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What are the prospects for mobile livestock systems in the face of the densification of rural areas and climate change in West Africa?

Thematic Reflection Note 2

This thematic reflection note was produced in the context of the implementation of the ECOWAS agricultural policy, ECOWAP, and more specifically of the 'Integrated and Secure Livestock and Pastoralism in West Africa' Project (PEPISAO), implemented by the ECOWAS Commission through its Directorate of Agriculture and Rural Development (DARD), and whose components 1 and 2 have been delegated to the CILSS Executive Secretariat.

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List of acronyms and abbreviations

APESS: Association for the Promotion of Livestock in the Sahel and Savannah

BOAD: West African Development Bank

C_3 : metabolic pathway of carbon fixation by photosynthesis (referring to 3-phosphoglycerate)

C_4 : metabolic pathway of carbon fixation by photosynthesis (by reference to oxaloacetate)

ECOWAS: Economic Community of West African States

REC: Regional Economic Community

CHIRPS: Climate Hazards Group InfraRed Precipitation with Station data

CH_4 : Methane

CIRAD: Centre de coopération Internationale en Recherche Agronomique pour le Développement

CIRDES: International Centre for Research and Development on Livestock in Subhumid Zones

CO_2 : Carbon dioxide

CRA: Regional Agrhymet Centre

CSE: Centre for Ecological Monitoring

CSFD: French Scientific Committee on Desertification

FAO: Food and Agriculture Organization of the United Nations

FAOSTAT: Food and Agriculture Organization Corporate Statistical Database

FARM: Foundation for World Agriculture and Rural Life

IPCC: Intergovernmental Panel on Climate Change

GIZ: Deutsche Gesellschaft für Internationale Zusammenarbeit

GMV: Great Green Wall

IPCC: Intergovernmental Panel on Climate Change (= IPCC)

IRAM: Institute for Research and Applications of Development Methods

N_2O: Nitrous oxide

NGO: Non-governmental organisation

PADEL: Livestock Development Support Project

PAPF: Pastoral self-promotion project in the Ferlo

PDDEPS: Programme de Développement Durable des Exploitations Pastorales au Sahel

PEPISAO: Integrated and Secure Livestock and Pastoralism Project in West Africa

GDP: Gross Domestic Product

PPZS: Pastoralism and Drylands

PRAPS: Projet régional d'appui au pastoralisme au Sahel

PREDIP: Regional Dialogue and Investment Project for Pastoralism and Transhumance

PRIDEC: Regional Investment Programme for Livestock Development in Coastal Countries

RBM: Billital Maroabe Network

RCP: Representative Concentration Pathways (IPCC climate scenarios)

ANR: Assisted Natural Regeneration

ROPPA: Network of Farmers' and Producers' Organisations of West Africa

IUCN: International Union for Conservation of Nature

UNCCD: United Nations Convention to Combat Desertification

ZDF: Zweites Deutsches Fernsehen (second German television channel)

Executive summary

The dynamics of livestock systems in sub-Saharan West Africa on the 2040 horizon will be determined more by current and expected societal changes than by climate change.

Climate change is expected to result in increases in the concentration of carbon dioxide in the air, in temperatures in the warmer seasons, and in rainfall mainly due to more frequent and intense heavy storms. These increases are expected to favour crop production, but also runoff, soil erosion and flooding.

The rapid and persistent increase in rural population density despite dramatic urbanisation is expected to fuel further expansion of cultivated lands and the reduction and fragmentation of rangelands, hampering pastoral mobility. This is likely to reduce the activity of seasonally mobile pastoral livestock farming, but also that of sedentary livestock farming deprived of rangelands and a source of competitively priced young animals.

A policy that would advocate the end of seasonal regional transhumance in favour of ranching and stabling, would precipitate the decline of pastoral livestock and increase their fragility in the face of climatic and security risks. This change would require an investment that is beyond the reach of livestock breeders, who would be reduced to working for private investors or agro-industrial companies.

The only policy that could sustainably support livestock systems in their diversity and complementarity would be resolute public investment by States and Regional Economic Communities (RECs) in the transformation and modernisation of pastoral mobility.

Access to pastoral resources and regional and local herd mobility should be secured by reaffirming the community or public status of water points and rangelands in hyper-arid zones, but also of non-cultivable land in wetter zones, as well as negotiated access rights to cultivated land after harvest. Frameworks for local and regional consultation should be established, and contractual agreements between pastoralists, agro-pastoralists and farmers should be facilitated.

It is necessary to complete, rehabilitate and manage the hydraulic and veterinary infrastructures, the livestock passage corridors, the land reserved for grazing, the lodgings or enclosures for the livestock, with a view to creating a network of infrastructures adapted to the available forage resources, established in consultation with the livestock breeders' associations and the local authorities.

A national and international commitment should overcome the civil insecurity that is rampant in many pastoral regions, along with significant investments in education, health, roads and telecommunications infrastructure that would ensure security and the adaptation of pastoral livestock farming to societal changes.

1 Introduction

1.1 Problems and issues

West Africa has enormous natural potential. According to FAO statistics, the region has about 236 million hectares of arable land in humid to semi-arid climates (Blein et al., 2008). About 55 to 60 million hectares are actually cultivated, or 24% of the potential each year. In addition to this cultivation potential, there are some 119 million hectares of pastureland suitable for the development of pastoral livestock farming. **Pastoral livestock farming is practically the only way to develop the hyper-arid, arid zones and the least fertile lands of semi-arid and sub-humid zones. Pastoral livestock farming is a major economic asset in the region, contributing 40-60% of agricultural GDP (UNCCD, 2019).** West Africa also has significant water resources. Indeed, according to FARM (2008), an average of 3,765 billion cubic metres of water falls in West Africa each year, with a variable distribution from one year to the next and very unequal between regions. Indeed, while the climate in West Africa south of the Sahara is governed by the West African monsoon (Redelsperger et al., 2006)the length of the rainy season and the volume of annual rainfall decrease from south to north, from the coast of the Gulf of Guinea to the Sahara, defining a bioclimatic gradient (Fig. 1) that structures primary resources (Aubréville and Chevalier, 1949; Le Houerou, 1989)but also agrarian systems in general and livestock systems in particular (Blein et al., 2008). Groundwater in the region is estimated at 316.7 billion m^3 and surface water is estimated at 271.5 billion m^3, but their geographical distribution is very uneven. The spatial distribution and seasonality of surface water is governed by the West African monsoon, but largely modified by surface or subsurface runoff patterns that define catchment areas, isolated in the endoreic regions of the hyper-arid and arid zones, or interrelated in the exoreic regions of the wetter zones (Malam Abdou, 2014). The distribution, depth, flow and recharge of groundwater depend primarily on the geology (Detay et al., 1992), with aquifers generally continuous, but often deep in the large sedimentary basins (Senegalo-Mauritanian; Taoudéni; Iullemmeden; Chad). On the other hand, the aquifers are discontinuous, often more superficial and localised along the streams in the socle (Mauritanides; West African craton; Nigerian shield; Hoggar-Ifoghas-Aïr shield).

West African agrarian systems are largely dominated by family farms, even if agro-industrial enterprises have a place in crops and plantations aimed at export, especially in the humid zones or in irrigated cultivation (sugar cane, bananas, pineapples, citrus, oil palm, etc.). The number of these family farms is very poorly known, probably more than 36 million for a rural population of 215 million in the ECOWAS countries in 2018 (FAOSTAT: http://www.fao.org/faostat/en/#data/QC). **These family agrarian systems are highly diversified in adaptation to regional bioclimatic layering, local agro-ecological particularities, peasant cultures, but also to the history of national economic and social policies** (Raynaut, 2001). Thus the climate layers the rainfed crops, with a limited choice of crops in the semi-arid zone dominated by millet associated with cowpeas, which expands with more rainfall to sorghum, groundnuts, then maize, cotton and soya, then tubers, yams, sweet potatoes and cassava, and finally rainfed rice and plantain, to mention only the main crops (Dixon et al., 2019).

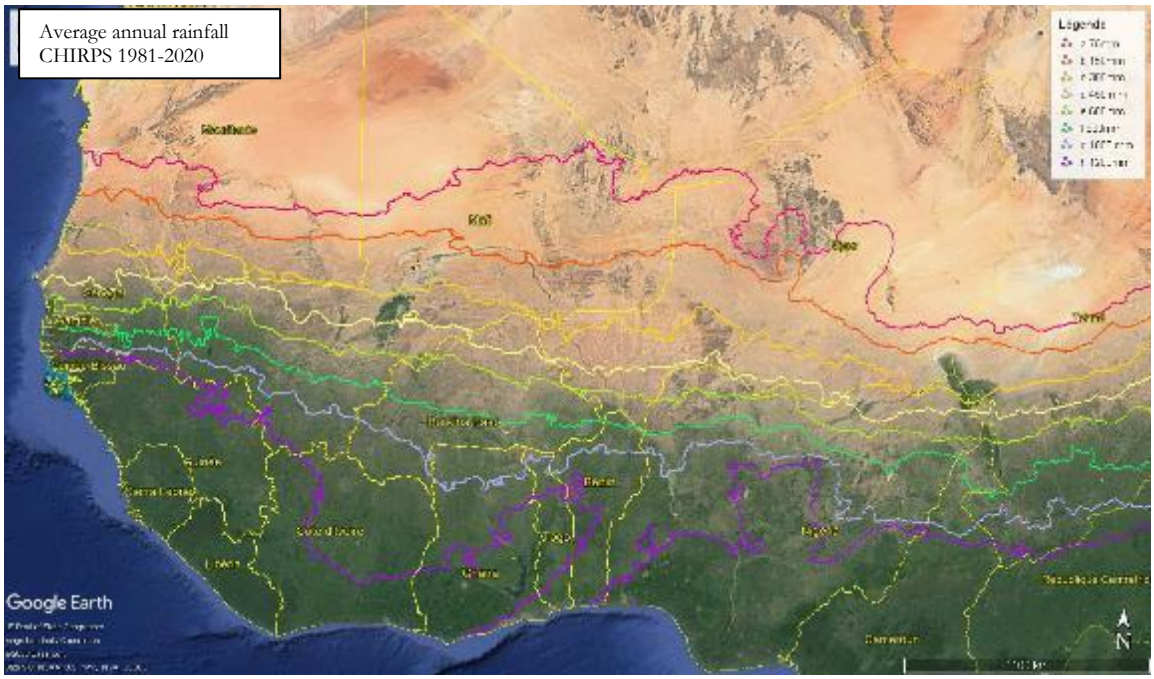


Figure 1: Map of average annual rainfall in West Africa (CHIRPS data 1981-2020). With the layered bioclimatic zones: hyper-arid, Saharan, north of isohyet 75 mm; arid, North-Sahelian, between isohyets 75 and 300 mm; semi-arid, South-Sahelian between 300 and 600 mm; sub-humid, Sudanese between 600 and 800 mm; sub-humid, Sudanese between 800 and 1000 mm; humid, Sudanese-Guinean between 1,000 and 1,200 mm; and very humid, Guinean above 1,200 mm. Sources Servir: https://climateserv.servirglobal.net/

At the same time, livestock systems and animal breeds are layered along the bioclimatic gradient, depending on the adaptation, as a result of centuries of selection, to the prevalence of climate-related zoonoses, such as trypanosomiasis, and to local agro-ecological particularities (Doutressoulle, 1947; Ickowicz et al., 2012). **The vast majority of livestock exploitations are also family-based, and are pastoral in the sense that the animals are fed almost exclusively from community or public grazing lands, including stubbles and fallow land** (Hiernaux and Assouma, 2020). Grazing is organised along a daily circuit, during the day and sometimes during the night (sometimes also organised over two or three days) that links the grazing areas to the watering points and the resting/rumination sites: stables, pens or simple lodgings. In addition to this daily mobility, seasonal movements of bigger amplitude may be conducted within or between countries by transhumant and nomadic pastoral livestock (ZFD, 2008; Turner et al., 2014). Whether local and daily, or regional and seasonal, pastoral mobility aims to optimise the quality of forage selection for grazing livestock (Assouma et al., 2018). **Whether they are sedentary or mobile, pastoral livestock farming is mainly for breeding, selling mainly young males and older, less productive animals** (Wilson, 1986; Wane et al., 2009). They form the main source of supply for fattening systems in peri-urban livestock farming and slaughterhouses in large cities. Consequently, the composition of their herd is largely dominated (70-85%) by females whose milk production, often seasonal, is only partially sold on local markets (Sanogo, 2011).

In contrast to southern and eastern Africa, ranching, in which livestock is also fed through grazing, but on private rangelands, is rare in West Africa (Thébaud & Corniaux, 2019). On the other hand, alongside pastoral livestock farming, there is sedentary livestock farming with stabling, in which the livestock is fed with fodder and distribution of feed at the trough (Lhoste et al., 1993). Stabled livestock farming is specialised in fattening, rearing, keeping traction or pack animals, or milk production. In hyper-arid and arid areas where cultivation is limited to oases and risky rainfed crops, pastoral livestock farming with seasonal mobility of regional amplitude dominates. In semi-arid and sub-humid areas, pastoral livestock farming with regional seasonal mobility coexists with sedentary pastoral livestock farming for which herd mobility is limited to local daily grazing circuits. In sub-humid and humid zones, mainly sedentary pastoral livestock farming coexists with stabled livestock farming, which are particularly developed in peri-urban areas.

Forage and water resources used by livestock farming are spread out along the bioclimatic gradient with sparse perennial herbaceous steppes with very sparse bushes and shrubs in hyper-arid rangelands whose production and forage quality vary greatly with rainfall from one year to the next. A single rainstorm can trigger the germination of ephemeral annuals, which are highly appreciated by livestock (a'acheb of Arab pastoralists) who complete their cycle in two to three weeks. In arid and semi-arid zones, rangelands are savannahs dominated by annual grasses, dotted with shrubs and small trees. The annuals are of excellent forage quality during the few weeks of growth, but die at the end of the rainy season and their straws are of poor forage quality and deteriorate during the long dry season of 07 to 09 months (Hiernaux and Le Houerou, 2006). However, many ligneous species provide strategically important green forage in the dry season (Assouma et al., 2017). In sub-humid and humid zones, herbaceous plants of the savannah are very productive turfy perennials whose forage quality decreases rapidly with growth (Fournier, 1996). On the other hand, the vegetative regrowth during the dry season, often made more accessible to livestock by fires that consume the mass of straw and litter, is of acceptable quality for maintaining the weighty state of the livestock (César, 1981). The density of woody growth in these areas varies from the extreme of grassy savannahs on superficial (*bowé*) or hydromorphic soils, to open forests and gallery forests, passing by more or less densely shrubby and woody savannahs. However, only a small number of these woody species are eaten by ruminants, so their forage value is limited despite the considerable masses of leaves produced (Guérin, 1994). Moreover, a large part of this mass of foliage is not directly accessible to animals because it is more than 3m high. In addition, crops provide a forage resource that increases with rainfall (Fig. 2). A large part of this forage is made up of the stubble of cereals, millet, sorghum, maize and rice, a large part of which is consumed by livestock by grazing directly in the field after the grain harvest. But an increasing share is also consumed after collection of the stubble, which is sometimes put in sheafs in the field or transported to the farm for private fodder use. On the other hand, the dual-purpose legumes, cowpeas, groundnuts, voandzou and soybeans, whose leafage is of high forage quality, is generally harvested and stored dry. Part of this fodder reserve is distributed at the trough and the rest sold in towns or along the roads through an animal feed chain that is beginning to be structured because of the recurrent shortages of forage resources in recent years. Finally, the residues of grain processing, husks and bran, feed

flour, cotton seed, cotton cake, groundnut cake, soya cake, sesame cake, are marketed as raw materials or after mixing as animal feed. So far, despite promotional efforts, the share of fodder crops remains minimal, with the exception of some irrigated crops (alfalfa and grasses for green cutting: Brachiaria ssp, Pennisetum ssp, Sorghum spp...) and legumes of variable nutritional value for animals used as cover crops in plantations in the humid zone (*Stylosanthes ssp, Arachis pintoï, Calopogonium mucunoides, Centrosema pubescesens, Mucuna pruriens...*) (Klein et al., 2014).

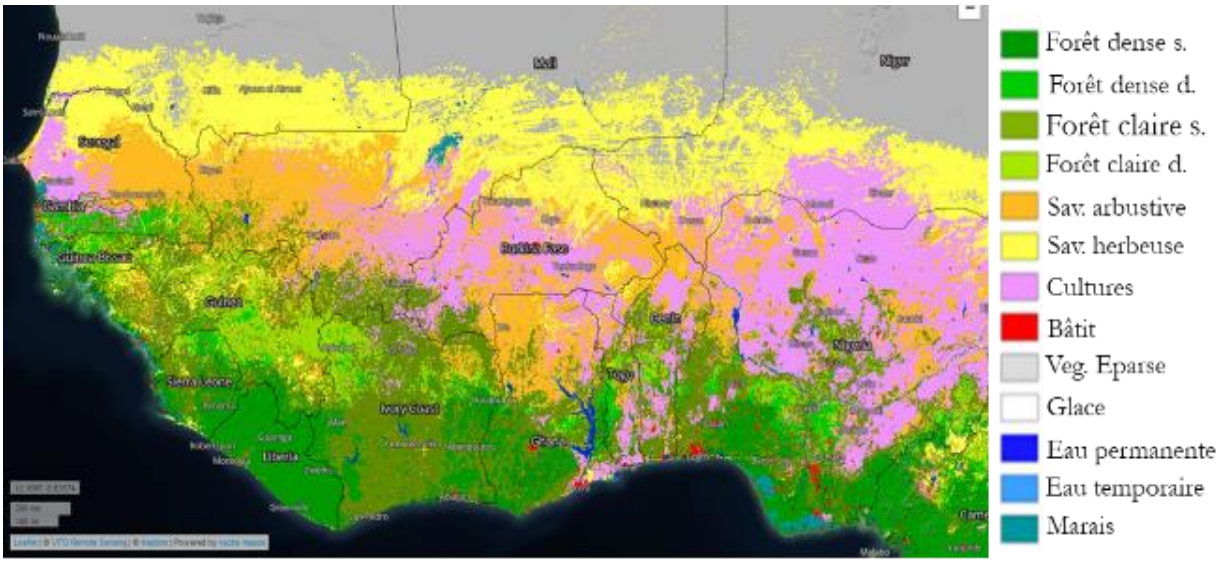


Figure 2: Land cover and type of vegetal cover map of West Africa produced by Copernicus Global Land Service (version 3 2015-2019).

For dense and open forests are distinguished from those dominated by evergreen species (s.) and deciduous species (d), For savannahs (sav.) shrubby savannahs are distinguished from grassy savannahs. Crops and plantations under forest cover should be added to crops. Source : Buchhorn et al. (2020).

Rangeland forage resources, whose area is decreasing due to the advance of agricultural fronts and urban sprawl, are increasingly faced with overexploitation and the impact of climate change (which is also anthropogenic), which reduce their productivity and quality. Indeed, cultivated land, which covered 520,404 km^2, 13.6% of the land of ECOWAS countries in 1975, covered 1,057,624 km^2, 27.8% of the land, in 2013, i.e. an increase of 104% in 35 years (Tappan et al., 2017). At the same time, built-up land increased by 141%, bare land increased by 10% due to soil erosion and the development of mining, while steppes and Sahelian savannahs decreased by 13%, Sudano-Guinean savannahs by 22% and forests by 20%. In addition, **the reduction in the area of rangelands is accompanied by their fragmentation and the occupation of livestock passage corridors, both of which reduce access to the remaining rangelands and sometimes to water points**. This reduces the room for manoeuvre for pastoral activities and limits the opportunities for future agricultural clearing. Nevertheless, depending on the country and the agro-ecological zone, the dynamics of resource exploitation play out differently; for example, there is an increase in cultivation in the arid pastoral zones of Mauritania and

Niger, a densification of agro-forestry in certain semi-arid agricultural terroirs, and an expansion of cultivated land in the vicinity of and in humid zones. **This situation has accentuated competition for access to natural resources and land for the two extensive production systems: agricultural family farming and pastoral livestock farming. Pastoral livestock farming is often perceived as a source of degradation of the vegetation through 'overgrazing', and of environmental degradation by accelerating erosive processes, and as an emitter of greenhouse gases, enteric methane in particular (Gerber et al. 2013). But many studies weigh the impact of grazing on production and plant diversity (Hiernaux 1998). The very strong seasonality of the growing season (Hiernaux and Le Houérou 2006), the non-equilibrium dynamics of the vegetation that derive from it (Behnke et al. 1993) and the very selective grazing behaviour of livestock (Krätli et al. 2013), which controls their herd behaviour (Moritz et al. 2014), would explain the moderation of this impact (Thébaud et al 1995; Assouma et al. 2019).** While many studies credit pastoralism with the capacity to regenerate soil fertility (Manlay et al., 2004; Hiernaux and Diawara, 2014; Rasmussen et al., 2018), land tenure policies that have been implemented have long favoured the expansion of cultivated land to the detriment of rangelands (Touré 2018) and thus of pastoral livestock farming. The growing difficulties of access to rangelands and water points for mobile livestock systems are at the root of often hasty proposals for reconversion or sedentarisation with the suppression of mobility (Nigeria Federal Government, 2019).

1.2 Objectives of this note

The objective of this second thematic note is to contribute to the prospective reflection on mobile livestock systems in the coming years in the Sahel and West Africa by considering the major trends of evolution in the sector.

Specifically, the note will seek to answer the following questions:

a. **What are the main medium-term evolution trends in the regional space** for pastoral and agro-pastoral production and resources, both forage and water, with regard to trends in the livestock, with attention for the preservation of local breeds and biodiversity? But also trends in access to these resources, land in relation to soil fertility, labour and the market for livestock products and inputs. These trends will be analysed in the context of climate change and societal changes: population growth, urbanisation, development of communications and new technologies, education and health, civil security, as well as the implications of current pastoral policies.

b. **How could such trends affect livestock systems in general, and pastoral livestock mobility in particular**, on the 2040 horizon in different agro-ecosystems? What are the resulting transformations in the performance, competitiveness and adaptability of these livestock systems?

c. **How will these transformations be able to meet demand for natural resources in the medium- and long-term** (forage and water, usage rights and land)? What will be the implications for agricultural policies concerning crops and livestock in the Sahelian,

Sudanian and Guinean zones (how to secure pastoral livestock farming in the absence of mobility, particularly during climatic crises, how to ensure the fertility of cultivated land)?

d. **How should land tenure policies anticipate the exacerbation of competition for access to natural resources,** to land, water, wood, herbaceous and woody forage, and accompany such transformations?

e. **What place for pastoralism and agro-pastoralism in future agricultural and land tenure policies?**

f. **What would be the multidimensional impacts of sedentarisation of pastoral livestock systems with regional mobility in the context of climate change and ongoing societal changes?**

g. **What would be the implications in terms of governance of space, terroirs and specifically agro-pastoral land** for access to land by sedentarised pastoralist livestock breeders?

h. What regional cooperation policy to establish peaceful transhumance and pastoral migration?

i. To propose and evaluate three alternative scenarios for livestock farming in West Africa in the coming decades.

1.3 Methodology

The production of this note will be based on two complementary approaches:

a. A documentary review, which should be based on the work of: (i) CILSS, in particular the CRA in Niamey, (ii) IUCN in Ouagadougou and CIRDES in Bobo Dioulasso. These institutions have carried out work on the state of natural resources and their recent evolution, the dynamics of pastoralism and animal diseases over the past decades. This analysis will also focus on documents (study and reflection reports) produced by international institutions (FAO, African Union, CIRAD and IRAM in Montpellier) in relation to pastoralism and natural resource management, notably land tenure, grazing land, water resources and livestock rangelands.

b. Conducting a number of interviews with: (i) resource persons involved in natural resource management in West Africa (CSE in Dakar, Abdou Moumouni University in Niamey, CIRDES in Bobo Dioulasso, PPZS in Dakar); and (ii) leaders of agricultural producers' organisations (ROPPA), livestock breeders and agro-pastoralists (APESS) and pastoralists (RBM) to gather their perceptions of past and future trends in the region's natural resources and the practice of pastoralism

2 Putting into perspective the climatic, land and forage mutations underway in West Africa and the Sahel

2.1 Climatic, land and forage change factors affecting pastoral livestock systems with regional mobility, and emerging dynamics

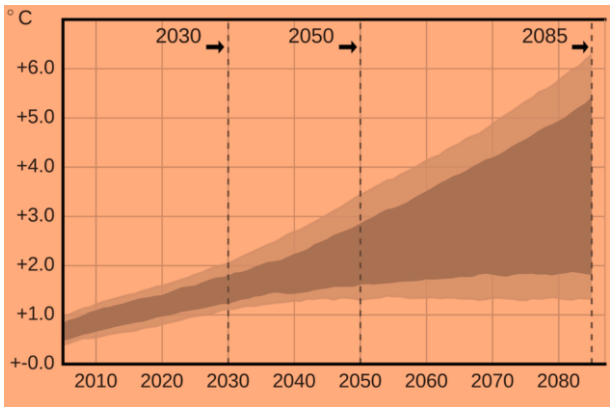
Climate change

As elsewhere on the globe, the climate is affected by rising air temperatures, as a function of increasing concentrations of greenhouse gases, in particular CO_2 , CH_4 and N_2 O (IPCC, 2013). The average annual temperature increased by 1 to 2°C in the Sahelian zone and only by 0.5°C in the Guinean zone between 1950 and 2010. And the temperature increase has accelerated to 0.24 to 0.30°C per decade in the Sahel and 0.15 to 0.20°C in the Guinean zone over the past 30 years. However, in the context of the West African monsoon prevailing in the region, the temperature increase affects mainly the hottest months at the end of the dry season (April-May-June), and a little at the very beginning of the dry season (October-November), mainly through higher daily and therefore nightly minimum temperatures (Guichard et al., 2017). **This increase in temperature therefore has little impact on the growth of plants, including crops, which grow during the rainy season**. According to the projections of the global models used by the Intergovernmental Panel on Climate Change (IPCC, 2013)temperatures are projected to continue to rise across the bioclimatic gradient during the 21st century (Fig. 3), by 1.7°C in the optimistic scenario (representative concentration scenario, RCP 4.5 Wm^2) and by up to 4.3°C in the pessimistic scenario (RCP 8.5 Wm^2).

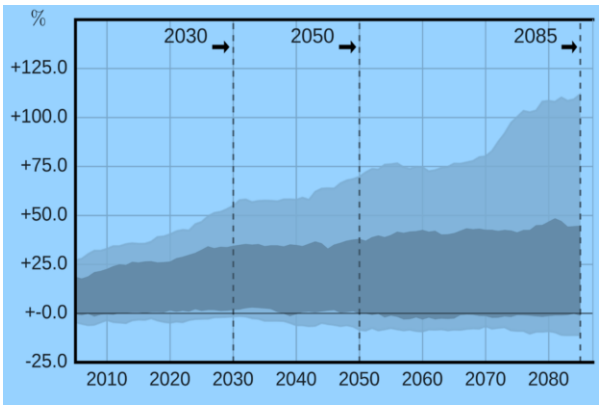
The annual rainfall trend observed so far (Lebel and Ali, 2009; Nicholson, 2013)and climate forecasts based on global modelling (Fig.2) contradict the popular belief disseminated by the media of a progressive aridification trend in West Africa (Boudet, 1972). Indeed, in the Sahel, after twenty-five years of low rainfall from the late 1960s, with two major droughts in 1973-74 and 1984-85, annual rainfall has increased in the central Sahel since the mid-1990s, and since early 2000 in the western Sahel (Nicholson, 2013). **However, this return to higher average rainfall is spatially uneven with large inter-annual variations and has not reached the rainfall levels of the 1950-1967 humid period**. In addition, the rainfall pattern has changed with the same number of rainy days as during the dry period 1968-1993 (Ozer et al., 2017) but with a higher frequency of heavy rains which increases the risk of flooding (Panthou et al., 2014). There is also a prospective trend towards a slightly later distribution of rainfall. These changes in distribution strongly influence rangeland productivity, with a sharp decline in some years when there is a long interruption of rainfall during the rainy season.

Rainfall was less affected in the Sudanian and Guinean zones than in the Sahel during the three dry decades 1970-1990, but over the last two decades average annual rainfall has increased, more markedly on the coast than inland and in the Sudanian zone, and more markedly in the east (Nkrumah et al., 2019). As in the Sahel, this increase is explained

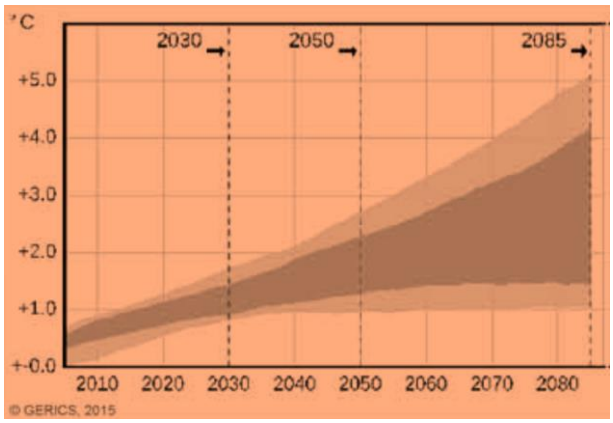
by a greater frequency of heavy storms, more marked during the second rainy period (September-November).



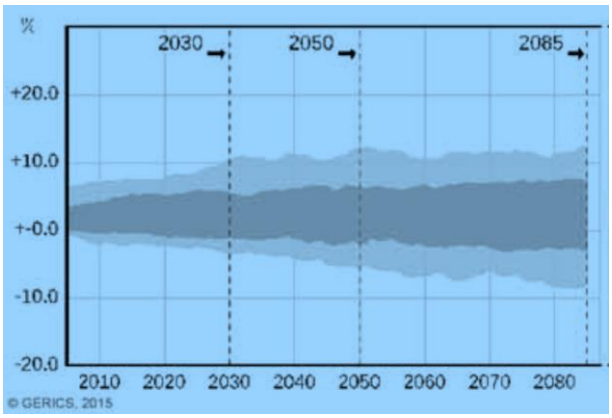
Niger: average temperature/year (°C)



Niger: total annual rainfall (%)



Benin-Togo-Ghana: average temperature/year (°C)



Benin, Togo, Ghana: total annual rainfall (%)

Figure 3. Predictions of IPCC AR5 global models for all scenarios (RCP2.6, 4.5, 8.5) with high (66%: dark band) and very high (90%: light band) probability. Source (GERICS, 2016) Climate fact sheet

These trends of increasing rainfall, accompanied by increasing temperatures, especially in the dry season, and increasing atmospheric CO_2 concentration should favour plant growth at least where soil nitrogen and phosphorus fertility allow, and in particular on the Saharan margins of the Sahel. Indeed, these same factors should also reinforce soil leaching, worsen acidity and accelerate the mineralisation of organic matter, leading to a drop in productivity (Penning de Vries and Djiteye, 1982). **It is also possible that these trends, especially the increase in CO_2 levels, favour plants with C3-type photosynthesis, in particular ligneous plants, to the detriment of plants with C4-type photosynthesis, in particular annual grasses in the Sahel and turfy perennial grasses in the savannahs** (Ghannoum et al., 2000; Poorter and Navas, 2003). This could eventually lead to the overgrowth of rangelands and savannahs, which is already very prevalent in southern and eastern Africa (O'Connor et al., 2014; Belayneh and Tessema, 2017).

The higher frequency of heavy rainfall and the local reduction of vegetation cover due to the extension of cultivated and built-up areas, as well as the increased pressure of livestock on the remaining rangelands, should favour runoff, leading to a drastic change in local water

balances with an increase in the share of rainwater flowing into rivers, ponds and aquifer recharge (Favreau, 2002; Gardelle et al., 2010; Gal et al., 2017). Even the flooding regime of the largest rivers has already been affected, as in the case of the Niger River in Niamey, which is now experiencing its first early flood, known as the 'red flood' because the water is very turbid, fed by local runoff (Descroix et al., 2012).

Societal changes

The major component of societal change in sub-Saharan West Africa is the rapid and persistent increase in population density at a rate of 3-4% per year since the mid-20th century (Guengant and May, 2011). This first affected the previously prevailing rural population, and then accelerated the growth of the urban population in the coastal countries and more recently in the interior countries (Denis and Moriconi-Ebrard, 2009). Among the consequences affecting pastoral livestock farming, cultivated areas are expanding at a rate close to that of human demography because there is little intensification of cropping systems (Breman et al., 2001; Powell, 2014; Dixon et al., 2019). Cultivated areas have increased at the expense of pasture and fallow land, and this has been accompanied by a fragmentation of land parcels, which isolates pastures that require more precautions to access, closer guarding of herds and more prior negotiation by pastoralists. In addition, the pastures converted to cropland were generally the most fertile, especially in the humid zones, leaving the least productive, hyper-arid and arid, rocky or cuirassed lands (Schlecht et al., 2006). The expansion of cultivated land is often accompanied by changes in land tenure towards private use, limiting communal use, including grazing rights (Turner et al., 2016). While access to residual grazing land is sometimes restricted, it remains free, while access to stubble and crop residues is increasingly monetised. In coastal countries, particularly Nigeria, but also Côte d'Ivoire and Senegal, land grabbing by agribusinesses is contributing to the privatisation of access by villagers. **The reduction in pastoral resources, the reduction of the surface and access to rangelands, are all obstacles to the regional and seasonal transhumance of pastoral herds.** However, transhumance towards the humid zone and the Sudanian zone at the end of the dry season is essential for the reproduction of livestock by maintaining their diet at an acceptable level, while the forage resources of the Sahelian belt are becoming very poor (Hiernaux et al., 2015). **The deficit of resources in the dry season is all the more serious as the density of livestock has also increased with the human population, albeit at a lower rate than the cultivated area** (Corniaux et al., 2012). The seasonal forage deficit is aggravated by the disparity in access to water, linked on the one hand to the irregular network of water points and on the other to their varying capacity and status. Water points are locally abundant, as in the Senegalese Ferlo, but form a very loose and disparate network in pastoral regions such as Gourma in Mali. Forage resources in under-equipped regions are under-utilised to the detriment of heavy loads around permanent surface water points and large boreholes (Béchir and Mopaté, 2015). On the other hand, civil insecurity in the Sahel and in the north of the coastal countries poses additional obstacles to livestock mobility in the wet and dry seasons (Déclaration de N'Djamena, 2013). In addition, land privatisation policies with the allocation of land titles to individual farmers and the sedentarisation of mobile populations in some of the coastal countries have adversely affected livestock mobility (Bassett, 1988; Moutari and Giraut, 2013). The first adaptation of families of pastoralist livestock breeders to restrictions on access to vital pastoral resources was to diversify their economic activities,

often by growing food crops to meet family food needs (Manoli et al., 2014). This implies a minimum of land access rights, usually denied to pastoralists in sub-humid zones, and sedentarisation for at least part of the year and/or part of the family, and in turn contributes to the expansion of cultivated land, particularly in the arid zone on the northern agricultural front. However, the increase in pluri-activity within pastoralist families (Magnani et al. 2019) has also contributed to a reduction in young men's skills in livestock farming techniques and day-to-day management of the animals, leading to a shortage of skilled labour (Turner and Hiernaux, 2008).

2.2 Public policies and other interventions related to climate change, densification of pastoral areas, and forage production capacity

All ECOWAS countries have signed or ratified the Paris agreements on climate change. However, the funding commitments of the States, which are also very much in demand due to the urgency of ensuring civil security and coping with natural disasters, are difficult to meet and funding is mainly based on international aid (Watson and Schalatek, 2020).

Environmental policies inherit a forestry tradition that places great emphasis on forest plantations as a tool for climate change adaptation and mitigation. The example of the international Great Green Wall project (Duponnois and Dia, 2010; CSFD, 2011) project is emblematic in all Sahelian countries. However, the achievements in the domain of plantations are far below expectations, partly due to a lack of monitoring of plantations in the first few years and low monitoring rates of young plants (Mugelé, 2018). Furthermore, this plantation policy does not slow down the exploitation of forest resources, in particular to meet the needs of growing cities for firewood, timber, service wood and charcoal. Even the sanctuaries of conservation areas, classified forests and national parks, are hardly spared. On the other hand, significant investment is being made in anti-erosion measures (terraces, stone barriers, half-moons, etc.), particularly in the Sahel countries, with the involvement of rural populations and NGOs, largely financed by international aid (Di Vecchia et al., 2007). Some of these anti-erosion schemes are accompanied by forest plantations, the impact of which on 'regreening' due to woody growth is unfortunately not assessed, regreening extending widely in the Sahel outside the developed areas (Brandt et al. 2016).

In addition to erosion control interventions, national agricultural policies aim to support the ‘modernisation’ and diversification of crops. In addition, they aim to promote agroecological practices to combat soil fertility degradation. In these so-called agro-ecological initiatives, the role of livestock is very often limited to the contribution of manure for organic amendments to crop soils and the valorisation of crop residues. The reasonable management of agroforestry stock, popularised under the term 'Régénération Naturelle Assistée' (Assisted Natural Regeneration), is widely promoted in Sahelian countries, particularly in Niger and Burkina Faso (Reij et al., 2005) but its long-term impact has not been assessed. The intensification of cultivation practices is more advanced for cash crops, in particular cotton, and to a lesser extent groundnuts, sesame and soya. This trend has also been observed for a long time for industrial crops, especially in coastal countries: sugar cane, pineapple, cocoa, coffee, rubber, oil palm and banana. **For food crops, and in**

particular the cereals millet, sorghum, maize, fonio and alluvial rice, cultivation practices remain very extensive overall, with differences between countries and regions in the use of animal traction and very rarely mechanical traction. The use of micro-doses of fertiliser placed in the furrow together with the seeds to increase yields is promoted, but is far from being widely adopted (Ibrahim et al., 2016). Similarly, the adoption of improved varieties created by agronomic research varies greatly from one country and region to another. It is true that these varieties only express their productive superiority under good growing conditions: soil fertility and rainfall (Walker et al., 2014).

In contrast to the domains of crops, forestry and agroforestry, investments in the domain of livestock are low, and not commensurate with the economic contribution of livestock (Zoundi and Hitimana, 2008). They focus on veterinary health and livestock markets, and locally on pastoral water infrastructure, but little on production and value chain development. In addition, a divide has emerged between the livestock policies of the Sahelian countries and the coastal countries. Indeed, the economic and social contribution of pastoral livestock farming is beginning to be officially recognised in the Sahelian countries with the recommendations of the Déclaration de N'Djamena (2013) followed by the political agreements of the Déclaration de Nouakchott (2013). This recognition has been accompanied by the funding of dedicated development projects such as the 'Projet régional d'appui au pastoralisme au Sahel', PRAPS1 (World Bank, 2015) whose phase 2 is under preparation, but also the regional investment programme for livestock development in coastal countries, PRIDEC (Magnani et al., 2017) which is slow to be launched due to lack of funding, the Livestock Development Support Project, PADEL (De Haan et al., 2016) the Regional Dialogue and Investment Project for Pastoralism and Transhumance in the Sahel and Coastal Countries of West Africa (PREDIP), the Sustainable Development of Pastoral Operations in the Sahel Programme (PDDEPS) and the Integrated and Secure Livestock and Pastoralism in West Africa Project (PEPISAO). In pastoral regions, the objective is to rehabilitate, complete and manage water and veterinary infrastructures in consultation with livestock breeders' associations and local authorities (Bonnet et al., 2005). In the agropastoral regions, the objective would be to set up local and regional consultation frameworks to make dry season transhumance more efficient and mutually beneficial (Oxby, 1985). However, in coastal countries, as in the south of some Sahelian countries, this objective is opposed to the desire to 'modernise' livestock farming by making it more sedentary, replacing grazing on the rangelands with the feeding and distribution of animal feed harvested on the farm or bought on the market. This objective of sedentarisation of livestock farming accompanies a policy of securing land for farmers, which aims at attributing land titles to farmers. Seasonally mobile pastoralists, who until now have played a dominant role in animal production in coastal countries (FAO, 2019), risk being excluded from this privatisation, as they are not permanent residents and use common areas without delimitation of the exploitation area (Robert et al. 2018). This policy of land privatisation accompanies the fairly general trend towards administrative deconcentration, followed in some countries by partial decentralisation, which is contrasted by the verticality of political power reinforced by the militarisation carried out in response to civil insecurity and terrorism. However, the importance of economic exchanges between Sahelian and coastal states argues for inter-state agreements to facilitate cross-border livestock mobility (FAO/CIRAD, 2020).

3 What evolution scenarios and perspectives on the 2040 horizon?

Regardless to which IPCC scenario the reality in 2040 will resemble, it will be 0.5-1°C warmer in the Sahel and 0.25-0.5°C warmer in the South, and average rainfall will have increased by 5-25% in the Sahel and 0-5% in the South, with, in all cases, a greater frequency of heavy storms, especially at the end of the rainy season. **Plant production of crops and rangelands is expected to increase slightly with the increase in CO2 and rainfall, with perhaps an advantage for woody plants and thus a tendency for overgrowth**. However, some agro-climatic models predict a reduction in millet and sorghum yields, mainly due to the temperature increase and its impact on evapotranspiration (Sultan et al., 2013). **Whatever happens with the crops, the supply of high-quality forage is expected to remain highly seasonal, varying from year to year with rainfall distribution and unevenly distributed in space locally, but also along the bioclimatic transect. The primary justification for pastoral mobility should therefore persist.**

However, in the next 20 years, social and institutional changes seem to be more important than climate change for the evolution of pastoral livestock farming. Indeed, the population boom is expected to continue, even if a slowdown in growth rates may be confirmed in coastal countries. And even if a resolute policy of investment in agricultural intensification were adopted in the meantime, the rural exodus is likely to continue. Nevertheless, the demographic growth of the rural population, in the absence of a (unlikely) very rapid development of alternative employment for rural youth, is likely to result in the continued expansion of land cleared for crops, with the saturation of already densely populated terroirs in the southern Sahel and northern Sudanian zone (Fig. 2), and also in the opening of new agricultural fronts at the northern margin of crops in pastoral areas, often as a result of the sedentarisation of pastoralists. As a result, pastoral space is expected to continue to shrink and fragment. The historical shrinkage of pastoral areas, their fragmentation and the obstacles to access by herds as herdsmen families and livestock numbers grow, are expected to push pastoral livestock farming to the limits of viability of animal production (Lesnoff et al., 2012).

No one knows what the civil security situation will be in 2040 in ECOWAS countries and neighbouring countries. Nevertheless, a persistence, extension or worsening of the current local insecurity situation could lead to population displacements, an acceleration of the rural exodus, and perhaps locally abandonment of agricultural and pastoral lands. The following evolution scenarios will be explored: i) continuation of current policies; ii) radical change with an end to transhumance; iii) resolute investment in the modernisation of pastoral mobility.

3.1 No policy change scenario: continuation of current policies

The consequences for climate change over the next 20 years of a continuation of current policies that differ between Sahelian and coastal countries are difficult to measure, but they are likely to mark the ways in which the economy adapts-mitigates to climate change. **The most sensitive area is likely to be the continued expansion of cultivated land to the**

detriment of rangelands throughout the region, with the exception of hyper-arid confines and uncultivable land (rocky, cuirassed). The already densely populated terroirs of western Senegal, southern Mali, central and western Burkina, southern Niger and northern and central Nigeria (Fig.2) are expected to reach saturation and cropping fronts are expected to spread along the northern borders of the terroirs in the arid zone in Senegal in the Ferlo and along the Senegal River, in Mali in the Kaarta, but also in the Séno Mango and southern Gourma, in Niger in northern Zinder and Gouré and Diffa, as well as on the periphery of the national parks located in subhumid and humid zones. (Robert et al., 2018)

Without international political will and monitoring of an effective implementation, this expansion of cultivated land is expected to rapidly reduce the mobility of pastoralists and their herds. Transhumance by Sahelian pastoralists to sub-humid zones at the end of the dry season and the beginning of the rains would become too risky and costly to enable herders to reduce the weight loss of livestock at this season and to maintain the reproductive performance of females which relies on the condition of the females throughout gestation. The already low fertility rates of adult females compared to livestock on other continents with an age of cows at first calving between 4 and 5 years and a calving interval of 1.5 to 2.5 years cannot be reduced without strongly affecting the productivity of the livestock (Wilson, 1986).

Conversely, the gradual abandonment of pastoral corridors is likely to make transhumance by pastoralists from the sub-humid and semi-arid zones to the rich rainy season rangelands of the arid zones, **very perilous.** This transhumance allow sthem to gain weight quickly while relieving the scarce rangelands of the semi-arid and sub-humid agricultural terroirs from pastoral pressure during the growing season. Of course, the vast rangelands of the arid zones and Saharan margins would maintain their pastoral status, allowing local and regional mobility of the herds and enabling them to optimise forage selection, which is very important to herd productivity. Nevertheless, **the progressive closure of the rangelands in the south should make the herds more fragile by confining their mobility to the north of the Sahel, with no way out in the event of a disaster: drought, devastating fires, locust invasion, epizootic disease outbreaks, civil insecurity, state of war** (Anderson and Monimart, 2009). In the long term, this fragilization is expected to reduce the livestock population and production of North Sahelian pastoral farming and thus its capacity to provide young animals, especially males, to the pastoral and specialised livestock exploitations of the South in a competitive manner. The increase in the price of young animals sold on the market by pastoralists can undermine the profitability of sedentary livestock exploitations specialising in rearing or fattening young or old animals, even though the demand for meat on the market is booming as a result of population growth and the emergence of a middle class in the towns (Zoundi and Hitimana, 2008).

Agro-pastoralist livestock farming in semi-arid and sub-humid zones are likely to be the most affected by the expansion of cultivation. Indeed, its access to northern Sahelian rangelands will be quickly compromised by the disappearance of passage corridors, and especially to pastoral enclaves, by the expansion of fields (Robert, 2010). **This type of livestock farming will be condemned to sedentarise, and a more optimal integration of agriculture and livestock farming will be required in the valorisation of crop residues**, **the recycling of organic matter in the fields** and the development of fodder crops.

However, the pressure on land will leave little room for fodder crops, except for crops associated with cereals, the main candidates of which are dual-purpose legumes, cowpeas, groundnuts and soybeans that are not grazed directly. At best, small plots could be allocated to the cultivation of fodder grasses (Brachiaria sp, Pennisetum sp, Sorghum sp...) which are mown green for feeding at the trough in the rainy season. In addition, initiatives such as the one underway in Burkina Faso to promote shrub fodder banks could enable agro-pastoralists to produce woody fodder throughout the year on small parts of their farms (Sib, 2018; Sib et al., 2020). It is obvious that the cost of labour and inputs would limit this practice to very small stabled livestock holdings. Here again, **it is likely to be necessary to count on a decrease in the number of livestock, which would lead to the impoverishment of rural people, and a reduction in the organic and mineral recycling carried out by the livestock via the distribution of their excretions** (Schlecht et al., 2004). In the long term, this decline in recycling, while crops densify, could aggravate the erosion of soil fertility unless it is compensated for by fertilisers, which are unlikely to be used on food crops, unless a resolute policy of providing farmers with access to organic and mineral fertilisers is implemented to increase productivity and meet the commitments to neutrality with regard to land degradation made by the Sahelian states in the framework of the UNCCD.

3.2 Scenario of radical change: the end of transhumance

A suspension of regional and seasonal herd mobility could only be achieved by coercion, particularly in the northern Sahelian rangelands. The difficulty of implementing a ban on cross-border transhumance justified by the authorities on the basis of economic, security or sanitary risks is evidence of this (SIRP, 2020). Nevertheless, policies to sedentarise pastoral livestock farming, sometimes presented as policies to combat the 'divagation' of livestock, are not new and have resulted in failure or have not been effectively implemented, as in the case of the Pastoral Self-Promotion Project in the Ferlo (PAPF) supported by GIZ in Senegal (Kiéma et al., 2006). On the other hand, this remains a policy envisaged in several coastal countries, in particular by the National Livestock Transformation Plan of Nigeria (Nigeria Federal Government, wants to be part of this perspective between 2019 and 2028[i] .) despite the major place (80%) that pastoral livestock occupies in the country's animal production (ruminants) (FAO, 2019). This is also the case in Benin, which for the past three years has been showing a desire to sedentarise its livestock while prohibiting transhumant herds from neighbouring countries from entering its territory. Benin is actively negotiating funding from regional donors, in particular BOAD, to launch its sedentarisation plan. On the other hand, elsewhere in Eastern and Southern Africa, and on other continents, in particular in Australia, the USA, Brazil and Argentina, there is an alternative to pastoral livestock farming with seasonal mobility: ranching, which is a kind of livestock farming also aimed at reproduction, with animals fed mainly by grazing. But in ranching, the grazing land is private (individuals or companies) instead of being pastoral commons. This requires the fencing of privatised grazing areas where the control of these loads can be managed. Fencing and the installation of watering points on the ranches require costly initial investments that could only come from external funding, then maintenance and labour costs are high, difficult to cover in the long term, as shown by the fate of fences and installations (watering troughs, contention corridors) of most private or public ranching attempts (Boutrais, 1990; Thebaud

et al., 1995). **Ranching implies a reduction in herd mobility even when a sophisticated and rapid rotation of cattle from one area to another is planned** (Savory, 1983). Maintaining a herd of fixed size within the same space implies that annual pasture production is stable. This stability of resources is impossible in the Sahelian environment because of the variable distribution of rainfall in time and space. Controlling the loading rate is an asset of ranching, but **the lack of flexibility quickly leads to under-utilisation of resources on part of the rangelands, in certain years and seasons, with increased risks of overgrowth or accidental fire**, and over-exploitation in other parts of the rangelands with the risk of favouring invasive refusals. These risks are reinforced by the keeping of a single species, often a single breed (Achard and Chanono, 2006) as observed on most ranches, thus losing the benefits of complementary feeding behaviour in multi-species livestock farming.

Socially, the high investments required to set up and manage a ranch excludes local pastoral families and isolates the owner, who is often distanced from the manager and salaried herders (Thébaud & Corniaux, 2019). This can lead to a rapid erosion of the professional skills of the herders who lose their full management responsibility. If ranching were to be developed, supported by land privatisation policies and investment in animal production by the wealthy, both national and foreign, it would exacerbate the reduction and fragmentation of pastoral space for the remaining seasonally mobile pastoralists herders. According to Sounon et al. (2019) '*the sedentarisation of mobile herdsmen would break the local complementarity between livestock systems and lead to a loss of meat production. Moreover, none of the explored improvement scenarios would be sufficient to compensate for the loss of meat production resulting from the sedentarisation policy''.*

Another alternative to pastoral livestock is to reduce seasonal and regional mobility, at least during the dry season: stabling. Stabled livestock (raised in stables or pens) are fed at the trough with large quantities of collected and preserved fodder such as hay, leguminous crop stalks (cowpeas, groundnuts, voandzou), cereal stubble or agro-industrial by-products (cotton seeds, oilcake, molasses, etc.). This trend is already present in pastoral livestock systems, which are faced with severe restrictions on access to grazing land in the dry season (Fernández-Rivera et al., 2005) and, of course, in specialised stabled livestock exploitations, especially in peri-urban areas. As a result, seasonal and regional herd mobility is reduced or eliminated, which allows for the decoupling of loading rates from local forage availability with the risk of overgrazing during the growing season, leading to a reduction in year-round forage resources and a risk of degradation, especially through invasion by species rejected by livestock, such as *Sida cordifolia* in the Sahel or *Hyptis suaveolens* in the sub-humid savannahs, which are already common in livestock concentration areas. In addition, Sahelian pastoral livestock farming is geographically not well situated to produce or import fodder or agro-industrial by-products, as they are generally located in remote, poorly connected and land-locked areas. The high cost of production, storage and transport requires investments that only the wealthy or external funding can support. Even where these investments could be supported by development projects, the real challenge is around the maintenance and monitoring of the investments beyond the project period.

Ranching and stabling could be combined in a ranching system in pastoral areas supported by feeding in stables during the dry season, either on site in the pastoral area or in agricultural or peri-urban areas where the animals would be moved seasonally. In

favourable situations, dry season stabling could benefit from green fodder from irrigated off-season fodder crops. In fact, the combination of stabling and ranching would be the only option for maintaining ranching in the long term, as the management of the few exceptions of operational ranches shows (Achard and Chanono, 2006). However, **the high cost of both types of livestock farming add up, increasing dependence on external funding and the associated social costs.** The risks of degradation from overgrazing in the wet season are increased by decoupling the load from local resources, with the load depending on external sources of feed in the dry season. **This solution reduces herd mobility, but at the cost of increasing the transport costs of the animals and especially of the animal feed, at the risk of calling into question the profitability of livestock farming in the context of an internationally competitive market**. **This option could make it possible to resolve the inter-community conflicts that arise during transhumance during the dry season and the beginning of the rainy season. However, it will remove the economic impact of transhumants on the economy of the host regions, the social links that are created during the stay of transhumants, as well as the benefit linked to the acceleration of the degradation of organic matter in the fields through the deposit of excretions.**

3.3 Scenario of resolute investment in the modernisation of pastoral mobility

Developing diversified livestock farming, with a pastoral component that is seasonally mobile on a regional, sometimes cross-border, basis, alongside sedentary pastoral livestock farming, both of which are mainly focusing on reproduction, and sedentary, stable livestock farming, specialising in rearing, fattening or dairy production, is the most suitable option for coping with the seasonality and inter-annual variability of forage availability and quality, both of which are likely to become even more variable and uneven with climate change. **Both pastoral components require securing the herds' access to pastoral resources, including water and forage from rangelands, stubble and weeds from fields. This implies maintaining the community status of water points and rangelands in hyper-arid, arid zones, but also in non-cultivable areas and conservation areas** (classified forests, buffer zones around national parks) in more humid regions (Lavigne Delville and Chauveau, 1998)as well as negotiated access to cultivated land after the harvest: stubbles and fallow land (Bonnet and Herault, 2011).

The optimisation of forage selection by grazing livestock that ensures the best possible productivity of pastoral livestock farming (Ayantunde et al., 1999) could be reinforced by the flexibility of pastoral mobility obtained by decentralising the organisation of daily grazing circuits and seasonal transhumance (Chirat et al., 2014). Shared community management also appears to be a more efficient and less costly solution for adapting to the variable distribution of resources (Krummel and Dritschilo, 1977; Cossins, 1985). It ensures more reactive livestock mobility, which is key to controlling the risks of degradation due to overloading during the rainy season and to promoting the resilience of ecosystems to the climatic hazards of the monsoon (Breman and De Wit, 1983).

In addition, pastoral livestock farming with regional seasonal mobility has a long history of connection with sedentary pastoral animal production systems, with which

there are numerous collaborations. Sedentary livestock breeders serve as 'hosts' and intermediaries, or even representatives, of transhumant pastoralist livestock breeders passing through. Pastoralists may entrust their 'hosts' with injured or sick animals, or with animals that need to be sold, and sedentary livestock breeders may entrust part of their livestock to mobile pastoralists for a transhumance. There are also many connections between transhumant livestock breeders and specialised sedentary agro-livestock breeders in semi-arid, sub-humid zones and peri-urban areas. Transhumant pastoralist livestock breeders supply young animals through direct contracts or through livestock markets (Touré et al., 2012). This includes young males either for transport (Vall et al., 2003)or for fattening, and young females for the renewal of dairy herds in peri-urban units. Dry season transhumance in sub-humid and humid agropastoral zones also benefits soil fertility management of cultivated land by accelerating the recycling of organic matter and transferring fertility to chosen fields for manuring (Landais and Lhoste, 1993; Hiernaux and Diawara, 2014).

However, the maintenance or revival of pastoral livestock farming in West Africa would require a pro-active policy on the part of regional bodies and states to address the main constraints faced by pastoralists. Civil insecurity, terrorism and banditry in several pastoral regions, which are not limited to the Saharan margins, deserve an urgent national and international engagement (Bonnet, 2013). Furthermore, the management of pastoral crises, which are becoming increasingly recurrent due to the non-availability of feed resources for livestock in the dry season, deserves particular attention through the implementation of seasonal forage balance mechanisms at the level of administrative units (municipality, departments, etc.) in the countries (FAO, 2020). In the longer term, major investments in appropriate education, health, road and telecommunication infrastructures would ensure security and help pastoral livestock farming to adapt to societal changes. More specifically for livestock, in pastoral regions, the objective would be to complete, rehabilitate and manage water and veterinary infrastructures in consultation with livestock breeders' associations and local authorities (Bonnet et al., 2005). A major investment should be made to complete the network of water points in relation to the available forage resources, in order to optimise their use and facilitate pastoral mobility. Surface water points, sumps, and pastoral wells should be favoured over high-flow boreholes, which lead to high seasonal concentrations of livestock and a risky dependence on technology that is difficult to maintain in isolated sites (Kiéma et al. 2014). It would also be necessary to set up a mechanism for marketing fodder through the organisation of a fodder value chain with the necessary infrastructure (storage warehouse, fodder market) (Sanon et al., 2018; Labiyi et al., 2019). In agro-pastoral regions, the objective would be to establish frameworks for local and regional consultation and to facilitate contractual agreements between pastoralists, agro-pastoralists and farmers (Brunet, 2009). These consultations would be facilitated by investments in infrastructure: installation of water points for watering, livestock passage corridors, land reserved for grazing, lodges or pens for livestock, contention corridors for veterinary treatments, shelters for transhumant herders in order to make transhumance in the dry season more efficient and mutually beneficial (Oxby, 1985). Consultations would also be facilitated by autonomising and strengthening the capacities of professional organisations and livestock breeders' associations.

4 Conclusions and recommendations

The prospective analysis of the dynamics of the livestock systems that exist in sub-Saharan West Africa on the 2040 horizon in the context of climate change and ongoing societal changes indicates that the expected dynamics of livestock sector policies differ along the bioclimatic gradient from the coastal humid zones of the Gulf of Guinea to the Sahara. Moreover, **these dynamics on the 2040 horizon are determined more by current and expected societal changes than by climate change**. Indeed, climate change will be all the more sensitive as the climate is arid, and should result in an increase in the concentration of carbon dioxide, an increase in temperatures in the already hottest seasons with little impact on plant growth, and an increase in rainfall mainly due to the increase in the frequency and intensity of heavy storms. **These evolutions are likely to favour plant production, both crops and rangelands, whose regreening could progress towards the Saharan margins**. The increase in the frequency of heavy storms and their intensity should intensify runoff, the filling of lakes, the recharging of the water tables, but also soil erosion and the risk of flooding.

The major component of societal change in the region is the rapid and persistent increase in rural population density despite dramatic urbanisation. This is leading to an expansion of cultivated land at a rate close to population growth, as cropping systems are scarcely intensified. This expansion is taking place at the expense of pasture and fallow land and is accompanied by fragmentation and reduction of rangelands, which are more difficult to access. In addition, the evolution of land tenure favours private use, limiting community usage rights, including grazing rights. Obstacles are multiplying, reducing forage resources and hindering regional seasonal pastoral mobility. In response, some pastoralist livestock breeders have sedentarised and are growing food crops to meet their families' food needs, which in turn contributes to the reduction of pastoral areas.

The prospective analysis was conducted around three scenarios for livestock policies. The first scenario is the continuation of current policies, bearing in mind that they differ between countries, particularly between Sahelian and coastal countries. A second scenario analyses the consequences of a policy of general sedentarisation of livestock farming in ECOWAS countries, leading to a halt in regional seasonal transhumance of herds and, in particular, cross-border transhumance. A third scenario envisages, on the contrary, a resolute investment in the modernisation of pastoral mobility and especially regional seasonal mobility, including cross-border mobility.

A continuation of current policies is likely to lead to a reduction in the activity of pastoral livestock farming with seasonal mobility, but also sedentary livestock farming, mainly because of the continued expansion of cultivated areas to the detriment of rangelands, but also reducing the access of herds to forage resources and drinking water because of the fragmentation of pastoral areas and the colonisation of livestock passage corridors. This decline could be accelerated if the trend towards privatisation of land that has started in some coastal countries continues. Pastoral livestock farming would be the first to be affected, but the decline in productivity would then affect specialised sedentary livestock farming, whose performance depends largely on the supply of young animals at competitive prices from pastoral livestock farming focused on

reproduction. It is unlikely that the increased pressure on cropland will allow the large-scale development of fodder production that would enable these sedentary livestock farms to ensure an abundant and competitively priced forage resource.

A policy that advocates an end to regional seasonal transhumance would precipitate the decline of pastoral livestock and increase their fragility in the face of climatic and security risks. In theory, it could be substituted by ranching, but this would require considerable prior investment, beyond the reach of the livestock breeders, who would have no choice but to work for private investors or agro-industrial companies capable of such investments. Even if this were to happen, ranching does not have the flexibility to adapt to climatic hazards of pastoral livestock farming, and would only be viable if additional feed is called on for each deficit situation or if herds are destocked, which is always costly. Both sedentary and specialised livestock farming would suffer from the decline of mobile pastoral livestock farming, which would no longer be able to supply them with young animals at competitive prices.

The only policy that could sustainably support all the region's livestock systems in meeting the growing demand for livestock products **would be resolute public investment by the States and the Regional Economic Communities (RECs) in the transformation and modernisation of pastoral mobility**. It would ensure the most efficient use of spontaneous forage and water resources, and contribute more to the maintenance of agricultural soil fertility. The two effects combined should ensure the best contribution to GDP from the livestock and crop sectors while facilitating the living together of communities. Pastoralists with seasonal regional mobility and sedentary pastoralists require that access to pastoral resources for their herds is secured. For this to happen, the community status of water points and rangelands in hyper-arid, arid, and non-cultivable areas must be reaffirmed, as well as a negotiated right of access to cultivated land after the harvest. The flexibility of pastoral mobility should be strengthened by decentralising the organisation of daily grazing circuits and seasonal transhumance circuits, which ensures more reactive livestock mobility, a key to controlling the risks of degradation and promoting the resilience of ecosystems to climatic hazards. This decentralisation will also involve the reaffirmation of the roles and more official recognition of representatives of transhumant groups in markets and municipalities, such as *rugga* or other 'local ambassadors' of mobile communities from Sahelian areas to dry season host areas. In the pastoral regions, water and veterinary infrastructure should be completed, rehabilitated and managed in consultation with livestock breeders' associations and local authorities. A major investment should be made to complete the network of water points in relation to the available forage resources, giving priority to surface water points, sumps, and pastoral wells that avoid the high seasonal concentrations of livestock and the risks of dependence on mechanised water extraction. In addition, it would be necessary to set up mechanisms to assess seasonal forage balances at the local level, in order to better anticipate periods of insufficient forage availability. In agro-pastoral regions, local and regional consultation frameworks should be established and contractual agreements between pastoralists, agro-pastoralists and farmers should be facilitated. These consultations would be facilitated by investment in infrastructure: development of watering points, livestock passage corridors, land reserved for grazing, lodges or pens for livestock, contention corridors for veterinary treatments, and shelters for transhumant herders in order to make transhumance in the dry season more

efficient and mutually beneficial. In general, a national and international commitment should overcome the civil insecurity that is rampant in many pastoral regions, accompanied by significant investments in education, health, roads and telecommunications infrastructure, to ensure the security and adaptation of pastoral livestock farming to societal changes.

Finally, three factors are decisive for the potential evolution of mobile livestock systems by their acuteness or by the trends they present:

- Governance, i.e. the set of public policy instruments deployed to manage and secure the system: land tenure, investments and access to resources
- The evolution of natural resources caused by the dual effect of climate change and the needs of livestock breeders and other users
- Demographic pressure, which increases competition for access to natural resources, both for livestock breeders and for farmers and other users (forestry, fishing, mining, urban dwellers).

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