

How does the policy environment influence pastoral adaptation? The case of Ngnith in the Senegal delta

Julien Meunier

ILRI

LADYSS (Laboratoire Dynamiques Sociales et Recomposition des
Espaces – Paris)

PPZS (Pôle Pastoralisme et Zones Sèches – Dakar)



International Livestock Research Institute (ILRI) report to the CCAFS
Flagship Program on Policies and Institutions

January 2017



RESEARCH PROGRAM ON
**Climate Change,
Agriculture and
Food Security**




ILRI thanks all donors and organizations who globally supported its work through their contributions to the [CGIAR system](#)

© 2017



This publication is licensed for use under the Creative Commons Attribution 4.0 International Licence. To view this licence, visit <https://creativecommons.org/licenses/by/4.0>.

Unless otherwise noted, you are free to share (copy and redistribute the material in any medium or format), adapt (remix, transform, and build upon the material) for any purpose, even commercially, under the following conditions:

 **ATTRIBUTION.** The work must be attributed, but not in any way that suggests endorsement by the publisher or the author(s).

Cover photo—[Cattle in Ngnith, April 2016] (photo credit: Julien Meunier)

Citation: Meunier, J. 2017. *How does the policy environment influence pastoral adaptation? The case of Ngnith in the Senegal delta*. Nairobi, Kenya: International Livestock Research Institute.

Patron: Professor Peter C Doherty AC, FAA, FRS

Animal scientist, Nobel Prize Laureate for Physiology or Medicine—1996

Box 30709, Nairobi 00100 Kenya
Phone +254 20 422 3000
Fax +254 20 422 3001
Email ilri-kenya@cgiar.org

ilri.org
better lives through livestock
ILRI is a CGIAR research centre

Box 5689, Addis Ababa, Ethiopia
Phone +251 11 617 2000
Fax +251 11 667 6923
Email ilri-ethiopia@cgiar.org

ILRI has offices in East Africa • South Asia • Southeast and East Asia • Southern Africa • West Africa

Contents

1	Preface	ii
2	Acknowledgements and disclaimer	iii
3	Acronyms	iv
4	Introduction	1
5	Methodology.....	2
6	Geohistory of the delta: evolution of the SES and environmental disturbances	3
6.1	The end of the 20 th century: rice and irrigation as watchword	3
6.1.1	The origins of irrigation: the anchoring of rice production in the delta	3
6.1.2	Irrigation facilities: capitalist development	4
6.2	Environmental disruptions of agricultural development.....	5
6.2.1	Water disruptions and their impacts	5
6.2.2	Effects of the land development.....	6
6.2.3	Social disruption.....	6
7	Policy and adaptation: how policy influence pastoral adaptation?.....	8
7.1	The actual SES composition	8
7.1.1	The social system	8
7.1.2	The ecological system	9
7.2	Policy environment: opportunity or constraints for adaptation?	10
7.2.1	The pastoral representativeness and decentralization	10
7.2.2	POAS: securing pastoral resources?.....	11
7.2.3	PDIDAS program: an inclusive development program?.....	13
7.2.4	Agribusiness and their agreements	14
7.2.5	Environmental protection.....	16
8	Conclusions	17
9	References	19

1 Preface

This paper is part of a project entitled *Analyzing the Science-Policy-Practice Interface in Climate Change Adaptation in East and West Africa* being carried out by the International Livestock Research Institute (ILRI) as a part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). CCAFS and ILRI are investigating what kinds of social, institutional and policy environments best facilitate the development of promising adaptation options, and lead to the establishment of effective agricultural adaptation plans and strategies at the national, regional and global level. One way in which the program is doing this is through use of different innovative modes of interaction between scientists and policymakers to influence the design and implementation of national policies regarding climate change adaptation. Understanding how and why different approaches to science-policy interaction succeed or fail is crucial.

The aim of the *Science-Policy-Practice Interface* project is to deepen understanding of policy and governance processes around climate change in order to contribute to more effective engagement between national governments and donors, and consequently towards climate smart food systems. What factors have influenced the development of existing policies? And how do policies interact with each other as they are being implemented? Pastoralist and agropastoralist livelihoods and adaptation choices are influenced by an array of policies and also by the interplay among policies. The role of science in feeding knowledge about livelihoods and household's adaptation strategies into policy processes, and the dynamics of how scientific information is produced, delivered, received and drawn upon in the shaping of policies is poorly understood.

This working paper is a contribution toward this effort, describing aspects of the policy environment in Senegal.

2 Acknowledgements and disclaimer

I thank ISRA and PPZS for the support, especially Jérémy Bourgoïn and Djibril Diop. I also thank communities living in Ngnith, all people who have helped for this study, Pape Natogo Thioye and his family. I also thank Todd Crane and Lance Robinson for the advices and the support for this report.

This work was implemented as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), which is carried out with support from CGIAR Fund Donors and through bilateral funding agreements. For details please visit <https://ccafs.cgiar.org/donors>. The views expressed in this document cannot be taken to reflect the official opinions of ILRI, the CGIAR, or the funding organizations.

3 Acronyms

AIV	Ndiael Inter-Villages Association
APES	Association for the Promotion of Livestock in the Sahel and Savannah
CADL	Support Centre for Local Development
CIRAD	French Agricultural Research Centre for International Development
CODEN	Defence collective of Ndiael Land
CSS	Senegalese Sugar Company
ISRA	Senegalese Institute of Agronomic Research
MAS	Development Mission of Senegal
ORSTOM	Office of Technical and Scientific Research of Overseas
PDIDAS	Sustainable and Inclusive Agribusiness Project
PDMAS	Agricultural Markets and Agribusiness Development Project
POAS	Occupation and Allocation Land Plan
PRACAS	Acceleration of the Pace of the Senegalese Agriculture Program
PREFELAG	Restoration Project of the Ecological Functions of the Guiers Lake
PSE	Emergent Senegal Plan
RSAN	Special Avifauna Reserve of Ndiael
SAED	Planning Society and exploitation of delta lands
SONES	National Company of Senegalese Water
UGB	Gaston Berger University
UPRINOL	Producer Union of the North-West Bank of Guiers Lake
UPROL	Producer Union of the West Bank of Guiers Lake
WAF	West African Farms

4 Introduction

At the present time, adaptation to climate change has an increasingly important role in research programs, but it remains a multifaceted concept. Our purpose here focuses on adaptation of pastoralism in the Sahelian zone, and especially in the delta of the Senegal River, where pastoralism is an historically important activity (Michel & Sall 1984). This space of the Senegalese territory has been the setting of many socio-environmental changes during the twentieth century. Analysing this local geohistory is important for broadening our view of understanding climate change adaptation as something situated in broader socio-environmental changes.

We know that Senegal will face the effects of climate change and that this will hinder human activities according to their ability to adapt. The expected changes include the increase in temperatures (McSweeney et al. 2010) the decrease in rainfall (Sall et al. 2011) and the likely consequences for human societies include a decline in crop yields, problems of access to water, a decrease in biodiversity, increased health problems (Niang et al. 2014).

Adaptation is thus a major issue of cross-scale harmonization. Climate change inevitably poses the problem of the extent to which State-driven adaptation measures and local adaptation measures are not necessarily aligned (Gagnol & Soubeyran 2012). We use a definition from Ericksen et al. (2015, p.524) inspired by Pelling (2011) to define adaptation as a “social process wherein social and political relations shape the simultaneous management of diverse changes, many of which are not driven directly or consciously by climate change”. Adaptation is thus a political and social act (Pelling 2011) shaped by the constraints of social, political, historical and economic processes at different scales (Smit & Wandel 2006). Adaptation cannot be addressed only as a practice or a policy referring explicitly to adaptation. We must broaden our perspective and integrate all the socio-economic and political context of a space to draw conclusions related to the processes and possibilities of adaptation. Following on this perspective, the purpose of this paper is to analyze how the overall policy environment and its manifestations influence pastoralists’ adaptive capacity?

For this purpose, we will use the concept of social-ecological system (SES) (Ostrom 2009) that allows us to read disturbances through the interactions between the fundamentally intertwined social and ecological systems. These systems each include two subsystems, the governance system and users for the first and the resource system and resources units for the second. These two aspects directly concern the adaptation of the pastoralists because they reflect the essence of pastoralism: the mobile exploitation of natural resources (Touré 2010). The SES lens allows us to illustrate how interactions influence adaptation and if adaptation more occurs like resilience or transformation.

5 Methodology

Using the SES conceptual framework, we start by reviewing the evolution of the Senegal River delta over the last century, highlighting how the present dynamics emerge from complex interactions between social and ecological drivers. This is an initial step to understand the present possibilities of pastoralism adaptation, as defined by the actual context where adaptation. To achieve this, we will trace the geohistory of the delta, i.e. the interactions between the main systems of the SES and their links, on the one hand, with social, economic and political framework, and on the other hand, with the derived ecosystems caused by disruptions of SES. This first part of the SES history is a kind of synthesis based on the many studies that have looked at changes in the delta. Nevertheless, they don't offer the overview we want to highlight. The delta has been the subject of publications of scientists for decades, notably under the auspices of ORSTOM, then the IRD, the universities of Saint-Louis and Dakar, as well as international researchers. The richness of the literature enables us to have a comprehensive look at the historical evolution of the delta and key dynamics at different levels, dynamics often implemented in the name of development. Also, we will underline some changes with collected data in the Ngnith municipality specially to illustrate how changes are present in the pastoral life.

The second part of this work will show the current state of the SES in order to analyse how pastoralists ongoing adaptation processes are influenced by policy initiatives and development interventions. This analysis will be based on data collected through original field work in the Ngnith as well as grey literature resources (reports of organization, programs, etc.). During this research, 31 meetings have been made for approximately 40 to 45 people interviewed¹. Semi-structured interviews were conducted in order to collect data on the way some users and the policy environment can influence the pastoralists resource access in the SES. To achieve this, we collect information about the identification of the person or the organization met; its relationship with pastoralism (what pastoralism represents for him, how pastoralism interacts with his daily life, what are the problems faced by pastoralism); relations with agribusiness and the development initiatives, the cooperation with these entities, the problems encountered; and finally a part on land, which is considered as important locally in land allocation decisions, what is the place of pastoralists in key related land, institutions which are the possible existing conflicts.

¹ Pastoralists, farmers, Councilors, Mayor, decentralized service and State agencies, head of village, an employee of agroindustry's, NGO or association member, agricultural or GIE union member.

6 Geohistory of the delta: evolution of the SES and environmental disturbances

6.1 The end of the 20th century: rice and irrigation as watchword

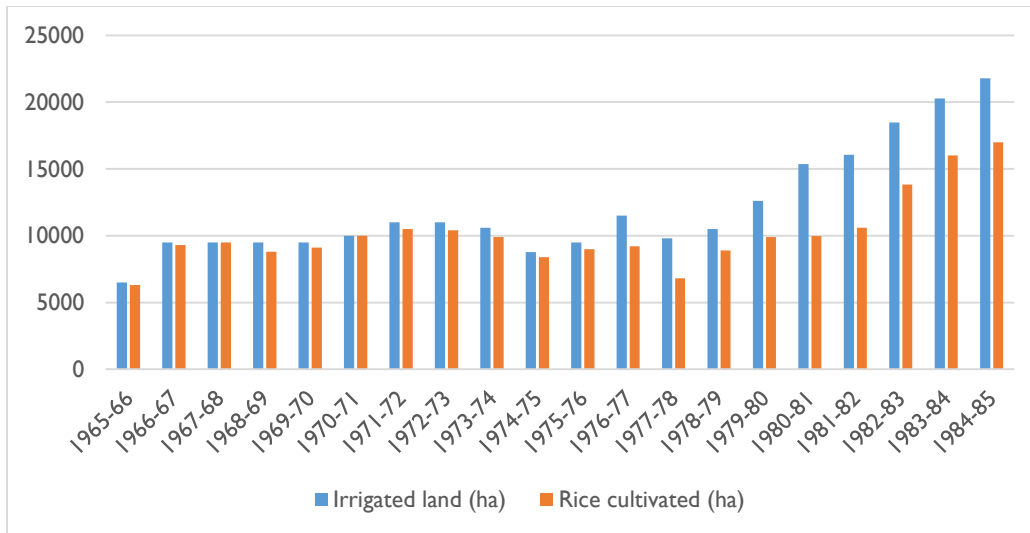
A historical review of the links between the socio-economic and political development and the ecosystems sheds light on the current state of the issues in the delta of Senegal and the town of Ngnith. Over the last 50 years the Senegal River delta has become a capital-intensive production for the global market and an area of production of rice for the domestic market (Kamara 2013). Indeed, for several years, the delta has been affected by the liberal policies on which we will return later, and a national development policy called Self-sufficiency National Rice Program (PNAR) launched in 2009 by the Senegalese Government. The implementation of this policy was carried out in order to deal with the deficit in the trade balance, since the country imports a large quantity of the consumed rice. But in what way is rice a new crop in the delta and how has this culture succeeded in establishing itself?

6.1.1 The origins of irrigation: the anchoring of rice production in the delta

In the light of the literature, the development of rice production in the delta appears to be an important part of the local history, which has shaped pastoral activities. However, this development has occurred in several steps, and although rice is one of the most popular foods in Senegal today, this was not always the case. The largest increase in the consumption of rice marked the second half of the twentieth century (Sène et al. 1971): in 40 years, it has increased by almost 1000% (Brüntrup et al. 2006). Rice has not always been an inescapable Senegalese food staple, and the influence of rice growing has not always been the one it is today.

Yet, rice cultivation was imported as tomatoes or manioc. The African variety would have been domesticated 6,000 years ago according to Bezançon (1995) who finds that a multitude of authors of antiquity till the beginning of the twentieth century, evoke the presence of rice production. One of the changes that has been made is the introduction of Asian rice for which the Portuguese colonization played an important role. However, the rice was not a homogeneous fact in West Africa. Indeed, the appropriation of rice agriculture in Senegal occurred among particular ethnic groups according to Dresch (1949), including the “Sérères” and not the “Wolofs”. He also notes that rice agriculture was well established in lower Casamance. In addition to accelerating the introduction of Asian varieties, colonization introduced rice in local customs, particularly among people who did not traditionally cultivate it. This is due to several facts. In Senegal, the peanut culture was imposed by the French colonizers, resulting in the neglect of food crops, which facilitated the consumption of imported rice. In addition, commercial crops led migrations of seasonal workers, nearly 70,000 in 1938 (*ibid.*). To feed these workers, rice was imported from Indochina, thus entering a wider part of the population eating habits gradually. In addition, given the importance of the peanut as a commercial crop, the country became dependent on rice imports (John 2015). The domestic production representing only about 24% of the total consumption (Hathie & Ndiaye 2015), the current economic situation pushes the country to search for self-sufficiency through the PNAR. Rice has been a motor for the development of irrigation facilities in the delta, but this took place in several stages. It's the SAED/DMEC that was in charge of the accompaniment of the peasants in the development of irrigation. Their data provide a first overview of the evolution of the rice farming in the delta and as well as in the irrigated lands (SAED 1985).

Figure 1 - Irrigated land and rice culture in the Senegal delta (1965-1985)



Source: data from SAED, 1985

6.1.2 Irrigation facilities: capitalist development

The development of irrigation facilities has motivated the actions of the authorities, both at the time of the French colonization as well as after independence. The implementation of these arrangements took place in several steps. To start with, the infancy of the agricultural water began under the French colonization in the early nineteenth century. The first attempt at rice development is attributed to the Baron Roger in 1822, when he was an Administrator of Senegal (Bélières & Touré 1999, p.100), but this operation was a failure. During this same period, 50 farms run by colonial settlers emerged between St. Louis and Dagana, with discouraging agronomic results (Tourrand 2000, p.32). The rest of the agricultural history of the region has been linked with the colonial objectives and the desire to refocus on the groundnut basin. Indeed, in the agricultural development of the area the climate of the delta did not offer the conditions expected by French settlers (*ibid.*).

The real development of irrigation took place after the second world war, initially in 1946 with the creation of the rice plot from Richard-Toll by the Senegalese Planning Mission (MAS), where 6 000 ha were prepared and managed in a dozen years (Jamin & Tourrand 1986). Then, there was the creation in 1957 of the Colons rice plot of 300 ha, which was the “first attempt at profit-sharing for the populations of the Delta (natives and foreigners in this case) in the irrigation culture” (Jamin & Tourrand 1986, p.24).

From 1961 to 1964, the creation of the peripheral dam on the left bank of the Senegal River triggered a new dynamic stronger than the previous. This allowed control of flooding of the delta and development of depressions in the land that were managed by rice-growing perimeters, a kind of decentralized management unit (Tourrand 2000, p.42). The creation of the Delta Management and Exploitation Company (SAED) in 1965 accompanied this construction to enhance 30 000 ha of irrigated lands. But that was one of the objectives of the time which has still not been achieved to this day.

The 1970s were marked by the strengthening of irrigation techniques and the development of agribusiness. So, there is on the one hand the installation of pumping station for cultures and on the other hand, new agents having the ability to exploit large areas. The Senegalese Sugar Company (CSS) moved in 1970 to Richard-Toll and reclaimed rice plots to convert them into exploitation of cane sugar. The Senegalese Company of Food Cannery (SOCAS) expanded also in 1972 at Savoigne to the National

Company of Industrial Tomato (SNTI) in Dagana in 1975. The implementation of the CSS resulted in important local developments with hydrological implications for the Guiers Lake. The Taoué marigot² which naturally allows the junction between the Senegal River and the Guiers Lake, was replaced by a 17km channel to facilitate the irrigation of the CSS. This channel entered service in 1979 and has also allowed the CSS to set up on the East shore of the Taoué (Niang 2011).

The next decade would see one of the largest infrastructures starting with the Diama dam in 1986. It was intended to hold the rise of the salty tongue of ocean water that intruded during the dry season. Salt could go beyond Dagana, more than 100 km from the ocean. The dam has allowed a longer duration of irrigation as farmers could grow rice in the dry season, because the amount of stored water was too low before (Tourrand 2000). Another dam has been in service in 1989. It was the one in Manantali in Mali on the Bafing river, one of the three rivers that give rise to the Senegal River. These works, managed by the Senegalese River Development Agency (OMVS) created in 1972, helped regulate floods.

All these facilities have mainly developed during the second half of the 20th century and allowed the installation of a capitalist economy connected to the international level (Kamara 2013; Mietton et al. 2005). Over the course of several decades, this process has progressively transformed an important pastoral zone into an intensive agricultural zone. This transformation results from development policy and state interventions that have shaped, and continue to reshape, pastoralists' access to resources crucial to adaptive capacity to climate stress.

6.2 Environmental disruptions of agricultural development

Irrigation and rice production development policies, brought changes in the practices of users on ecosystems as well as new rules and the standards of farms of the resource systems of the SES. These interactions have resulted in changes in the ecological system, bringing a new configuration of essential environmental resources for pastoralism.

6.2.1 Water disruptions and their impacts

One of the first consequences was the end of flood in the delta as a result of the construction of the dike to the South Bank of the River in the 1960s. The deltaic arms of the river (marigots) thus found themselves cut off from their source of water. With waters no longer flowing in the major bed of the Senegal River, the marigots have dried up. It has been similarly the same case even on the bowls of the delta that were not developed for irrigated cultivation (Bélières & Touré 1999; Santoir 1997). The recharging of groundwater has also been upset because the recharging occurred during floods. Now, the recharging occurs occasionally with the irrigation (Gac 1991). These changes led also a blockage of some parts of the river system and an accentuation of the wind erosion (Philippe et al. 1997; van Lavieren & van Wetten 1988; Michel & Sall 1984). By creating greater stagnation of water after the construction of the Diama dam, the upheaval of the hydraulic system has also affected the biology of Guiers Lake. According to Cogels and Gac (1994), "*Typha australis and Pistia stratiotes are 2 species that had the most benefits from the stabilization of the level of the Lake since 1991. Additionally, there has been an addition of the changes in salinity.*"

² A marigot is an area of closed water often devoid of water during the dry season. It can be a river arm which gradually disappear.

6.2.2 Effects of the land development

In addition, the implementation of irrigated agriculture can have negative environmental consequences for natural resources. Particularly, the technique of water drainage can be a problem for soils management and for underground water, especially related to hydrosaline dynamics (Diene 1998). In the absence of a 'correct' drainage, the salts present in the sediments are dissolved and rise to the surface under the influence of evaporation (Diene 1998; Houma 1993). The evacuation of crop protection products is also an important issue with a bad drainage. Salinization of land has resulted in abandonment of some plots, prompting Mietton and al. to speak of "itinerant rice" (Mietton et al. 2005). These technical obstacles are linked to the fact that rice was not a locally rooted culture for local people, but rice is a national macro-economic choice supported by international financial institutions. The deficit of technical supervision that could play a role in the weakness of drainage control is particularly related to the disengagement of the SAED in 1984 as a support structure for farmers. This disengagement was triggered by the International Monetary Fund's structural adjustment plan, so the liberal discourse

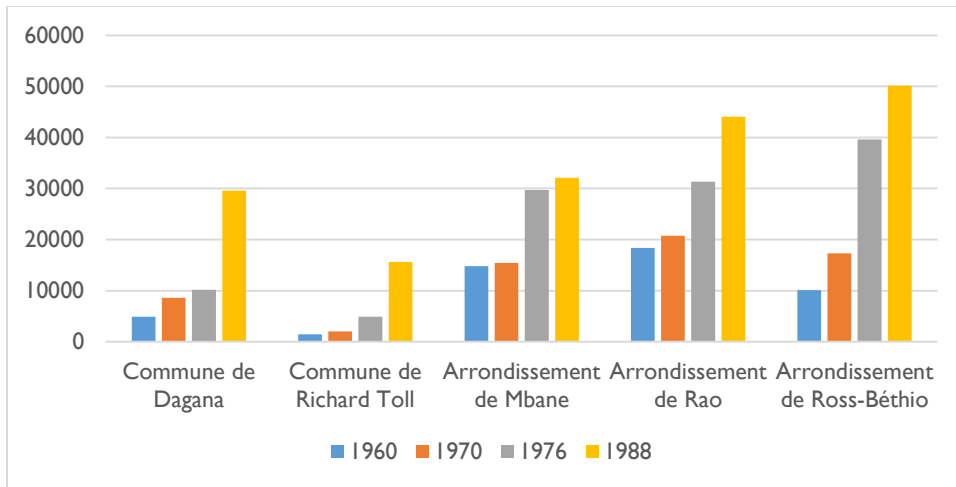
6.2.3 Social disruption

This development of irrigation facilities also caused particular health and social problems. To illustrate the importance of these health consequences, we can refer to the book "Irrigation development and health (Valley of the Senegal River)" (Hervé & Brengues 1998) constituting the proceedings of a conference held in 1994 in Dakar and that followed a research program entitled "water and health in the context of development". This book shows the importance of the impact of these disturbances. The example of intestinal bilharzia reflects on our previous remarks. Richard Toll was the scene of an unprecedented epidemic that broke out in 1988. However, conditions for the development of the pathogen (the *Schistosoma worm*) did not appear to be in place. So, the facilities implemented under development policies led to a favorable context by allowing the presence of perennial water and by reducing the salinity of water. Very probably this helping hand to nature was brought by the commissioning of the Diama dam mainly, but also of Manantali dam (Handschumacher et al. 1998).

Furthermore, the successive developments and the implementation of irrigated culture has led a change in the social balance. According to Corniaux (2005, p.22), this area was originally a region devoted to extensive herding, but interventions in recent history have decidedly changed the human ecology of delta. The first imbalance is related to the colonial intervention which led to compartmentalization and limitation of trade between pastoralists and farmers. There was also a progressive failure of the balance between spaces and the uses of these groups' respective spaces (Mathieu et al. 1986).

The construction of the dike on the left bank in 1964 launched a new demographic dynamic. The Lampsar area was a desert before 1965 according to Philippe et al. (1997). Irrigated agriculture has attracted many people, as shown by the growth rate of the Ross Béthio population between 1960 and 1988 which is close to 6% (Bélières & Touré 1999). The evolution of the population in some municipalities and districts of the Department of Dagana also underlines the extent of demographic changes:

Figure 2 – Evolution of the population in some municipalities and districts (1960-1988)



Source: data from Bélières & Touré, 1999.

These migrations are also confirmed for the margins of the Guiers Lake, but starting in the 1990s with the introduction of irrigated agriculture and market gardening (Corniaux 2005, p.25). In addition, Mar and Magrin (2006) stressed that the Guiers Lake is operated for four uses: fishing, pastoralism, irrigation facilities for local farmers and agribusiness, and water for Dakar. The Dieri became a “colonizable” area and there are several interests including those of local farmers or Senegalese settlers for market gardening, especially for sweet potato, a culture of widespread speculation, and the interests of agribusiness as the WAF and Senhuile which produce for international market.

Technocratic development which marks the delta brought a new social configuration for herders that evokes the renewal of the “*basics of functional specializations of ethnicity between the Fulani pastoralists and the Wolof farmers*”, illustrated by the increase of nearly 75% of the average acreage between 1985 and 1990 by the Fulani (Schmitz 1995, p.57). This fact is also linked to the 1970’s and 1980’s droughts (Corniaux, 1999).

It is in this context that pastoralists are trying since several decades to pursue their livelihoods. At this part’s conclusion, we can see that the delta SES has undergone several changes. So, it seems necessary to stop for a moment on the current state of the SES, and focus our attention on the SES of the study area in the Ngnith area.

7 Policy and adaptation: how policy influence pastoral adaptation?

If the delta was a strongly pastoral region (Michel & Sall 1984), today's reality shows significant changes in the social, environmental and economic balance. It means to clarify the current context, i.e. to describe the systems of the SES before focus on the influence of the policy framework.

7.1 The actual SES composition

7.1.1 The social system

The social system includes users and governance systems, two aspects for which we will try to illustrate their interests for our study insofar as they overlap with those of pastoralists. Therefore, this list resulting from our research is not exhaustive.

Users

Users/actors		Interests and comments
Local population	Farmers	Irrigated, rainfed agriculture: land and water access
	Herders	Mobility, access to water and pasture land:
	Fishermen	Access to water
State actors and local authorities	The State	Development of irrigated agriculture, agribusiness
	The commune	Management of resources (land), social peace
	The CADL	Support to farmers
	The SAED	Support to farmers
	DIREL	Support to farmers limited by human means (no agent in the town), animal health
	Water and forests	Application of the rules of the Ndiael reserve
Private actors and non-State organizations	UPROL, UPRINOL	Development of irrigation, connect to the market
	Senhuile	Land for agriculture (6000 ha cultivated - estimates), resource water for irrigation, connect to the global market
	WAF	Land for agriculture (300 ha), water for irrigation, connected to the global market
	AIV	Protection of the environment, the PREFELAG partner
	CODEN	Fighting Senhuile, connection to national and international NGOS. Its representative in the town is the same as that of the APESSE.
	AFESSED	Federation of the herders of the Department, low anchor in the commune, is involved in interactions with the CSS
	APESSE	NGOS of herders with local ramifications (Departmental Office) West Africa. Its representative in the town is the same as the one in the CODEN.

The governance processes

Here, we will give an overview of the main governance processes concerning the management of critical resources for farming: land (related to pasture and mobility) and water.

Process		Interests - comments
Formal	Municipality/POAS	Assignments of land, planning
	Agribusiness agreements	Management of crop residues, water points
	PDIDAS/PDMAS	Reorganization of land
	PREFELAG	The refilled/rewetted of Ndiael
	Regulation of the reserve	Restrictions on pasture access
Informal	By organizations	Awareness of farmers to the needs of herders (water access)
	Family	Access to the crop residues

7.1.2 The ecological system

Now we will focus on the ecological system in order to understand what are the systems of resources that can be distinguished and what are the associated resources for pastoralism. We make the choice to identify three major groups:

- The Ndiael depression which was classified Special Reserve of avifauna by Decree N°65 053 of 02nd February 1965. Ndiael was then classified as a site of international importance under the Ramsar convention in 1977. In 2005, UNESCO designated the Reserve of the Ndiael as part of the central area of the Transboundary Biosphere Reserve bordering Senegal - Mauritania. Its water supply was disrupted by the hydraulic facilities. It is a watering and grazing area for pastoralists even if Ndiael's reserve status should lead to interdictions.
- The Guiers Lake is supplied with water by the river channeled the Taoué. The banks are coveted for market gardening and cash cropping. The proximity of water facilitates development of the irrigated plots near the Lake. The Lake is also coveted by fishermen and the SONES who settled at Gnith in 1972 to supply water Dakar (65% of its drinking water supply) and other surrounding cities. It is a livestock point for watering.
- The Dieri, formed by the lands which are never flooded in the delta. It is historically a pastoral area where rainfed agriculture can be practiced. Water place for pastoralists are present.

Resources systems	Associated resources
Ndiael	Pastures, water
Lake Guiers	Water, fish, land
Dieri	Pastures, water, land

Environmental impact of irrigation development was stressed during the research field in the Ngnith municipality:

“That is to say [...] there are diseases in the water, the Waalo, which often kills most cattle. Sometimes even, the qualities of grass we saw here and trees, they change. There is a change in level, compared to before, because of the trees” (Belal Mbaye 20/04/16)

However, the consequences in terms of biodiversity are difficult to quantify. To understand more what it is, we should have more detailed studies on the present species. Nevertheless, the parallel between a reading of environmental problems focused on climate change and a reading related to local actions have been given to us:

“There are a lot of trees that no longer exist in the area, and it's not the advance of the desert as others claim” (Belal Mbaye, 20/04/16)

This citation highlights differences which may exist between the international and local policies. Indeed, as we will see, the policy framework influences the use of natural resources and the occupation of the space which affects the adaptability of pastoralists.

7.2 Policy environment: opportunity or constraints for adaptation?

The local SES includes a special configuration between the interests for natural resources of the actors and governance systems. These interests have been shaped by the evolution of the social, economic and political framework. We will establish how policies allow the adaptation of pastoralists using discourses collected during the field research. For this purpose, we will focus on some key aspects identified during the field research which are tools, projects, organization or law shaping the policy environment: particularly decentralization, POAS, the PDIDAS program and agribusiness.

7.2.1 The pastoral representativeness and decentralization

The decentralization policy and land policy are intertwined in Senegal (Faye 2008). Indeed, by changing the powers of the local authorities and by redistributing skills related to land use, decentralization plays a role as a land-use “actor”. The last step in this process is the Act III of decentralization enacted in 2013 which resulted in the removal of regions as a local community, the erection of all rural communities of Senegal in full exercise municipality (“commune” in French). Environmental and resource management skills date from Act II in 1996. The municipality plays a role in the allocation of land, because a request for land is subject to prospecting of the land commission as well as approval by the municipal council.

But the municipality is a space of power where different interests negotiate policies regarding access to and use of environmental resources. The question of the representation of pastoralists is important for how they are able to lobby for continued access to the resources necessary for the mobile exploitation of resources in a context of irrigation development.

Observations and interviews have highlighted the predominance in the commune of local actors in key positions. These actors often also have or have had important functions in other organizations. Indeed, when looking at the municipal Council of Ngnith, we observe the predominance of actors connected to the sweet potato sector organizations, so more potentially favorable to the development of irrigated areas. These observations echo Magrin remarks on the possible consequences of the decentralization policy (Magrin 2008). The Mayor is the previous president of the UPROL and the current president the sweet potato; the technical advisor of the Mayor is Chairman of the UPROL and Secretary general of the potato industry sector organization; the Chairman of the planning commission is the Chairman of the

UPRINOL. The three-year program of priority Actions 2016-2018 of the commune of Ngnith considers, for example, the extensive nature of farming as a constraint to its development.

Our observations have revealed also that UPROL is the organization that is also a local base for the SAED and the CADL in Ngnith, one being a deconcentrated administration and the other a state supported center. Terms used by the local farmers illustrate a certain overflow of the logic of subsistence agriculture. The term "micro-entrepreneur" is thus often used³. Production of sweet potatoes as a cash crop conforms to a vision of land use that is reflected in farmers' discourses of rural development. Given that the political history of the area, we can think that the policy framework is able to exercise some influence on the subjectivities. The irrigation development supported by the State and some international organizations were able to produce a process of governmentality⁴ that has reshaped partly the local identity. This movement which move towards the direction of the major "development policies" also accompanies the issues of extensive pastoralism. Further, this model wish the "modernization" of pastoralism, i.e. the settlement. Indeed, as the interviews highlight, the speech of local farmers often show that extensive pastoral practices are not considered to be 'good' and reflect the logic of settlement of pastoralists:

"The herding that is good in the area, is to have farms to grow forage crops, control livestock, not to let the cattle wander, ... We cultivate forage, we maintain it, we watch over it to get a good quality."
(Ngnith mayor, 17/04/16)

Nevertheless, this vision of pastoralism is also found among pastoralists. Our research underlines that in Ngnith, there is a new consideration of their own practices, an awareness of the difficulties that the socio-economic and political context generates for them. One of the consequences of the interactions of the SES would be the change in design of the pastoral practices that would be so adapted by transformation of the system and not by an increased resilience. But to what extent this transformation is possible?

Decentralization, by giving more competence in the management of natural resources, could allow to increase the adaptability of the herders. Because of the dynamics of power at the municipality level, pastoralists are in a minority. Thus, an adaptation by implementing sustainable management of resources does not seems possible because they do not have sufficient control over their own essential resources. In addition, land policy is also linked to the POAS of the municipality, which deserves special attention for the local rules imposed in land use.

7.2.2 POAS: securing pastoral resources?

As an instrument of land planning, we focus on POAS for the consideration of pastoral land tenure, especially for cattle trails. The terms of decisions in this process of governance highlight also the barriers to "political adaptation", i.e. how the policy environment shape pastoral adaptation.

POAS in the area was adopted first by the former rural community of Ross-Béthio which asked it. A pilot operation was launched in 1997 and completed in 1999 with the support of the SAED and research

³ During the field research, we observed a meeting for the creation of an organization GIE (*Groupement d'intérêt économique*) where people talk about them with the term "micro-entrepreneur".

⁴ Governmentality, inspired by Foucault's research, refers to how subject make themselves, focusing on technologies of power and with respect to involvement in different forms of practice shape the self-formation (Agrawal 2005).

(CIRAD, ISRA, UGB). POAS was created to provide better land management to local elected representatives whose role has been strengthened with the decentralization; to strengthen the complementarity between agriculture and other activities for integrated and sustainable rural development and; to encourage the involvement of the local populations (Bourgoin 2014). The municipality of Ngnith follows the 2009 elections has implemented its own POAS in the continuity of Ross-Béthio.

The definition of the POAS and its application are related on the one hand to the municipality council for the choice of the types of occupation, to the land commission for the allocation of land, and on the other hand, to private actors, whether the agribusiness or local farmers, by their ability to circumvent the rules or appropriate them. The Senhuile example illustrates how scales can allow to circumvent local rules (POAS) and national rules (the Ndiel reserve). Indeed, Senhuile has benefitted from a presidential decree exempting it from POAS rules of land planning.

The territorializing proceeds together with the decentralization dynamics, but its effectiveness depends on the ability of the actors who set the norms and rules, as well as those who enforce them.

POAS, as a system of governance, influences the power of local actors as well as the availability of resources and the balance of resources systems. This research find that pastoral adaptation is effectively not allowed, because POAS' rules could not counter the national government's reassignment of a large pastoral area to an agribusiness investor. It's more important to secure these lands when they can provide resources to face the climatic variations and to the effects of climate change. In addition, research also underlines the pervasive logic of intensification. This logic is a part of a climate change and environmental disruption adaptation by a transformation of pastoralism through "modernizing" it, hoping to change extensive herding toward more intensive agropastoralism.

Nevertheless, the POAS can play a role in this transformation by allowing adaptation by anticipation. Indeed, the speech of the herders illustrate two important elements related to this:

- The observation of the limits of pastoralism in the context of irrigation development: *"herding is like a patient who is dying" (Belal Mbaye, 20/04/16);*
- The proposed transformation: *"in the future, maybe things will change, there will be more cattle that wander in the space like this, and there will be farms, you're exploiting for agriculture, you used for farming, but on a limited basis" (Dourki, 20/04/16).*

The definition of the POAS areas should allow to anticipate this transformation by avoiding to define areas too restrictive in the implementation of agropastoral practices, *"they project themselves in the future in the context, with all for (...) agriculture, they also say that perhaps tomorrow we can transform ourselves or combine agriculture and livestock" (SAED, 12/05/16).*

Also, as observed during the research in Ngnith, the official rules of the POAS are complemented by informal arrangements that allow farmers to access to some resources despite the spatial pressures of irrigated farming on the cattle trail and water access places. Indeed, the POAS allows a certain security of the pastoral activities by formalizing the cattle trail, the openings on the Lake and temporary pools. It specifies for example that *"access of livestock to the post-harvest cattle trail of any course is compulsory in all liberated exploitation"*. However, the POAS trails are not always respected, especially the width of the cattle trail. Despite this, informal agreements come to fill the gaps. As we have seen on the ground, non-cattle pathways are used by pastoralists to facilitate their mobility. In fact, this commits them to use of unofficial cattle trail for livestock, thus accentuating the risks of wandering and conflict. For example,

we have seen this type of move in an agricultural area of agriculture priority (ZAPA – agricultural zone with agricultural priority) and we have seen that farmers had set up protective barriers.

Photography 1 – A pathway used as a cattle trail near Nder, Ngnith municipality, April 2016



Also, other arrangements are found to limit conflicts between agriculture and livestock, conflicts that have increased along the Guiers Lake with the development of irrigation (van Lavieren & van Wetten 1988). Conflicts are often resolved amicably, but awareness of the interests of each can help to avoid conflicts and to facilitate access to natural resources:

"Conflicts are regulated in part by the municipality, but they are also regulated, in part, by organization [by UPROL]. During our meetings, we try to raise the actors' awareness regarding the resource because the resource is shared between herders and farmers and often there are problems of resource access for herders. Moreover, most farmers, our members especially, are on the bank of the Lake, and often, there is an access problem" (Technical mayor advisor and UPROL chairman, 09/05/16)

So, POAS affects the adaptability of pastoralists by allowing a fragile security of pastoral areas, providing them opportunities for transformation. But above all, their adaptation capacity is being accompanied by informal agreements. Partly, in the municipality of Ngnith, another land-use policy is in progress and can influence the adaptation of pastoralists: PDIDAS program.

7.2.3 PDIDAS program: an inclusive development program?

Today, the PDIDAS is aligned with past policies, particularly with the PDMAS, by promoting the development of irrigated agriculture and the development of agribusiness. It's also conform with the national policy framework, the Emergent Senegal Plan (PSE) and its agricultural part, the PRACAS. This program declares that it is a participatory program. Therefore, pastoralists should theoretically find their place. However, it was found some ambiguities in the process of land selection in this project for the Nder site. The program has chosen lands, but no agribusinesses have been selected for now. A disagreement existed about the status of certain lands between Fulani and Wolof. Key stakeholders, notable people and local politicians were favorable to the georeferencing of these lands despite the opposition of a part of the local population. The "participatory" process seems so have limitations, which can induce a decrease of pastoral space, space which has already been reduced in recent decades

on the edge of the Guiers Lake. Faye and al. (2016) have calculated that the steppe grasslands and shrub steppe areas represented in 1973, respectively 8 891 ha and 11 718 ha. In 2010, these areas were 3 175 ha and 3 523 ha. This decrease was simultaneously accompanied by the increase of irrigated agriculture exploitations. We can also precise that their data don't integrate the implementation of WAF and Senhuile. A recent research underlines the current importance of irrigated land in the delta. In 2015, there is more than 70 000 ha of irrigated land mainly for agribusinesses (Bourgoin et al. 2016).

Further, PDIDAS program aims the increase of the irrigated land for the local population in parallel with the implementation of large scale agribusiness. This logic can only accentuate the fragmentation of space, thus limiting the mobility of pastoralists. So, it is their ability to adapt which is threatened. Some authors have already underlined that mobility was an adequate response to droughts in the 1970's and 1980's (Magrin et al. 2011). Fragmentation of space can be also accentuated by the logic of spatial location of the project:

"There is trouble for herders, because the project requires blocks of 500 ha, and in the zone, there are producers, herders, the land we have, it is land for agriculture, and there is also land for herders. The concern we have is that if we give land for agriculture, can we have land for herding? There's no more pastoral area, because we gave pastoral areas, that had been reserved for herding, we gave it to agribusiness as Senhuile. All that remains, if we still give it to investors, what will be left for pasture?" (POAS facilitator and PDIDAS focal point for Ngnith, 18/04/16)

So, in this context, the agropastoralism can be seen as a process of adaptation by transformation. The complementary document review helped us to underline that the perspective of cost-shared funds ("*fonds à frais partagés*") offered by the PDIDAS (PDIDAS 2015) could be a part of this dynamic in providing financial assistance to local populations and help herders to transform themselves. Indeed, the pastoralist activities are not eligible (PDIDAS n.d.), but if the area offers possibilities for irrigation, pastoralists should benefit from them in order to produce fodder and overcome the deficit of resources that can be caused by climate change. But if we focus in more detail on the allocation procedures, we see that funding is oriented for commercial crops for the national or international market. So, herders cannot benefit from them for produced fodder for their livestock consumption. The development of irrigation in view of a local fodder production does not seem to be supported by this policy.

Finally, the PDIDAS wants to be a source of inspiration for the ongoing land reform. Given PDIDAS' effect on pastoral livelihoods, this reform could further increase land insecurity for pastoralists regarding the local power relationship and other prospects looming.

7.2.4 Agribusiness and their agreements

Other actors can influence the adaptability of pastoralists by changing the availability of natural resources and the mobility of farmers. Here we will focus on agribusiness because their implementation is a part of important policies (PDMAS, PDIAS). Agribusiness are just two in the municipality of Ngnith, but because of their spatial control, they are significant stakeholders and their actions shape the pastoral adaptation. Indeed, with their implementation, they establish agreements with the municipality to implement solutions to the problems caused by their installation.

These agreements include cattle trail implementation, the installation of water access place or the access to the company plots so that pastoralists can benefit from crop residues. These three aspects are essential for farmers because they reduce obstacles to mobility, to benefit from water points that allow

them to avoid travel certain distances, or to compensate the lack of pasture. These aspects directly affect the ability of farmers to climate change adaptation.

Another example of cooperation between agribusiness and herders influencing the pastoral adaptation was met in the neighboring municipality of Richard-Toll. The Senegalese Sugar Company (CSS) opens its plots to herders so that they can access to crop residues. The residue of sugar cane could be used by the company to produce energy, but they preferred to give them to local farmers in order to maintain social peace. In 2015, this interaction saved a lot of cattle according to a member of the federative association for the understanding and the solidarity of herders of the Department of Dagana (AFESED), the association that makes the link between herders and the CSS. This interaction however raises the question of the scope of benefits for herders: who are the herders who have benefited from this interaction and how far the spatial influence of impact extends? And how this interaction allows autonomy or dependence for pastoralists? The agreement was built from the CSS willingness and compensation are given whereas CSS exploitation spreads in the Dieri, the pastoral land. In addition, the CSS also built trough for farmers to preserve social peace.

The WAF has also implemented a trough at the north of the exploitation where we met local pastoralists. One of these herders explained to us that this trough, even if it useful, bring some problems:

"Here, the drilling is useful but it poses other health problems related to the presence of bacteria that bring a new disease called "Waalo". You know, if the drilling water comes from the River [the Guiers Lake], and currently the river itself is infected. This stagnant water proliferates bacteria. This disease attacks the lungs and liver of animals and makes them vulnerable. "(Group interview with pastoralists near the trough set up by the WAF, 17/04/2016)

So, this collected evidence echoes the environmental consequences that we have highlighted previously through the development of bilharzia, this disease locally called "Waalo" that affect cattle.

The impact on mobility was also emphasized during this interview:

"Other problems are related to the pathway of animals, because of fields of individuals and companies such as WAF. Today there are paths of pasture (Deurlou) which are closed and forces us to make a substantial detour. "(Group interview with pastoralists near the trough set up by the WAF, 17/04/2016)

We were also able to realize such consequences of the Senhuile company. This company dug large trenches surmounted by a slope so that locals cannot enter on their plots. Since its installation in 2012, this company has crystallized strong opposition, particularly organized by the collective for the defence of the lands of Ndiael (CODEN). CODEN succeeded to set up a relatively broad network, including Senegalese as NGO's as ENDA and foreign NGOS allowed to mediate the local contestation. The Senhuile has implemented the livestock paths between his plots. However, some of the implemented paths are quite lacking in pasture. Their usefulness for pastoralists is thus questionable.

Photography 2 – A cattle trail created by Senhuile, April 2016



Policies favouring agribusiness implantation can provide mixed answers in terms of pastoral adaptation. Municipalities having weak financial resources, the opportunity to benefit from agribusiness agreements is seen as an opportunity to develop the local area. Agreements can allow them to respond to basic needs without taking into account the overall integration of pastoral activities. For example, WAF has supported the health centre of Yamane, allowed access to irrigation to a part of the population. In addition, few representatives have the skills to master all the implications and processes for a fair negotiation. Also, the autonomy of local collectivities is challenged by WAF addressing problems that would be otherwise addressed by the state.

7.2.5 Environmental protection

Lastly, we will discuss the possible consequences of the restoration project of the ecological functions of the Lake of Guiers (PREFELAG) which aims to improve the dynamics of the hydrological system of the Guiers Lake, including facilitations implementation for the rewetting of the Ndial wildlife reserve. The PREFELAG working locally with the Inter-Village Association of the Ndial (AIV) created in 2004 and involves 32 villages. The AIV rewets water bowl in 2010 thanks to a micro-GEF grant, leading a recovery of the colonization of the avifauna between the months of September and December.

We can make a few assumptions about the impact of the RSAN rewetting:

- It could improve the adaptability of pastoralists by improving their resilience by an improvement of the trough, and both in quantity and quality terms, because if the water flow is restored, the "Waalo" could greatly decrease.
- It could offer opportunities of jobs for pastoralists of the RSAN if rewetting generates a development of tourism, which is desired by some residents.
- Contrary, if rewetting is accompanied by stricter regulations for tourism, and if the of irrigation development for farmers and agribusiness continues, this could generate pressures for pastoral adaptation, even more compelling in their mobility and for resources access.

8 Conclusions

The delta of the Senegal River was a pastoral area, especially given the low agricultural potential of this space before the 1960s. However, political, economic and social history emphasizes a radical change of space occupation following a common thread since the colonization to the present time. This thread reflects in the will to "enhance" a space considered as 'non-productive' by the establishment of an irrigated agriculture, especially to increase the production of rice in Senegal. This goal has really started from the 1960s and has generated the beginning of the delta anthropization following the canalisation of the river by the dike on the left bank. All of the irrigation facilities (dikes, dams, etc.) have led to significant ecosystem changes (change of the flow of waters, invasive plants, etc.). Irrigation management policy also led to social changes, especially with the arrival of new residents.

To face the environmental disturbances and the effects of climate change, the policy framework does not show a real interest in pastoral adaptation issues. However, as the adaptation is not only constituted by actions that directly respond to climate change, or refer to it, we have seen that other policies have implications in terms of pastoral adaptation. Support for the development of irrigation led to an increase of permanently cultivated areas. This creates pressure on the paths, grazing areas and access to water. On the other hand, agricultural residues can compensate the lack of natural fodder. Other policies shape the adaptation capacity by affecting local collectivity (decentralization), land use (POAS, PDIDAS), natural resources availability and the space occupation (agribusiness implementation, PREFELAG).

Interactions allowed by these policies limit with more or less success problems for access to pastoral resources. Pastoral adaptation does not seem to be a real transformation of their activity or an adaptation by the resilience of the system. Pastoral adaptation would be more a coping strategy in response to constraints and opportunity allowed by the political context:

- POAS allows zoning which may allow the securing of pastoral areas but its application is not complete and the POAS cannot effectively fight the encroachment of pastoral area. Informal agreements complement the POAS to ensure mobility and access to the resources of the herders.
- The responses of the agribusiness in return for occupied spaces do not always correspond to the needs of herders and do not always take into account local realities. They are mostly developed in a technocratic logic: a trough can be created in compensation for closure of access to a former trough or access to Lake. But the example of the trough of the WAF shows that this solve the problems encountered by herders only in part. The health dimension that frequently concerned herders is not taken into account. In addition, the agreements providing for access to crop residues, although they may correspond to adaptation in times of drought, pose the question of the independence and autonomy of pastoralists. In this case, adaptation depend on the willingness of agribusiness.
- The operating forces working in Ngnith are characterized by the strong presence of the sweet potato sector actors sector who are interesting by irrigation facilities. It is an important factor in local development. This reflects the economic development of the area and their place is enhanced by the decentralization policy. They are present at key positions in the municipality and they are the relay of other organizations such as the SAED. This questioned of the representativeness of the herders, and their ability to influence local politics, so their capacity adaptation;

- The pastoral transformation logic is very discernible among herders who often refer to fodder crops as a possible opportunity for their future. Nevertheless, the possibilities for a real transformation are limited, funding opportunities being more oriented for trade agriculture;

The PDIDAS wants to be a model for land reform that should be adopted in 2017. The land dimension is important to increase the pastoral adaptation. This reform is an important issue and a change in the representation of space development is necessary. Indeed, a productivity logic induced a weak integration of pastoral area: “the land law is interpreted in a sense that the fact to maintain and regularly operate a pasture land is not considered to be an enhancement to giving pastoralists recognized and protected land rights” (CNRF 2016).

Finally, in a perspective of pastoralism resilience, the PREFELAG program could potentially offer solutions, but this adaptation doesn't seem to be a realistic option. The wish for pastoral transformation that we perceive among farmers and a large part of herders seems to be the future the most likely and realistic giving of the local context. Also, the social and cultural dimension of pastoralism should not be left out. It is easier to think about practice adaptation, but the social and cultural dimension should be integrated, especially if the pastoralism tends towards a radical transformation:

"God gave a great place for herding, but the population does not, or rather the State, within the general framework, gives no place for pastoralism, because if someone is dies, we'll buy an ox, or a sheep, or goats [from the herders]. We are going kill that." (Pastoralist in Dourki village, 20/04/16)

9 References

- Agrawal, A., 2005. Environmentality: Community, Intimate Government, and the Making of Environmental Subjects in Kumaon, India. *Current Anthropology*, 46(2), pp.161–190.
- Bélières, J.-F. & Touré, E.H.A., 1999. Impact de l'ajustement structurel sur l'agriculture irriguée du delta du Sénégal.
- Bezançon, G., 1995. Riziculture traditionnelle en Afrique de l'Ouest : valorisation et conservation des ressources génétiques. *Journal d'agriculture traditionnelle et de botanique appliquée*, 37(2), pp.3–24.
- Bourgoin, J. et al., 2016. Le delta du fleuve Sénégal: quel modèle agricole. In *Une nouvelle ruralité émergente. Regards croisés sur les transformations rurales africaines*. pp. 52–53.
- Bourgoin, J., 2014. Réflexions autour de la mise en place d'un observatoire participatif sur le foncier. Analyse de l'accès à l'information foncière et spatiale au niveau local. Expérimentation et analyse dans 4 communes autour du lac de Guiers,
- Brüntrup, M., Nguyen, T. & Kaps, C., 2006. Le marché du riz au Sénégal. *Agriculture & Développement Rural*, 1, pp.23–26.
- CNRF, 2016. Document de politique foncière. Draft 3,
- Cogels, F.-X. & GAC, J.Y., 1994. Modifications de l'environnement et approche de la problématique de gestion d'un lac sahélien dans le bassin du Sénégal,
- Corniaux, C., 2005. Gestion technique et gestion sociale de la production laitière: les champs du possible pour une commercialisation durable du lait. Cas des modes de production actuels du Delta du fleuve Sénégal. CIRAD, INRA, ISRA.
- Diene, R.S., 1998. Riziculture et dégradation des sols en vallée du fleuve Sénégal : analyse comparée des fonctionnements hydro-salins des sols du delta et de la moyenne vallée en simple et double riziculture. Université Cheikh Anta Diop.
- Dresch, J., 1949. La riziculture en Afrique occidentale. *Annales de Géographie*, 58(312), pp.295–312.
- Eriksen, S.H., Nightingale, A.J. & Eakin, H., 2015. Reframing adaptation: The political nature of climate change adaptation. *Global Environmental Change*, 35, pp.523–533.
- Faye, J., 2008. Foncier et décentralisation. L'expérience du Sénégal,
- Faye, V.M., Mbow, C. & Thiam, A., 2016. Évolution de l'occupation et de l'utilisation du sol entre 1973 et 2010 dans la zone agropastorale du lac de Guiers (Sénégal). *Vertigo*, 16(1). Available at: <http://vertigo.revues.org>.
- Gac, J.Y., 1991. Environnement et qualité des eaux du Sénégal. Rapport scientifique n°4.
- Gagnol, L. & Soubeyran, O., 2012. S'adapter à l'adaptation. La condition sahélienne à l'épreuve de l'injonction au changement climatique. *Géographie et Cultures*, 81. Available at: <http://gc.revues.org/200>.

- Handschumacher, P. et al., 1998. D'une urgence en santé publique à une géographie de la santé à Richard-Toll. In J.-P. Hervé & J. Brengues, eds. *Aménagements hydro-agricoles et santé (vallée du fleuve Sénégal)*. Paris, pp. 151–168.
- Hathie, I. & Ndiaye, O.S., 2015. Etat des lieux des impacts des importations de riz sur la commercialisation du riz local au Sénégal,
- Hervé, J. & Brengues, J., 1998. Aménagements hydro-agricoles et santé (vallée du fleuve Sénégal) ORSTOM.,
- Houma, Y., 1993. Les contraintes à la riziculture irriguée dans la vallée du fleuve Sénégal. Université Cheikh Anta Diop, ISRA.
- Jamin, P.Y. & Tourrand, J.F., 1986. Évolution de l'agriculture et de l'élevage dans une zone grands aménagements : le delta du fleuve Sénégal. *Les Cahiers de la Recherche-Développement*, 12, pp.21–34.
- John, A., 2015. The origins of Senegal's dependency on rice imports. *Rice Today*, (July-September), pp.28–30.
- Kamara, S., 2013. Développements hydrauliques et gestion d'un hydrosystème largement anthropisé. Le delta du fleuve Sénégal. Université d'Avignon, Université Gaston Berger.
- van Lavieren, L.P. & van Wetten, J.C.J., 1988. Profil de l'environnement de la vallée du Fleuve Sénégal,
- Magrin, G., 2008. Dynamiques territoriales et place de l'élevage au Sénégal. Document de travail Icare. Notes de synthèse n°2,
- Magrin, G., Ninot, O. & Cesaro, J.-D., 2011. L'élevage pastoral au Sénégal entre pression spatiale et mutation commerciale. *Mappemonde*, 103(3). Available at: <http://mappemonde.mgm.fr/num31/articles/art11304.html>.
- Mar, N.F. & Magrin, G., 2006. *Dynamiques spatiales, territoires et gestion foncière autour du lac de Guiers*, Available at: https://agritrop-prod.cirad.fr/533854/1/document_533854.pdf.
- Mathieu, P., Niasse, M. & Vincke, P.-P., 1986. Aménagements hydro-agricoles, concurrence pour l'espace et pratiques foncières locales dans la vallée du fleuve Sénégal. Le cas de la zone du lac de Guiers. In B. Crousse, E. Le Bris, & E. Le Roy, eds. *Espaces disputés en Afrique Noire : pratiques foncières locales*. pp. 217–238.
- McSweeney, C., New, M. & Lizcano, G., 2010. UNDP Climate Change Country Profil: Senegal. Available at: http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/UNDP_reports/Senegal/Senegal.lowres.report.pdf.
- Michel, P. & Sall, M., 1984. Dynamique des paysages et aménagement de la vallée alluviale du Sénégal. In C. Blanc-Pamard et al., eds. *Le développement rural en questions : paysages, espaces ruraux, systèmes agraires : Maghreb-Afrique noire-Mélanésie*. pp. 89–109.
- Mietton, M. et al., 2005. Le delta du fleuve Sénégal Une gestion de l'eau dans l'incertitude chronique. In P. Allard, D. Fox, & B. Picon, eds. *Incertain et Environnement*. pp. 321–336.
- Niang, A., 2011. Aménagement du lac de Guiers de 1824 à l'avènement des grands barrages du fleuve Sénégal : Prospective géographique. *Climat et Développement*, 12, pp.27–38.

- Niang, I. et al., 2014. Africa. In IPCC, ed. *Climate Change 2014: Impacts, Adaptation and Vulnerability - Contributions of the Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. pp. 1199–1265.
- Ostrom, E., 2009. A general framework for analyzing sustainability of Social-Ecological Systems. *Science*, 325(July), pp.419–422.
- PDIDAS, *Fonds à frais partagés pour le financement de sous-projets*, Available at: http://www.pdidas.org/sites/default/files/Fiche_Presentation_FFP_PDIDAS_ANO_Vf.pdf.
- PDIDAS, 2015. *Formulaire F1 de demande de financement de sous-projet*, Available at: http://www.pdidas.org/sites/default/files/FormulaireF1_FFP_PDIDAS_Vf.pdf.
- Pelling, M., 2011. Adaptation to climate change - from resilience to transformation,
- Philippe, C. et al., 1997. Aménagement hydrauliques et gestion de l'environnement dans le delta du fleuve Sénégal. In Singaravélou, ed. *Pratiques de gestion de l'environnement dans les pays tropicux*. pp. 389–401.
- SAED, 1985. Rôle et activités de la SAED dans le développement rural des vallées du fleuve Sénégal et de la Faleme,
- Sall, M. et al., 2011. Changements climatiques , stratégies d'aptation et mobilités. Evidence à partir de quatre sites au Sénégal,
- Santoir, C., 1997. Une ressource "durable" : l'élevage chez les villageois du Fouta (vallée du fleuve Sénégal). *Autrepart*, 3, pp.105–128.
- Schmitz, J., 1995. Évolution contrastée de l'agro-pastoralisme dans la vallée du fleuve Sénégal (Delta et moyenne vallée). *Natures Sciences Sociétés*, 3(1), pp.54–58.
- Sène, D., Deleuse, P. & Biries-Habas, J., 1971. Le riz au Sénégal : production et recherche, situation actuelle et perspectives. *Agronomie Tropicale*, 26(4), pp.433–455.
- Smit, B. & Wandel, J., 2006. Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, 16(3), pp.282–292.
- Touré, O., 2010. Études de cas sur la vulnérabilité et l'adaptabilité des éleveurs face aux événements dans la commune de Tessékéré au Sénégal,
- Tourrand, J., 2000. L'élevage dans la révolution agricole au Waalo, delta du fleuve Sénégal CIRAD.,



The International Livestock Research Institute (ILRI) works to improve food security and reduce poverty in developing countries through research for better and more sustainable use of livestock. ILRI is a member of the CGIAR Consortium, a global research partnership of 15 centres working with many partners for a food-secure future. ILRI has two main campuses in East Africa and other hubs in East, West and Southern Africa and South, Southeast and East Asia. ilri.org



CGIAR is a global agricultural research partnership for a food-secure future. Its science is carried out by 15 research centres that are members of the CGIAR Consortium in collaboration with hundreds of partner organizations. cgiar.org