing. These factors, combined with climatic factors, have led to severe degradation of some forests.

1.4 Climate change: temperature variations and rainfall

The impact of extreme weather events to $ 520 billion in lost consumption per year, according to the World Bank (2018), puts 26 million people into poverty each year.
A study by the World Bank shows that these changes are already having measurable effects on human health, and these effects are expected to increase. Each year, carbon emissions cause more than 7 million premature deaths, and it is estimated that it will be between $ 2 billion and $ 4 billion per year by 2030 according to the World Bank (2018). Undernourishment will be one of the most serious health effects of climate change. In Senegal, the temperature trend is marked by an average warming of 1.6 ° C, which also varies from one region to another. The highest increase is observed in Senegal with 3.0 ° C in Linguère and the lowest in the south with 0.7 ° C in Kédougou (CSE, 2010). It is now widely accepted that climate change, through its various manifestations, has consequences for human societies and the natural ecosystems on which they depend for their survival. In addition, the emission of greenhouse gases such as methane and carbon dioxide by global warming (Veillard, 2010, Sommerhalter, 2008, FAO, 2006, Scoones, 1999, Carrière, 1996).
In addition to these determinants, other factors may influence the restriction of pastoral areas, such as insecurity in rural areas, animal health, and the disengagement of the State.

2. Literature review

2.1 Population growth and production: the theories of Malthus and Boserup

The existence of relationships between the economy in general and the human population is no longer to be demonstrated. Indeed, according to Hakizamungu (1986), the demographic variable increasingly occupies a prominent place in the development policies of all countries, mainly those of the Third World. The central problem posed by these relationships is a problem of balance Population/ Resources in general, a problem of balance Population/ Food resources in particular according to Boserup[5]. The latter author argues that it is not the population that adjusts to the agricultural production process but that it is the production process that is determined by demographic pressure. This explains the role that demographic pressure plays in agriculture. We also know that livestock farming has a very close relationship with agriculture. The performance of livestock farming is closely linked to that of agriculture. To schematize the different positions that have been taken on this issue of demographic pressure, it can be said that they reflect an opposition between two theses concerning the effect of population growth on the evolution of

[5] cited by Tapinos (1985)

agricultural production. The first of these positions refer to Malthus' thesis that the increase in the rural population leads to an increase in pressure on resources and in particular on the land, as set out in his famous book "Essai sur le principe de population" (1798).This phenomenon results in a decrease in the fertility of the land, generating a decrease in crop yields and therefore a decrease in available agricultural production, eventually causing famines which, in a way, restore the balance between the population and the productive capacities of the areas considered according to Malthus (1798).

According to Boserup, the classic theory of Malthus and Ricardo referred to by Sauvy in his quote: "An increase in the number of men, sufficient to put them in difficulty, provokes a reaction on their part", focuses on the long-term effects of population growth on the consumer-to-arable land ratio. It is recognised that the amount of food per head will decrease, either as a result of the cultivation of less fertile land or by allocating more labour to a farm of a given size, thus reducing production per worker. As a result, the decline in per capita food production causes livelihood crises, increasing mortality and/or decreasing fertility.

In the modern version of this thesis adopted by the neo-Malthusians, it is the exodus that replaces famine when there is too great an imbalance between the productive capacity of an environment and the needs of the populations living there. Ester Boserup's thesis is opposed to this point of view. In his book "The conditions of agricultural growth", this is the opposite of Malthus' thesis, considering that, in non-industrialized countries, the increase in the rural population is a factor favourable to agricultural intensification and that under these conditions it is illusory to expect an intensification of agricultural production if the population density is low. In doing so, it rejected Thomas Malthus' proposal that agrarian methods defined population size. On the contrary, it demonstrated that it is demographic pressure that imposes the evolution of agrarian techniques, so population growth can be positive. This theory has been challenged on the basis of a number of historical examples (medieval France, disappearance of certain Mesopotamian civilizations). But it remains widely used in debates on the conditions of economic development in third world countries and in discussions on sustainable development. The analysis of agrarian situations in sub-Saharan Africa shows that some of these situations do indeed evolve in a Malthusian way, while others follow the Boserupian logic. According to Sabine Henry (2007), however, in some Burkinabe villages, a Malthusian crisis has indeed been observed. After hosting several migrant households, these villages have chosen to no longer respect the traditional rule of hospitality and therefore no longer accept new facilities. Thus, the evolution of the state of natural resources in Yatenga (Burkina Faso) under the effect of the increase in land pressure, described by Marchal (1983), or that of the Serer country in Senegal reported by Lericollais (1972), confirms a Malthusian-type dynamic. In most cases on the African continent, the increase in land pressure has resulted in over-exploitation of the environment and environmental degradation that threatens the sustainability of agriculture and, consequently, livestock. In addition, there are also regions where the high population density has not led to environmental degradation but, on the contrary, has promoted agricultural intensification and sustainable management of the environment's productive capacities. This is the case in the Bamiléké country in southwest Cameroon, where some areas, with a population density of around 1,000 inhabitants per km2, manage to produce surpluses to supply the cities of Douala or Yaoundé according to Youve (2006). The latter author also cites the particularly demonstrative example of a Boserupian-type evolution, which is the Machakos district of Kenya, where population growth over several decades has been accompanied by undeniable agricultural intensification and improved management of environmental resources, as reported by Mary Tiffen, Michael Mortimore and Francis Gichuki in their very explicit book, "More people less erosion".

2.2 Restriction of pastoral spaces: the theory of "the tragedy of collective goods

The main characteristic of public goods is that they are typically non-marketable and relatively accessible to all. The Earth's atmosphere and its climates, fresh water, oceans, forests, biodiversity, and even the vulnerability of micro-organisms, etc. are all examples of what Carriere (1996) calls public goods. In his famous article, Garett Hardin (1968) showed how public goods are easily overexploited, even when those who profit from them believe they are making reasonable use of them. The basic logic is always the following according to Carriere, (1996): "Et si je faisais paître un animal de plus sur ce pré?". Comme l'élevage de cet animal ne profitera qu'à son seul propriétaire, tandis que l'ajout d'une tête de bétail entraîne une nouvelle réduction de la superficie pâturable disponible dont l'inconvénient est assumé par tout le monde, il est fort probable que chaque berger laissera grossir indéfiniment son troupeau et que la capacité régénérative du pré sera bientôt ». Since the breeding of this animal will only benefit its sole owner, while the addition of a head of cattle leads to a further reduction in the available pasture area, the disadvantage of which is borne by everyone, it is highly probable that each shepherd will let his herd grow indefinitely and, that the regenerative capacity of the meadow will soon be exceeded. According to Bernard Sinclair-Desgagné, this theory stipulates that « le bénéfice individuel provenant de l’introduction d’un maximum d’animaux appropriés privativement, est supérieur à la perte individuelle consécutive à la réduction du pâturage disponible, entraînée par l’introduction de plus de bétail. Chaque animal ajouté au troupeau apporte donc un gain supplémentaire à l’éleveur, alors que le coût de réduction des parcours est supporté collectivement ».According to the Haute-Normandie Regional Environment Agency, animal production is a land, energy and water-intensive activity. One of the arguments they put forward is that it takes 10 to 15 kg of vegetable protein for a ruminant to have 1 kg of animal protein, or about 8 kg of cereals to have 1 kg of meat (Veillard, 2010). Thus, pastoral livestock farming, particularly in the Sahel, is not immune to this type of criticism or even stigmatization because it is considered irrational, unproductive and devastating to natural resources.

3. Methodology

3.1 Theoretical framework of the Model

To identify and analyse the determinants of restriction of pastoral areas, this study is based on the Vector Autoregressive (VAR) model, which is a statistical model developed by Christopher Sims in the early 1980s that captures interdependencies between several time series. This model has been widely used in several previous studies, notably by Morrissey et al. (2002) in "Aid, investment and growth in sub-Saharan Africa"; Ahmed Zakane (2009) in "l'impact des dépenses d'infrastructures sur la croissance en Algérie. Une approche en séries temporelles multivariées (var)"; Anass Melloul (2016) in "le capital humain et la croissance économique marocaine : une analyse économétrique par le modèle vecteur autorégressif (var) ".

In a VAR model, the variables are treated symmetrically so that each of them is explained by its own past values and by the past values of the other variables.

3.2 Model specification

We will examine the factors that determine the restriction of pastoral areas. We start from a simple regression model:

$$Y = \alpha_0 + \alpha_i X_i + \varepsilon$$

Empirically, the model to be estimated can be written as follows:

$$Esp = \alpha_0 + \alpha_1 Poprural + \alpha_2 Zag + \alpha_3 ZFr + \alpha_4 Tp + \alpha_5 Pluv + \varepsilon$$

where:

Esp: represents the area of pastoral areas; Poprural: the rural population of Senegal; Zag: the area of agricultural areas; ZFr: the area of forest areas; Tp: the temperature variations; Pluv: the annual average rainfall; α_0: the constant and ε: represents the error term.

Stationarity tests

The database includes all factors that can contribute to the reduction of pastoral areas in Senegal. The study period runs from 1990 to 2015 and the data are mainly from the World Bank (WB) database updated in 2018, FAO 2018, ANSD 2016 and 2018, and Knoema 2018.

The dependent variable in this study is the area of pastoral areas over time. The main variable of interest (explanatory) is the demographic pressure, through data, on the evolution of Senegal's rural population. The other explanatory variables are the extension of Senegal's agricultural areas, the evolution of the surface area of forest areas, climatic factors through temperature variations and rainfall data according to the years.

Table 1 : Variables description in the empirical model

Variables	Meaning	Description	Source
Esp	Pastoral areas	Evolution of the area of pastures and permanent meadows [6] in hectares from 1990 to 2015	Knoema (2018)
Poprural	Rural population	Evolution of Senegal's rural population from 1990 to 2015	ANSD (2018)
Zagr	Agricultural zones	Evolution of the surface area of Senegal's agricultural zones in hectares from 1990 to 2015	FAO (2018)

[6] Meadows: Land producing grass for livestock feed.

ZFr	Forest areas	Evolution of the area of Senegal's forest areas in hectares from 1990 to 2015	FAO (2018)
Tp	Temperature	Temperature variations according to years	World Development Indicators (2018)
Pluv	Rainfall	Rainfall Annual average annual rainfall data in m3 according to the years	World Development Indicators (2018)

Source: author

Table 2: Descriptive statistics

	N	Minimum	Maximum	Mean	Standard deviation
Esp	26	5600000	5744000	5642076,92	43452,892
Zagr	26	8390000	9488000	8860000,00	262411,890
ZFr	26	8273000	9348000	8796076,92	330645,057
Poprural	26	54,10	61,10	58,44615	2,191297
Tp	26	0,33	1,49	0,9292	0,30294
Pluv	26	65,52	66,29	65,7980	0,17240
N valid (listwise)	26				

Source: author

The descriptive statistics of the model variables, represented in Table 2, show that the pastoral areas constituting our dependent variable, represent on average 5642076.92 hectares during the sampling period (1990-2015), or 28.68% of the country's surface area (19671200 hectares), with a maximum of 5744000 hectares (29.20%). Agricultural areas represent on average 886,000,000 hectares or 45.04% of the country's surface area. Forested areas represent 879,6076.92 or 44.71%. However, it should be noted that livestock farming is practised in some forest areas, but also in some agricultural areas through agro-pastoralism in which farmers are both pastoralists. The rural population of Senegal represents on average 58.44% of the population of Senegal. Concerning climatic factors, the average temperature variation is 0.93 degrees Celsius while rainfall averages 66 mm.

Table 3: Correlation test

Correlations							
		Esp	Zagr	ZFr	Poprural	Tp	Pluv
Esp	Pearson Correlation	1	-0,229	0,929**	-0,852**	-0,658**	0,484*
	Sig. (bilateral)		0,260	0,000	0,000	0,000	0,012
	N	26	26	26	26	26	26

Source: author

Stationarity tests

The stationary properties of time series variables are examined using Augmented Dickey Fuller's unit root tests (ADF), Phillips-Perron tests (PP), KPSS test (Kwiatowski, Phillips, Schmidt, Shin).

NB: It should be noted that for some variables with very large numbers, we used the logarithmic function before performing the stationarity tests. Thus all variables preceded by the letter "L" are on a logarithmic scale: this is the case for the variables Esp, Zagr and Zfr which become LEsp, LZagr and LZfr

Table 4: Stationarity tests

Variables	ADF			PP			KPSS		
	Level	Difference 1st	Observations	Level	Difference 1st	Observations	Level	Difference 1st	Observations
LEsp	-1,806*		Stationary at level, without trend or constant	-2,176**		Stationary at level, without trend or constant	0,713**		Stationary at level around a constant
LZagr	-2,866*		Stationary at level around a constant	-2,902*		Stationary at level around a constant	0,218***		Stationary at level around a constant
LZFr	-1,229*		Stationary at level around a constant	-1,322*		Stationary at level around a constant	0,160*		Stationary at level, with trend and constant
Poprural		-3.296*	Stationary at the 1st difference with constant trend	-5,083***		Stationary at level, without trend or constant	0,646*		Stationary at level around a constant
Tp	-3,755***		Stationary at level around a constant	-3,755***		Stationary at level around a constant	0,114***		Stationary at level, with trend

									and constant
Pluv	-3,284**		Stationary at level around a constant	-3,222**		Stationary at level around a constant	0,256***		Stationary at level around a constant
Significance	***= (1%) *=(10%)								** =(5%)

Source: author

The results of the unit root tests (Table 4) show that the dependent variable LEsp is stationary at level with all tests (ADF, PP and KPSS). This is the same situation as with the explanatory variables LZagr, LZfr, Tp and Pluv, which are also stationary at level with the 3 tests performed. The Poprural variable is stationary at the first difference for the ADF test but is stationary at the level for the PP and KPSS tests.

In summary, not all our variables are integrated in the same order.To model this phenomenon, only one equation is not sufficient. The specification requires several interrelated equations. This system of multiple equations can be studied through a VAR model.

4. Results

Table 5 : Test of specification of the optimal number of delays

VAR Lag Order Selection Criteria
Endogenous variables: LESP
Exogenous variables: C LZAGR LZFR PLUV POPRURAL TP
Date: 07/07/19 Time: 11:44
Sample: 1990 2015
Included observations: 23

Lag	LogL	LR	FPE	AIC	SC	HQ
0	107.8774	NA*	8.42e-06	-8.858906	-8.562690	-8.784408
1	110.4017	3.512088	7.43e-06*	-8.991455*	-8.645869*	-8.904541*
2	111.0074	0.790070	7.77e-06	-8.957169	-8.562215	-8.857839
3	111.9178	1.108313	7.94e-06	-8.949378	-8.505054	-8.837632

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

According to the results of the tests performed (Final Prediction Error, Akaike Information Criterion, Schwarz Information Criterion and Hannan-Quinn), the optimal delay to remember is 1. Thus in the model

Autocorrelation of estimation residues

The autocorrelation test (Coat rack) (appendix) allows us to confirm that the errors are not self-correlated to each other at the 5% threshold for delays ranging from 1 to 10 periods.

Table 6: Results

Dependent variable: Lesp	Adj. R-squared: 0,877362	
Explanatory variables	Coefficient	Standard deviation
Lesp(-1)	0,324384***	0,20437
Poprural	-0,000511*	0,00202
Lzagr	-0,008021*	0,02024
Lzfr	0,128293***	0,12383
Tp	-0,002404*	0,00229
Pluv	0,002376**	0,00759
Constant	8,455220	2,89240

Source: author

Significance level ***=1%; **= 5%; *=10%

Based on the characteristics of the Skewness and Kurtosis, the Jarque-Bera normality test confirms that the errors are normal. Thus, according to the post-estimate tests, we can maintain the specification of our model:

$$\mathbf{Lesp=0{,}324384\ lesp(-1) -0{,}000511poprural -0{,}008021Lzagr+0{,}128293LZfr-0{,}002404Tp +0{,}002376Pluv +8{,}455220}$$

From the estimates, it appears that the coefficient associated with the rural population variable is statistically significant at the 10% threshold. Its negative sign is consistent with the specificity of the study area. So then, everything being equal everywhere else:

- if the rural population increases by 10%, pastoral areas would decrease by 0.005%. Indeed, this result confirms Malthus[7] thesis that the increase in the rural population leads to an increase in pressure on resources and, in particular, on land. On the other hand, the work of Chauveau et al, (2015) confirms that due to the growth of the human population and its needs in space and products from the land, as well as the liberalization of access to resources, competition for access to land has become very acute in many places.

Our estimates also show that the coefficient associated with the variable agricultural areas is statistically significant at the 10% threshold. Its negative sign is consistent with the specificity of the study area. Indeed, the cultivation areas increase more and more over the years, to the detriment of livestock areas. These results may corroborate several previous studies, particularly those of Carrière, 1996. According to the latter author, demographic pressure has led to the cultivation of increasing areas of marginal land, which has been excluded from livestock farming; in the last 10 years before his study, in Western Radjasthan, where the cultivated area has increased by 49%, leading to a 15% decrease in pastoral land. So then:

- if agricultural areas increase by 10%, pastoral areas would decrease by 0.08%.

[7] Explained in his famous book Essai sur le principe de population (1798)

Similarly, as the variables mentioned above, the coefficient associated with the temperature variable is statistically significant at the 10% threshold. Indeed, our results show that temperature increases are negatively correlated with pastoral areas. So then:

- if temperatures increase by 10%, pastoral areas would decrease by 0.024%. This could be justified by the fact that high temperatures can kill grasses and consequently reduce pastoral areas.

However, our estimates reveal that the coefficient associated with the variable forest areas is statistically significant at the 1% threshold. Forest areas are thus positively correlated with pastoral areas. So then, everything being equal everywhere else:

- If forest areas increase by 10%, pastoral areas would increase by 1.28%.

These results are in line with the work of CSE (2015) which shows that in Senegal, between 1975 and 2010, at a time when cultivation areas increased by 6412 km2, savannah areas declined by 8708 km2. Much of the clearing for agriculture has been done in savannah areas, where rainfall conditions are more favourable to rainfed agriculture. There has been a strong increase in cultivated areas in these savannah areas, particularly in the departments of Tambacounda, Kaffrine, Kolda, Koungheul, Bakel, Vélingara, Kédougou, etc. The extension of rainfed crops is thus noted in the agro-sylvo-pastoral, forest areas of the south and in the southern part of the groundnut basin (CSE, 2015).

The coefficient associated with the rainfall variable is statistically significant at the 5% threshold. Rainfall is therefore positively correlated with pastoral areas. Indeed, good rainfall makes it possible to have better pastures for animals, which leads to an increase in pastoral areas.

5. Conclusion and policy lessons

The overall aim of this research was to identify and analyse the determinants of the restriction of pastoral areas in Senegal. It was carried out using a database based on data from the World Bank, ANSD, FAO and Knoema. The methodological approach adopted is the estimation of the determinants of the restriction of pastoral areas by the VAR model using the Eviews9 software. The results of the estimates show that forest areas and rainfall have a positive effect on pastoral areas while agricultural areas, rural population and temperature have a negative effect. In other words, the increase in forest areas or rainfall leads to an increase in pastoral areas, while the increase in crop areas, rural population or temperature leads to a decrease in pastoral areas.

In summary, the restriction of pastoral areas in Senegal is further encouraged by the extension of agricultural areas, demographic pressure in rural areas and rising temperatures, while the extension of forests, or the increase in rainfall, favours the increase in pastoral areas.

In an increasingly complex context, the Senegalese people and their leaders must seek a balance in order to satisfy the immediate needs of a growing population and protect the environment that will ensure their survival in the future in order to have a more sustainable future.

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7. Appendices

Appendix1 : Autocorrelation of residues

The autocorrelation test (Portmanteau) allows us to confirm that the errors are not autocorrelated to each other at the 5% threshold for delays ranging from 1 to 10 periods.

VAR Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Date: 04/10/19 Time: 13:59

Sample: 1990 2015

Included observations: 25

Lags	LM-Stat	Prob
1	1.216337	0.2701
2	0.123809	0.7249
3	4.066127	0.0438
4	1.843793	0.1745
5	0.168697	0.6813
6	0.119885	0.7292
7	0.402236	0.5259
8	0.012844	0.9098
9	2.214387	0.1367
10	0.007656	0.9303

Probs from chi-square with 1 df.

Appendix 2 : Correlation test between residues and explanatory variables

According to the LM autocorrelation test, there is no autocorrelation between the variables and their error terms for delays ranging from 1 to 10 periods

Residue normality test

VAR Residual Normality Tests

Orthogonalization: Residual Correlation (Doornik-Hansen)

Null Hypothesis: residuals are multivariate normal

Date: 04/10/19 Time: 12:47

Sample: 1990 2015

Included observations: 25

Component	Skewness	Chi-sq	df	Prob.
1	-0.695483	2.601576	1	0.1068
Joint		2.601576	1	0.1068

Component	Kurtosis	Chi-sq	df	Prob.
1	3.146192	0.005207	1	0.9425
Joint		0.005207	1	0.9425

Component	Jarque-Bera	Df	Prob.
1	2.606783	2	0.2716
Joint	2.606783	2	0.2716

Appendix3 : Estimation

Vector Autoregression Estimates

Date: 04/09/19 Time: 17:20

Sample (adjusted): 1991 2015

Included observations: 25 after Adjustments

Standard errors in ( ) & t-statistics in [ ]

	LESP
LESP(-1)	0.324384
	(0.20437)
	[1.58721]
C	8.455220
	(2.89240)
	[2.92326]
LZAGR	-0.008021
	(0.02024)
	[-0.39626]
LZFR	0.128293
	(0.12383)
	[1.03600]
PLUV	0.002376
	(0.00759)
	[0.31295]
POPRURAL	-0.000511
	(0.00202)
	[-0.25344]
TP	-0.002404
	(0.00229)
	[-1.04776]
R-squared	0.906288
Adj. R-squared	0.875051
Sum sq. resids	0.000107

S.E. equation	0.002438
F-statistic	29.01307
Log likelihood	119.0457
Akaike AIC	-8.963656
Schwarz SC	-8.622371
Mean dependent	15.54502
S.D. dependent	0.006898