Open ideas

CLIMATE CHANGE AND SMALL SCALE LIVESTOCK FARMING IN AFRICA

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enea CONSULTING

DIERENARTSEN ZONDER GRENZEN | VETERINAIRES SANS FRONTIERES BELGIUM

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Executive summary

Open philosophy

ENEA Consulting is an independent French consulting company, specialized in energy and sustainable development. According to its values, ethics and business model, ENEA Consulting voluntarily dedicates a significant amount of its consulting time to pro-bono missions, in conjunction with energy access and sustainable development. In that respect, ENEA Consulting frequently works with NGOs and social businesses, on projects targeting an improvement of energy access conditions and/or sustainable energy use in developing countries.

As these concerns are widespread, ENEA Consulting's philosophy is to maximize the impact of its missions, making sure they can benefit to a large number of actors implied in development. Consequently, open reports (so called "open ideas") are produced by ENEA Consulting, with a knowledge sharing approach. The present report is one of these. ENEA Consulting thus invites every person directly concerned by, or who knows someone concerned by, the interaction between Climate Change and Small Scale Livestock Farming (SSLF) to read and share this open idea, while respecting the Creative Commons conditions mentioned above.

Vétérinaires Sans Frontières Belgium (VSF-B) is a Belgian NGO, concerned with Small Scale Livestock Farming and sustainable development. This report has been produced with the assistance of VSF-B, and benefiting from their knowledge, which ENEA Consulting is thankful for.

Objective and perimeter

The initial question of VSF-B can actually be extended to SSLF generally speaking: While SSLF has already been widely analyzed and debated regarding its economic and social performances, how should the environmental performance be taken into account? More precisely, what is the actual contribution of SSLF to climate change, and reversely, what are the expected consequences of climate change on SSLF?

These questions are all the more important in Africa, where VSF-B operates, since this continent is massively exposed to the consequences of climate change. This is why this study has been intentionally focused on Africa.

Though climate change and its consequences can already be observed, the corresponding adaptation and mitigation strategies cannot solely be analyzed in a short term perspective. As a consequence, the timeframe of this study and of the analysis enclosed (climate change megatrends) relates to 2020 at the earliest.

Lastly, this report obviously does not pretend to provide readers with definitive solutions to limit the impact of SSLF on climate change (mitigation), nor to make SSLF more resilient to climate change (adaptation). However, it provides:

- Some useful documented, quantitative and mapped pieces of information regarding climate change related megatrends in Africa;
- Some possible mitigation and adaptation actions that can be seen as a starting point to build, on a case by case basis, mitigation and adaptation strategies for stakeholders concerned with the link between SSLF and climate change.

ENEA Consulting and Vétérinaires Sans Frontières Belgium therefore hope that this open idea will consist in a good introduction to this complex subject. They would like to invite other actors to use it in their specific cases and further investigate the ideas raised to result into efficient mitigation and adaptation strategies.

Climate change and SSLF in Africa

Small Scale Livestock Farming refers to a livestock farming system where the livestock farmer (one single person, a family, or a small cooperative) is involved in both the ownership and the management of the farm. All parameters (social, economic and environmental) are equally important in the decision making process.

Generally speaking, environmental and social impacts can be perceived as major challenges that need to be overcome to ensure a sustainable development. All environmental and social megatrends do not affect all industrial or agricultural sectors to the same extent. The most relevant environmental and social megatrends regarding the SSLF sector in Africa have been selected in this study, with the aim to analyze the mutual impacts between climate change and SSLF, and to identify the possible adaptation and mitigation measures that could be implemented.

In a nutshell, the most significant megatrends analyzed can be summarized as follows:

Climate change and associated disturbance: The IPCC estimates that Africa is the most exposed continent to climate change. It would be the most affected by temperature changes and rainfall patterns evolutions that would change agro-ecological zones in Africa, particularly due to the sea level rise pressure. The frequency and the intensity of extreme weather events are likely to increase under climate change and will affect Africa through more frequent and more violent floods and droughts causing crop losses and livestock fatalities.

Population: Most of demographic evolutions will take place in the South, and especially in Africa. Africa is rapidly urbanizing due to population growth and changes in land-use. This will result in new challenges to respond to a higher and more concentrated demand for animal products. Human and animals health is also affected by climate change: vector borne diseases for example are expanding in Africa due to changes in humidity and temperatures.

Depletion of resources: Natural resources, like water, land, biodiversity and energy, are under pressure due to climate change and to the higher demand for these resources driven by population growth. The IPCC assessed that about 25% of the population were under water stress in Africa in 2007, with a probable increase ever since. Agriculture land must be considered as a depleting resource because of anthropogenic impacts and climate change. The SSLF in arid and semi-arid areas in Africa will have to cope with further land alteration through desertification. Conflicts on land use and foreign land purchasing are two additional factors that are pressuring land availability.

Environmental impacts of economic activity: The SSLF sector uses less energy, nutrients and others inputs than intensive systems, especially in Africa; but the GHG emissions related to land use may be higher than for the extensive systems. The increasing demand for food products driven by the expected high population growth in Africa and its changing food habits will put higher pressure on livestock systems in terms of GHG management.

Geopolitical pressure: Though quite difficult to assess, and even more difficult to forecast, the geopolitical pressure impact on population needs to be taken into account, especially on the poorest and in remote areas. The access to natural resources is increasingly a geopolitical matter, especially in the regions that faced such situations for decades, as some African countries did. Water or land availability can be at stake, and result into conflicts, for small crop farmers and livestock farmers in remote areas.

Secondly, Small Scale Livestock Farming should not be seen as limited to the economic valorization of the animal production, but goes beyond, including both environmental and social aspects. Therefore, the megatrends that compose the global Small Scale Livestock Farming have been studied as well, and cross-analyzed with the previously mentioned environmental and social megatrends.

Such an approach highlights that each of the environmental and social related megatrends presents both risks and opportunities for the SSLF sector in Africa. This is why a few adaptation and a few mitigations actions the SSLF sector could adopt have been mentioned in this study.

The following adaptation actions the SSLF sector could implement are namely been described:

- Coordinated strategies and actions: regional planning, cooperation & knowledge management, capacity building, mobility management, early warning systems & seasonal forecasting tools, financial tools
- Natural resources management: water management, energy management and land management
- Herd management: animal switch & animal diversification, market oriented diversification, veterinary medicines, animal nutrition (crop switch & crop diversification), farming and household infrastructure

The following mitigation actions the SSLF sector could carry out within a coordinated mitigation strategy to minimize its impacts on natural resources already affected by climate change and its contribution to GHG emissions have also been identified in this study:

- Coordinated strategies and actions : regional planning and financial incentives to GHG reduction
- Mitigating GHG emissions: from animals, from infrastructures, through behavioral modifications, through reduction of soil emissions and GHG sequestration (CO_2 sequestration into biomass)

- Protection of biodiversity: limitation of biodiversity degradation
- Water management: improved water-use efficiency

Glossary

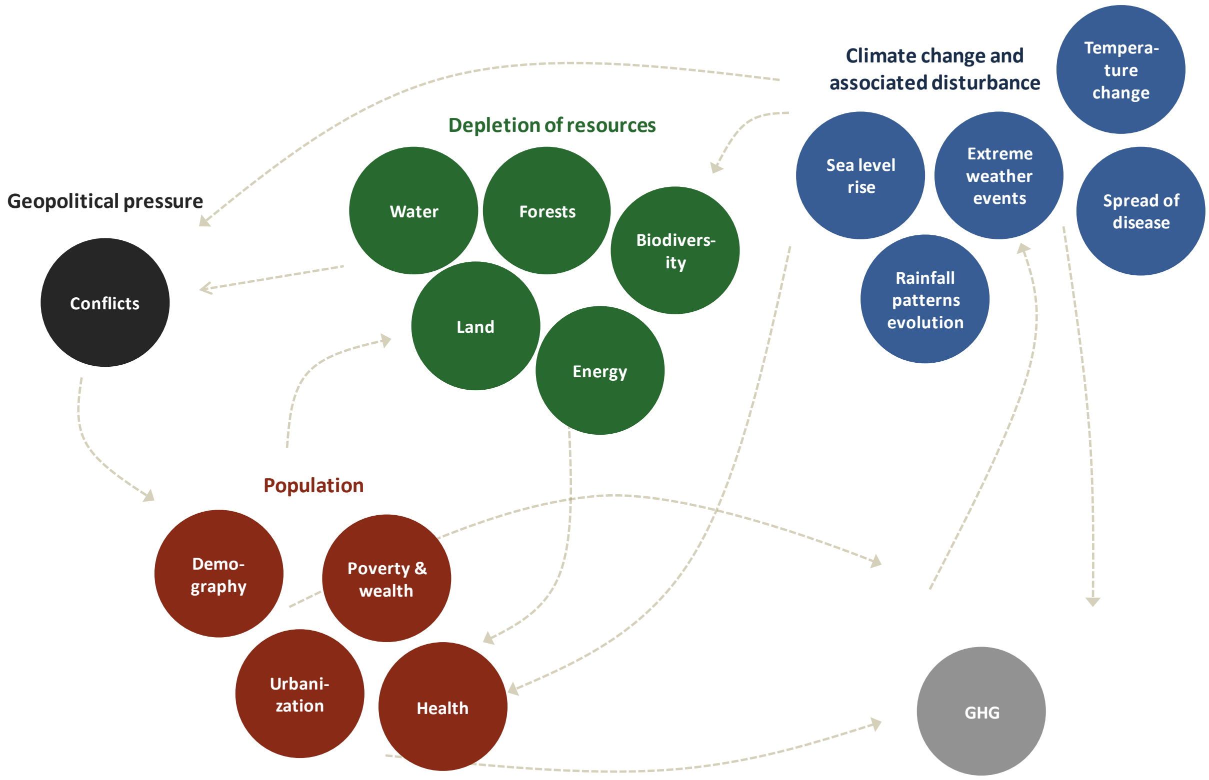
Acronym	Meaning
CC	Climate Change
FAO	Food and Agriculture Organization
GHG	Green House Gases
GIS	Geographic Information System
HR	Human Resources
IPCC	Intergovernmental Panel on Climate Change
LECZ	Low Elevation Coastal Zones
LF	Livestock Farming
LGP	Length of Growing Period
LSLF	Large Scale Livestock Farming
NGO	Non Governmental Organization
PAR	Platform for Agrobiodiversity Research
UNDESA	United Nations Department of Economic and Social Affairs
SSLF	Small Scale Livestock Farming

1 Mid-term environmental and social megatrends

1.1 Megatrends: Mapping adapted to livestock farming in Africa

Environmental and social impacts can be perceived as two challenges that, along with economic performance, are required to ensure a sustainable development. These impacts can be modeled by environmental and social megatrends, which are representative of the various stakes worth including in any evaluation of the "sustainable performance" of a project.

All environmental and social megatrends are not necessarily relevant when focusing on livestock farming. Figure 1 thus mentions those megatrends that should be taken into account when discussing livestock farming issues in the African context.



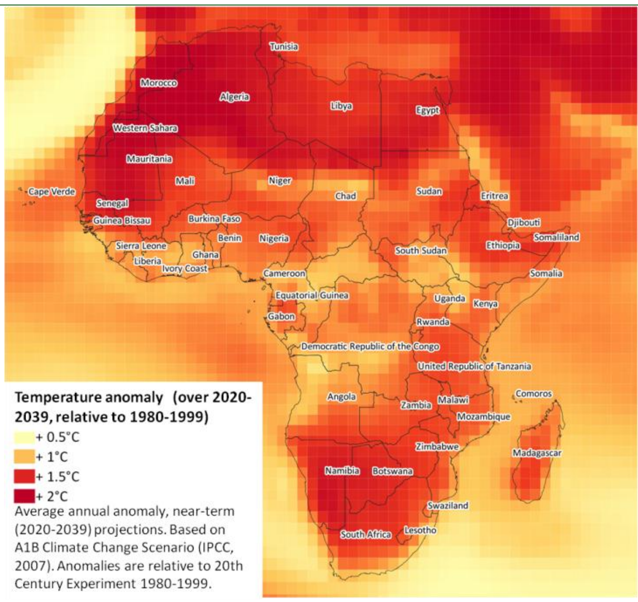
Source: ENEA Consulting

Figure 1 : Mapping of the main environmental and social megatrends likely to affect livestock farming

Some more details regarding the five families of megatrends listed in Figure 1 are provided hereafter.

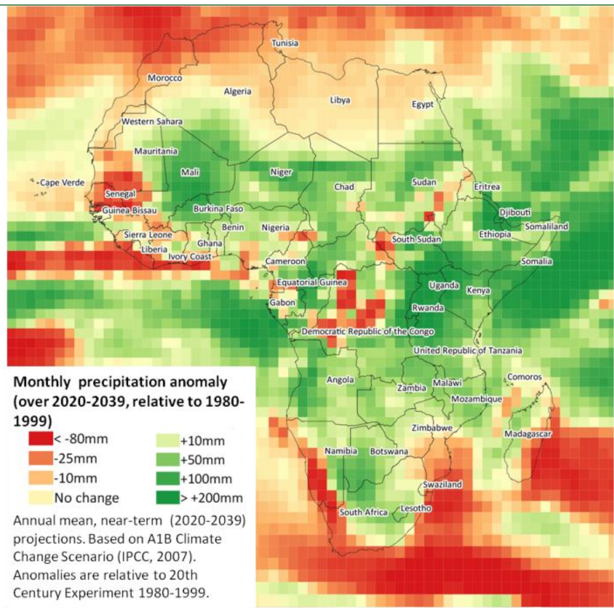
1.2 Climate change and associated disturbance

The Intergovernmental Panel on Climate Change (IPCC) has been working on climate change issues since 1988, providing scientific content on past climate evolutions as well as prospective data (based on climate models, run under various scenarios) on mid-term and long-term changes that can be anticipated. It is now common knowledge among international institutions that "*Africa is one of the most vulnerable continents to climate change and climate variability*" [1]. **Temperature change** and **rainfall patterns evolution** are the main two drivers for disturbance related to climate change. From a global point of view (see Figure 2 and Figure 3), the African continent will need to cope with higher temperatures (especially in Northern, Western coastal and Southern areas) and more precipitations (especially in Eastern and Southern Africa), leading to several changes in the repartition of agro-ecological zones (refer to Figure 4 and Figure 5). One should note however that such projections are indicative of general trends only; high uncertainty remains in some regions (see Box 1). The Sahel region is particularly at stake (especially when it comes to uncertainty about precipitation projections), since climate variability has been very high over the last century: "*very little* *consensus exists on what the long term climate signal [for rainfall pattern evolution] is likely to be for most of the region, under a business as usual future scenario*" [2].



Source: ENEA Consulting, based on NCAR GIS Program (2012). Downscaling procedure in: T. Hoar and D. Nychka (2008), Statistical Downscaling of the Community. Climate System Model (CCSM) monthly temperature and precipitation projections. *Accessed on 03/28/2013.*

Figure 2 : Temperature rise in Africa by 2020-2039 under IPCC A1B Scenario



Source: ENEA Consulting, based on NCAR GIS Program (2012). Downscaling procedure in: T. Hoar and D. Nychka (2008), Statistical Downscaling of the Community. Climate System Model (CCSM) monthly temperature and precipitation projections. *Accessed on 03/28/2013.*

Figure 3 : Rainfall evolution in Africa by 2020-2039 under IPCC A1B Scenario

Note: The A1B Scenario corresponds to "*A world of very rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies*", benefitting from a balance across all energy sources. The associated global temperature change by the end of the 21st century[1] is in between +1.7 and +4.4°C [1].

Overall, these trends will have negative effects on the length of growing period[2] (LGP), impacting the agricultural sector, including in areas where rainfall is expected to increase, since global warming should increase evaporation [3], as shown in Figure 4 and Figure 5. Studies have shown that small farms that rely on goats and sheeps are less impacted by higher temperatures than larger farms that possess animals which are not heat-tolerant (such as cattle) [1].

Besides, Figure 4 and Figure 5 tend to indicate that the Sahel region is among the regions in Africa that are likely to be the most negatively impacted by climate change, with a significant reduction of the LGP expected.

[1] 2090-2099 relative to 1980-1999
[2] "The growing period defines the period of the year when both moisture and temperature conditions are suitable for crop production" **Source spécifiée non valide.**

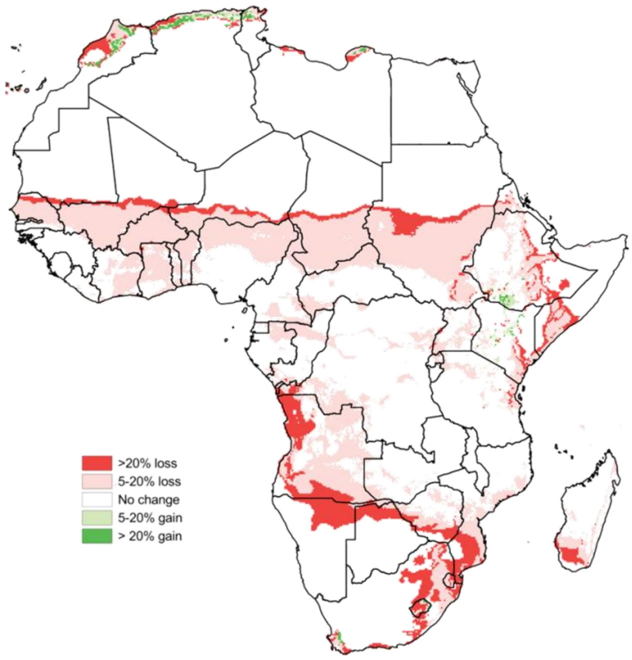


Figure 4 : Percentage change in LGP (2000-2020) [4]

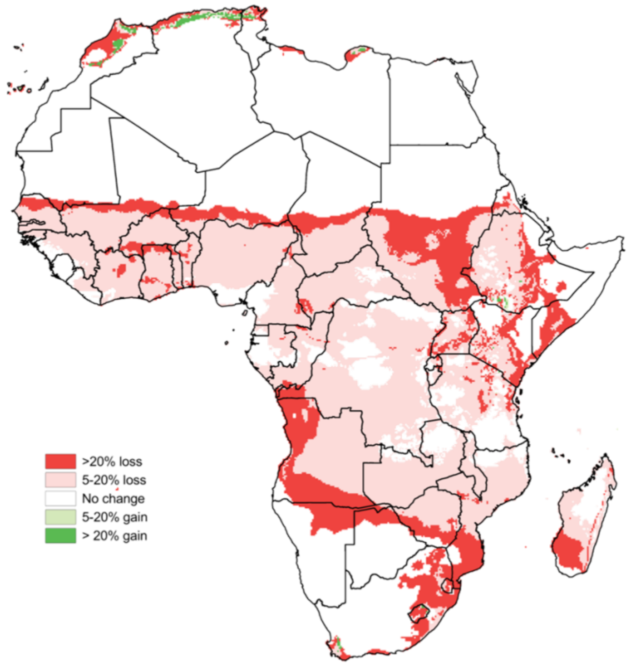


Figure 5 : Percentage change in LGP (2000-2050) [4]

Note: Results are based on HadCM3 climate model under IPCC B1 scenario. The B1 scenario corresponds to *"A convergent world, with the same global population as A1, but with more rapid changes in economic structures towards a service and information economy".* The associated global temperature change by the end of the 21st century is in between +1.1 and +2.9°C [1]. No information is available regarding the LGP evolution under A1B scenario.

Climate change is also likely to increase the frequency and the intensity of **extreme weather events**. Over the last decades, an increasing trend in the number of hydro-meteorological disaster has already been observed as shown in Figure 6. Extreme rainfall might increase floods frequency in sub Saharan Africa, and more droughts may occur as a result of higher rainfall variability and global warming. Crops losses and livestock fatalities are also likely consequences of these extreme weather events.

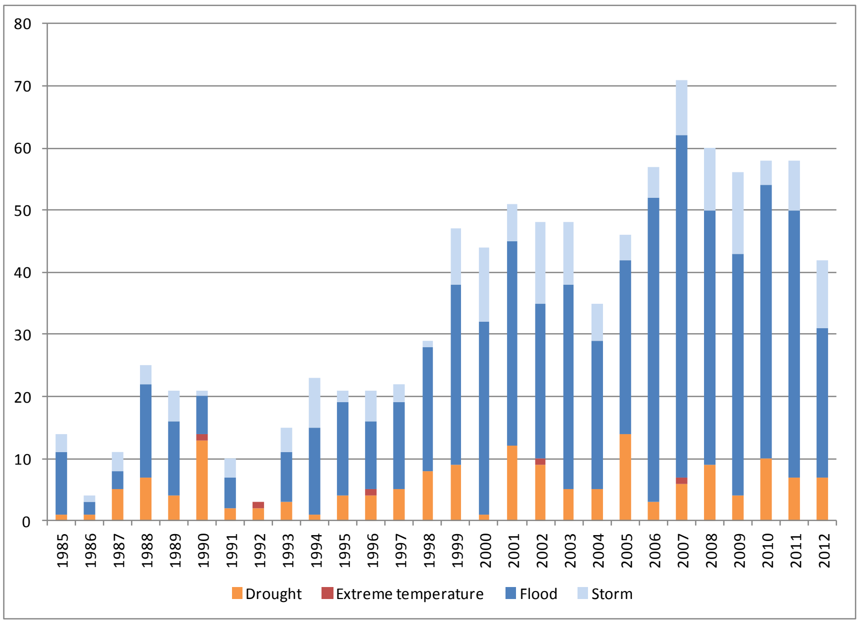


Figure 6 : Number of reported hydro-meteorological disasters in Sub-Saharan Africa (1985-2012)[5]

Box 1 : Data analysis, forecasting tools and uncertainty

Over the last decades, several datasets and models have been computed to forecast climate-related megatrends. They are the basis of political recommendations and provide useful information in order to design development strategies. The major part of the scientific community tends to agree on the main findings and the global ongoing trends regarding climate change and its consequences. However, one must keep in mind that some uncertainty remains[3], especially when it comes to local consequences of climate change. The main reasons for such uncertainty are reminded below:

- Climate variability (especially for rainfall patterns) is already high in Africa (refer to Figure 7). Over the last century, the Sub-Saharan region, for instance, has been marked by "great variations in inter-annual and intra-annual precipitations" [3]. As a result, extreme events and droughts are inherently bound to happen, and it is hard to depict a general trend for rainfall pattern in the future.
- Climate projections are hindered by a lack of comprehensive data in some region: the World Bank refers to "sparse meteorological data networks, spurious data records, and/or difficult data access in many parts of the continent" [3]. The Stockholm Environment Institute indicates that, due to economic difficulties but also frequent conflicts in the continent, fewer meteorological monitoring stations were available in Africa in 2007 compared to 20-30 years before. [6]

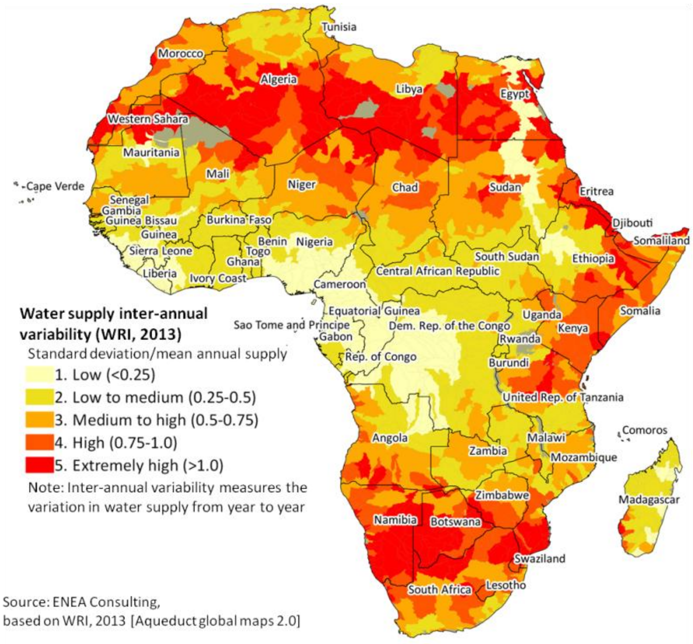


Figure 7 : Water supply inter-annual variability in Africa [38]

- Projections may vary from one climate model to another, especially regarding downscaling procedures, namely deriving global trends (e.g. a continent) to a local scale (e.g. a region). In addition, regional models for Africa may be improved. The IPCC notes that "climate scenarios developed from GCMs are very coarse and do not usually adequately capture important regional variations in Africa's climate. The need exists to further develop regional climate models and sub-regional models" [1]. The Stockholm Environment Institute quotes the Climate System Analysis Group in Cape Town (South Africa) as the sole African institution providing empirically downscaled climate data. [6]
- Besides, it must be reminded that climate projections rely on assumptions (input data) on future trends (on GHG emissions for instance) over the next decades. Details in the projections (not the global trends) vary depending on these assumptions. This is why different scenarios are often considered.
- Lastly, human resources and computational power can also be a limiting factor in climate forecasts in Africa. [6]

Consequently, the subject of the reliability of the forecast covers the following:

- The previously mentioned aspects must be taken into account, especially when it comes to climate change adaptation strategies. Indeed, many actors have pointed out the need for better climate forecasting tools (e.g. for precipitation) in order to prioritize and anticipate actions. Due to the existing high variability, some aspects might not be easily forecast, especially on the long run, or at a very local scale.
- Historical data would on top of that be necessary, in order to increase the reliability of the climate change models currently under development. Such data is frequently missing in Africa. However, as a complement to figures originating from official meteorological stations, it could be possible to consider using unofficial stations figures, provided the data can be digitized beforehand. Kenya for instance is reported to house 25

[3] Scientific models do include uncertainty aspects in the forecasting process. As an example, the IPCC always associate a "degree of uncertainty" to its findings [1].

official stations, and 600 volunteer operated stations. [6]

Lastly, the following can be suggested to improve the significance of the climate change models developed:

- Some efforts would be necessary regarding capacity building (training climate scientists in Africa), easiness of the interpretation of the calculated models (so as to make them more straightly usable), and training of the potential users (decision makers). [6]
- Collaborative platform would be a great hint to share good practices relative to climate change and associated adaptation strategies. Such platforms would be all the more relevant if they could gather agriculture and livestock farming actors on the one hand, as well as small and large scale livestock farming actors on the other hand. To date, “weADAPT” could be considered as the most comprehensive web platform sharing climate change adaptations recommendations throughout the World. [7]

Climate change may also trigger **sea level rise.** Low elevation coastal zones (LECZ[4]) concentrate a lot of the world’s urban population. In Africa, more than 55 million people live in LECZ, and nearly 60% of them are in urban areas[8]. Two main factors contribute to the long term mean sea level rise: thermal expansion and the melting of land-based ice. Sea level rise may have tremendous impact such as population migration, increased frequency of floods, reduction of water quality, soil salinization…

The population migration induced by this sea level rise would in turn impact the livestock farming (modification of land use, displacement of consumers).

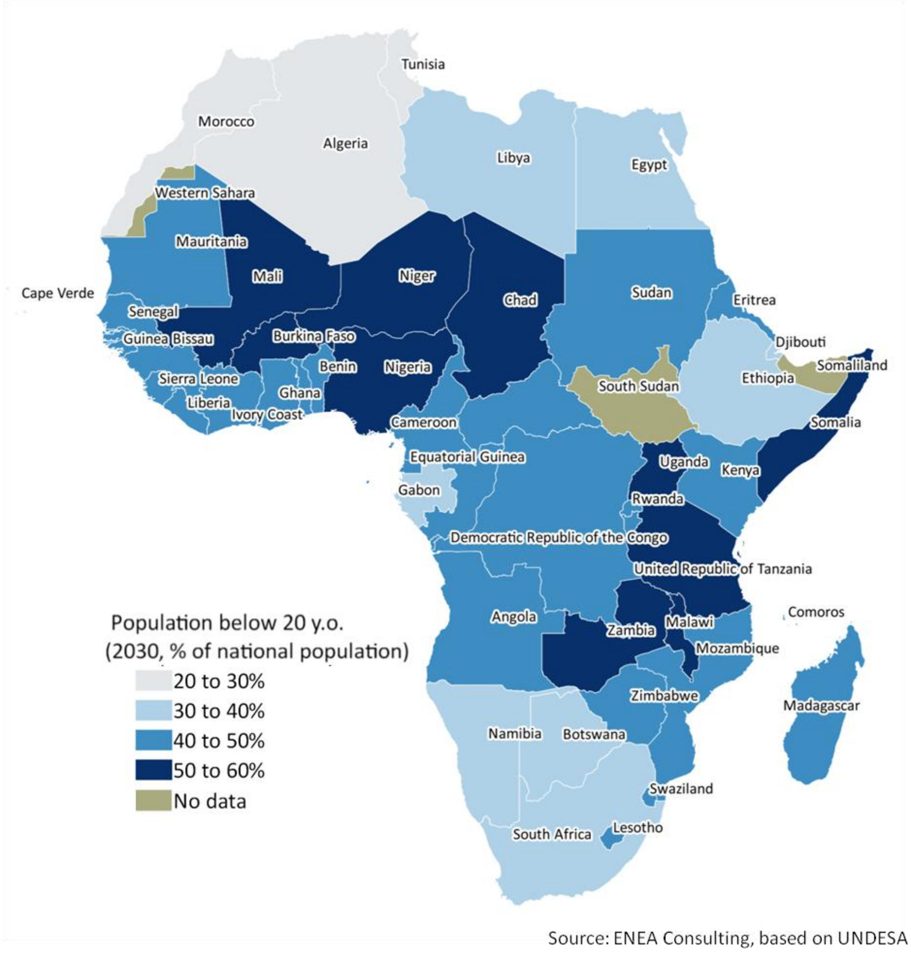
1.3 Population

In the coming decades, most of the demographic evolutions will take place in developing countries, and especially in Africa. The analysis of **demography** encompasses the study of the size, structure and distribution of populations and subpopulations as well as the related spatial and/or temporal changes, in response to birth, migration, ageing and death. According to the UNDESA [9], by 2030, Africa will represent almost a fifth (18.5%) of the world population, namely 1.6 billion people (500 million people more compared to today’s population). One of the key topics regarding African demography is the population pyramid, since 45% of African people will still be under 20 years old in 2030. The youth will thus represent a large part of the workforce, and unemployment issues could be part of major economic concerns over the next decades.

	2010	2030	2010	2030
Total population	1.027 billion	1.572 billion	769 million	786 million
Population < 20 y.o.	520 million (50.6%)	716 million (45.5%)	157 million (20.4%)	155 million (19.7%)
Population growth rate (2010-2030)	+53% (i.e. +2.2%/yr)		+2% (i.e. +0.1%/yr)	

Figure 8 : Main demographic trends in Africa compared to Europe (UNDESA [9])

[4] LECZ refers to the area along the coastline that is less than 10 meters above sea level.



Source: ENEA Consulting, based on UNDESA [9]

Figure 9 : Population below 20 y.o. in Africa by 2030

These demographic changes will go along with increasing **urbanization** trends, with a global shift towards a more urban population. In 2011, 60% of the African population was rural. By 2035, half of the population should live in urban areas [10]. Various studies show direct link between urbanization and economic development in most parts of the world ([11], [12], [13]), and today, the young "are 40% more likely than older generations to move from rural to urban areas or across urban areas[5]". Yet, rural-to-urban migration is reported to account for only 25% of urban population growth [13]. The growth of urban population is also due to natural population increases and the changes in land-use (reclassification of rural areas into urban areas). Between 2012 and 2025, cities with highest population growth rate in the world will be located in Asia and Africa (especially in Nigeria, Democratic Republic of the Congo, and Kenya). Among the 20 fastest growing cities[6] over this period, 17 will be African cities.

This high expected growth of urban population in Africa will result in a new challenge when it comes to feeding urban population, through new organizational schemes of SSLF (periurban SSLF). The SSLF sector will have to deal with two main following constraints: the decrease of available rural areas, and a higher and more concentrated demand for animal products.

[5] UN-HABITAT, (2010), *State of the Urban Youth 2010/2011*, §1.6, p.9

[6] Cities with more than 750k people, sorted by population growth rate over 2012-2025.

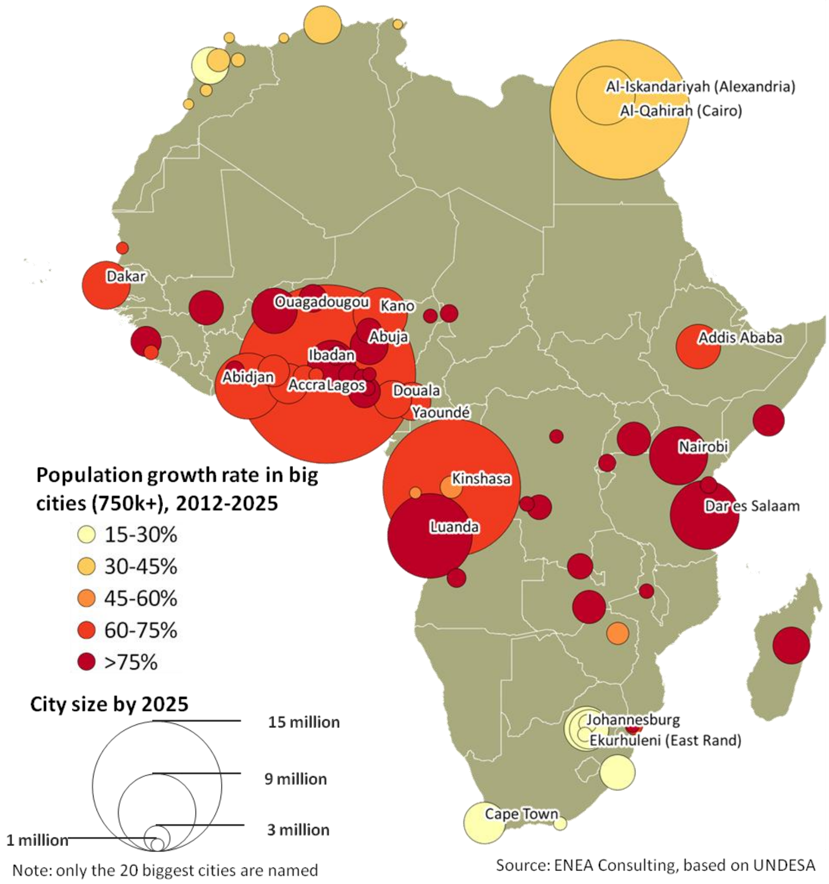


Figure 10 : African cities (750k+ people) by 2025 and population growth rate (2012-2025)

Poverty and wealth is also a key issue for Africa. Several methods are used by economists to assess the evolution of wealth and poverty at a global or local scale. The three most common methods are based on income, assets (meaning accumulated wealth in the form of money, and real estate) and socioeconomic metrics. Measures in the last category go beyond financial data to account for health, nutrition, infant mortality, sanitation, and other aspects of human well being. \$1.25/day is the average of the national poverty lines found in the poorest 10-20 countries. This threshold is used in the world to define poverty at a global scale. Therefore, poverty in the world as a whole is being assessed by what "poverty" means in the world's poorest countries. Over the last years, the population living in poverty has been decreasing (from 1.742 billion of poor people in 1999 to 1.288 billion in 2008 [14], with a poverty line at \$1.25/day, 2005 \$ PPP[7]). But the global trend is much lower if one excludes China, underlying the dynamism of this country and the fact that progress has been uneven across regions and countries within these regions. The Bottom of the Pyramid market (BOP, see ENEA Consulting paper on the subject [15]) gathers the poorest households, and is a key opportunity for food products and the African agricultural sector: "*Purchasing food takes more than half of BOP household budgets in many countries, especially in Africa and Asia. In Nigeria, food accounts for 52% of BOP household spending (…). As incomes rise, the share of household spending on food declines. Food nevertheless represents the largest share of BOP household spending and the largest BOP market*"[16].

Overall, these demographic changes, associated to the evolution of lifestyles (consumption patterns) will drive a fast rising demand for animal-source food, especially in the developing countries. As an example, the FAO forecasts that poultry demand by 2030 in Sub-Saharan Africa will grow by +170% (compared to 2000). Such changes are the conjunction of a growing population and a growing consumption per capita (e.g. +94% growth in poultry demand per capita over 2000-2030) [17].

At last, **health** is also directly impacted by climate change, especially when it comes to vectorborne diseases (e.g. tick-borne or mosquito-borne diseases). Changes in humidity and temperatures can affect the reproduction rate of

[7] Purchasing power parity (PPP) is an economic theory and a technique used to determine the relative value of currencies, estimating the amount of adjustment needed on the exchange rate between countries in order for the exchange to be equivalent to (or on par with) each currency's purchasing power.

mosquitoes and other insects, as well as the incubation period of pathogens inside vectors. Overall, vector distribution may expand as the Earth warms. Some diseases (zoonosis) can be transmitted between different species (among animals, and humans). As a result, livestock health can be highly correlated to human health.

1.4 Depletion of resources

Natural resources are under pressure due to two main factors. On the one hand, climate change will have negative impacts, especially on water and land availability, as well as on biodiversity. On the other hand, global population growth will drive rising demand for these natural resources, which can deplete fast if they are not managed on a sustainable basis.

In 2007, the IPCC estimated that 25% of Africa's population were already experiencing high **water stress**, and between 75 and 200 million people were projected to experience a higher water stress by 2020 [1]. The most common tool used to assess water scarcity is the Falkenmark index, which measures the amount of renewable freshwater that is available per person each year (m^3/cap./yr). Yet, this index does not take into account the actual accessibility of the resource [18]. According to the Falkenmark Water Stress Index, a country or region is said to experience water stress when annual water supplies drop below 1,700 cubic meters per person per year. At levels between 1,700 and 1,000 cubic meters per person per year, periodic or limited water shortages can be expected. When water supplies drop below 1,000 cubic meters per person per year, the population faces water scarcity. Studies made by the IPCC on several climate models show evidence that water stress is likely to increase over the next decades in Northern and Eastern Africa, and may decrease in Southern Africa on the long run (see Figure 19).

Forests also account for depleting resources at a global scale. Deforestation, namely the process of turning forested lands into other types of land (agricultural, urban, infrastructures) started to gain momentum in the beginning of the 20th century, mainly in developing countries which need more agricultural fields to fulfill their development. It raises global concerns when it involves primary rain-forests (such as forests located in the Congo Basin), since they are considered as carbon sinks and biodiversity reservoirs at a global level, among other concerns. Deforestation may have multiple negative impacts including soil erosion and flood aggravation, land speculation and land use conflicts, loss of biodiversity, migrations, GHG emissions, and reduction in rainfalls (evapotranspiration). According to the FAO, the total forest area in Africa has dropped by 10% (75Mha) between 1990 and 2010 [19].

Agricultural land itself has to be considered as a depleting resource for several reasons that can result from human activity or climate change. Soil degradation, which is measured in terms of net primary productivity[8], is the result of erosion, pollution, or desertification processes. The latter can reduce the total amount of arable land in some regions. Arid and semi-humid areas, where most of the small-scale farming activities are located in Africa (refer to Figure 15, and Figure 19), may experience further land alteration through desertification over the next decades, and are the most vulnerable areas (see Figure 11) [20]. Besides, in regions which are vulnerable to desertification, high population density can cause further degradation, and countries such as Morocco, Algeria, Burkina Faso, Mali, Nigeria could be at risk in the future due to these combined factors.

On top of the depletion of agricultural land, conflict on land use (agriculture, cereals production to feed livestock, grazing land) further impacts the available resources. According to the FAO, 40 to 50% of the global cereals production is intended to feed livestock.[21]

[8] The results of this measure are adjusted, since land degradation is not the only factor accounting for declining soil productivity; for instance, rainfall variability also affects productivity.

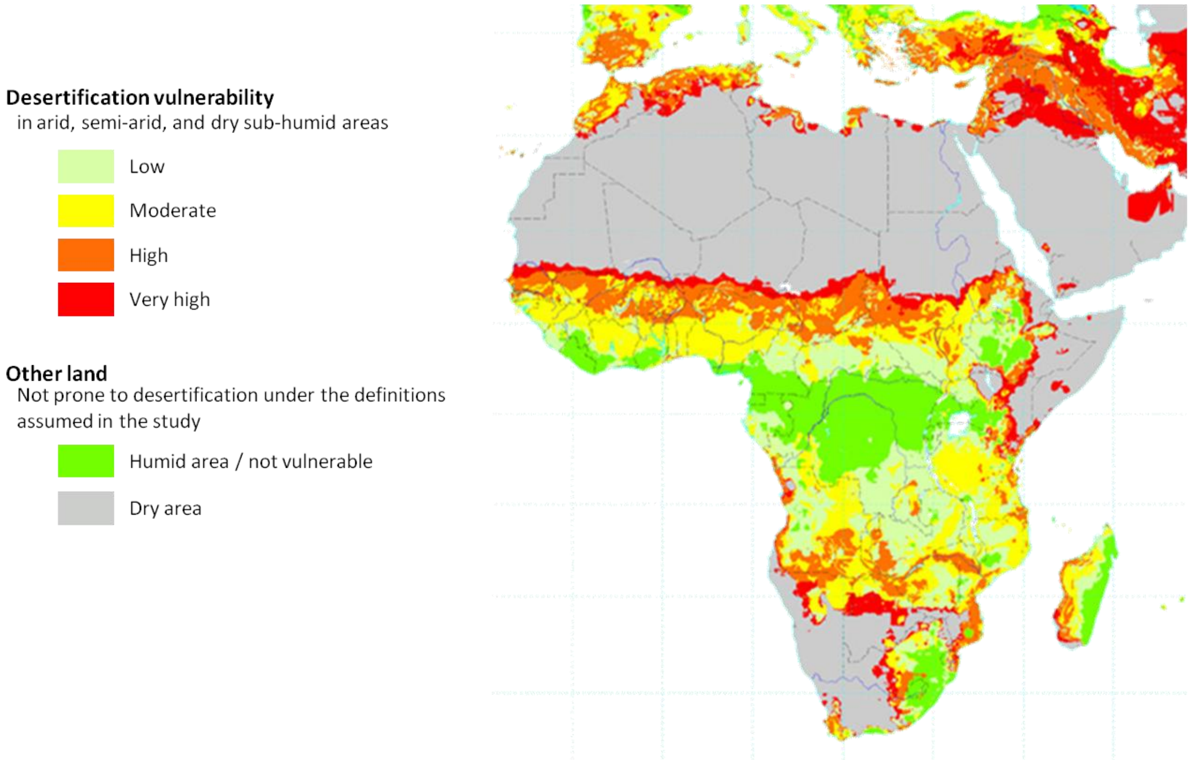


Figure 11 : Desertification vulnerability[9] in arid, semi-arid, and dry sub-humid areas of Africa [20]

From a domestic point of view (and especially in terms of food sovereignty), land availability is also under pressure because of foreign land purchase, related to the conjunction of several factors such as food, water, and energy security, as well as the financial crisis (agricultural land is a new investment product). The NGO GRAIN defines what it calls "land grabbing" as "the acquisition (lease, concession, outright purchase) by corporations or states of large areas of farmland (>10,000 ha), in another country and on a long-term basis (often 30-99 years), for the production of basic foods that will then be exported" [22]. Data published on this issue is controversial, but the NGO has published a list of land grab deals that occurred between 2006 and 2012: in Africa, more than 16 million hectares felt under the control of foreign interests [23].

Besides, **biodiversity** losses must be considered as key issues for small scale farmers. Given the low access to resources (financial constraint on small farmers, poor infrastructures in remote areas) for small scale farmers, experts estimate that agricultural biodiversity needs to be part of the new resources to be taken into account in order to make this kind of agriculture sustainable. In a recent report by the FAO and the PAR, one can read that "agricultural practices will need to become increasingly flexible (…) to deal with change and uncertainty. Resilience and adaptability will become more important properties (…). Production systems will need to have greater reliance on ecological processes" [24]. Yet, recent trends have shown a global decline in biodiversity, with losses of animal and vegetal populations, erosion of genetic variety, as well as degrading natural habitats[10] (for instance, through urbanization, or agriculture-based nitrogen deposition on soils). Prospective trends are expected to be similar. In Africa, the Sahel region is at stake and its degradation could "*continue to cause loss of biodiversity and shortages of food, fibre and water in Western Africa*" [25].

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[9] This assessment is based on several considerations, including variability of rainfall, the depth of soil, the presence of impermeable layers, the chemical and physical conditions (e.g. extreme pH conditions), the resilience of soil (defined as its ability to recover from mismanagement), and general information retrieved from soil classification.
[10] Biodiversity is usually defined through these three main components, namely genes, species, and ecosystems.

Source: ENEA Consulting, based on Conservation International [26]

Figure 12 : Inland biodiversity hotspots in Africa (colors are meant to distinguish adjacent hotspots and used to ease visualization; they do not have any specific meanings)

Regarding **energy** at last, energy scarcity is a problem in many African areas since it is estimated that 57% of the population do not have access to electricity and 68% live without clean cooking facilities[11] [27]. Today's energy mix in Africa mostly relies on bioenergy, which accounted for 48% of the total primary energy demand in 2010 (the share of bioenergy in primary energy demand in the European Union was only 4% at the same time). Biomass will continue to be a key resource for African countries in the next years. The livestock sector in parallel can play a role in the development of energy systems (e.g. through small scale biogas production for households).

1.5 Environmental impacts of economic activity

In order to address climate change, most countries have set **GHG emissions** reduction targets. Achieving these targets may lead to the implementation (or extension) of restrictive measures such as CO_2 quotas and taxes. In most of the world's areas, this leads to the implementation of mechanisms aiming at encouraging economic actors to control their GHG emissions.

Various figures are available on GHG emissions in the agricultural and livestock sectors. When dealing with such issues, it is important to define the scope that is used when counting the emissions[12]: agriculture by itself (*ie* the production of crop and livestock product) accounts for 13.5% of the global GHG emissions (IPPC official figures for anthropogenic GHG emissions in 2004) [1], whereas the livestock sector including upstream and downstream processes of the value chain (transport, packaging, nutrients…) is estimated to account for about 18% of global GHG emissions (FAO figures based on data recovered in 2006) [28]. There is little available data on small scale livestock farming emissions: these production systems use less energy and nutrients and other inputs than intensive systems (hence lower upstream GHG emissions), but the emissions related to land use (e.g. land-use change via stubble burning for small scale agriculture, emitting CO_2 and transforming biomass into ashes) may be higher for the extensive systems, especially in Africa. Depending on the metric used to monitor GHG emissions, data will favor intensive (e.g. when assessing emissions in kg CO_2-eq/kg of meat produced) or extensive (e.g., when assessing emissions in kg CO_2-

[11] The figures date back to 2010.
[12] All GHG emissions are counted in CO_2-equivalent, so that gases with a higher global warming potential such as CH_4 are counted on an equal basis with CO_2.

eq/ha of land, or in kg CO2-eq/working people involved) systems [29,30]. Undoubtedly, the rising demand for food products, resulting from the very high population growth rate expected in the continent, will put higher pressure on livestock systems in terms of GHG management, as shown in Figure 13.

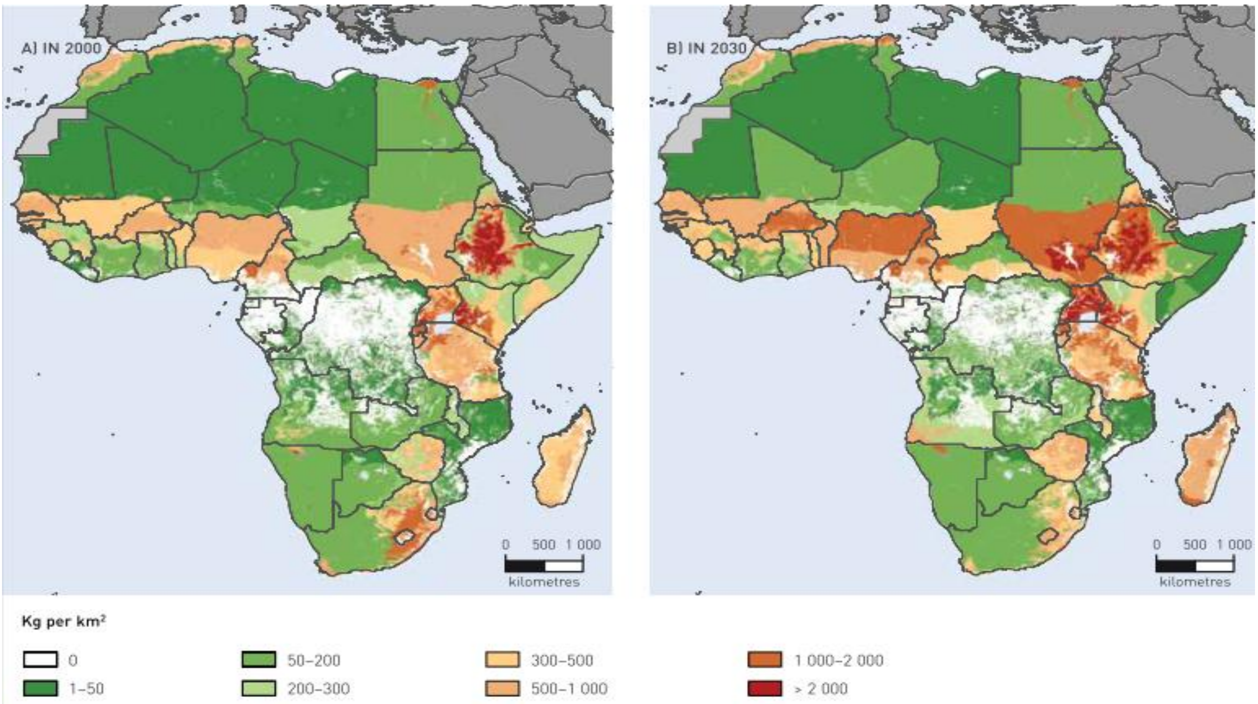


Figure 13 : Spatial distribution of methane emissions from African domestic ruminants in 2000 and 2030 [31]

1.6 Geopolitical pressure

Geopolitical pressure is hard to assess, and even harder to forecast, but it does have impacts on population, and especially on the poorest and the remote areas. Issues such as conflicts, human rights, bribery, and trade barriers are part of the global geopolitical pressure.

« **Conflicts** » can be categorized under several natures: war, riots, homicides, etc. As a matter of fact the conflict intensity observed in a country relies on the defined perimeter of the "conflict" notion. According to the 2012 Global Peace Index [32], which assesses world peacefulness following a broad set of conflict natures and violence encouraging factors, almost every region in the World improved in peacefulness for the first time since 2009 (excluding Middle East and North Africa). For the first time, Sub-Saharan Africa is not the least peaceful region. Yet, events such as the Arab spring have shown how unpredictable the extent of today's conflicts can be. Although it remains impossible to forecast conflicts, historical data show prevailing trends in the nature of conflicts and violence. "21st century violence does not fit the 20th-century mold" [33]. Interstate war and civil war have declined (the number of death from these conflicts has dropped 4 fold since the 1980s), while new forms of violent crime have been generally emerging in countries that had successfully signed peace agreements. In addition, new forms of protestation can escalate into violent outburst, as it recently happened in the Middle East and North Africa. As a consequence, many countries are now under repeated cycles of violence and political instability. Besides, access to resources is increasingly a geopolitical matter, which triggers conflicts in countries where populations are the most vulnerable. For instance, water or land availability can be at stake, and can result into conflicts, for small farmers and livestock farmers in remote areas.

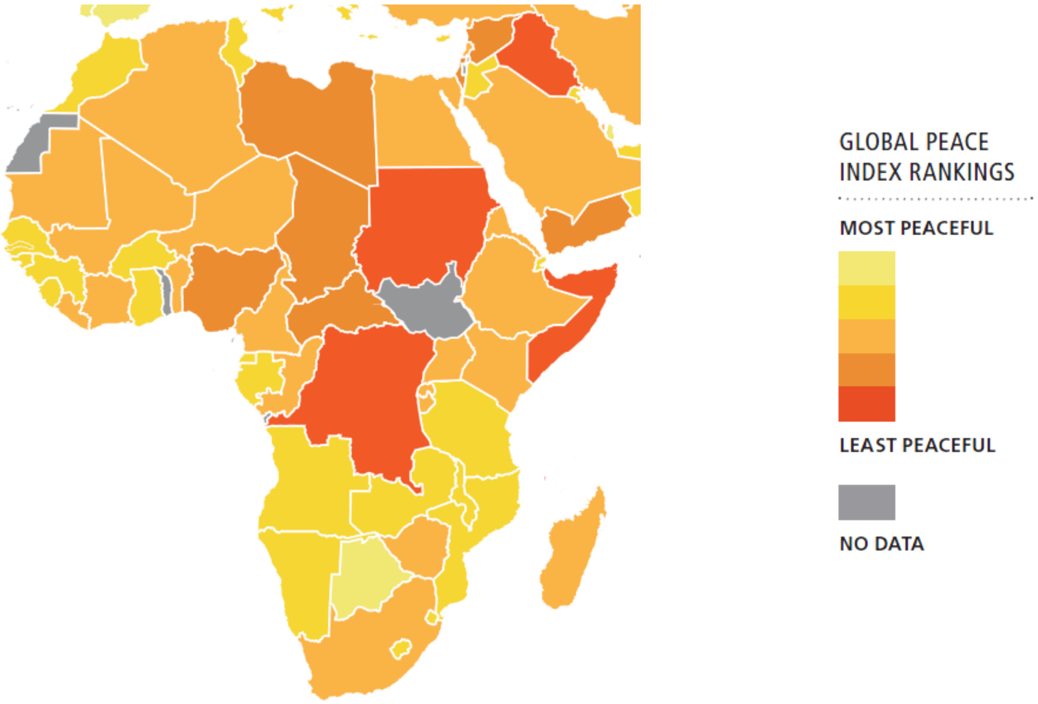


Figure 14 : Global Peace Index in Africa in 2012 [32]

2 Small Scale Livestock Farming megatrends

Small Scale Livestock Farming (SSLF) refers to a livestock farming system where the livestock farmer (one single person, a family, or a small cooperative) both owns the animal(s) and manages it (them), taking directly all decisions necessary to guarantee the sustainability of the animal or herd. The map hereafter (Figure 15) shows the different land-use systems in Africa that are suitable to livestock farming, as well as the actual livestock density. Other studies have been trying to map the farming systems, based on farmer's activity (thus mapping proper pastoral and agro-pastoral farming areas) [34], but there is little recent GIS data available.

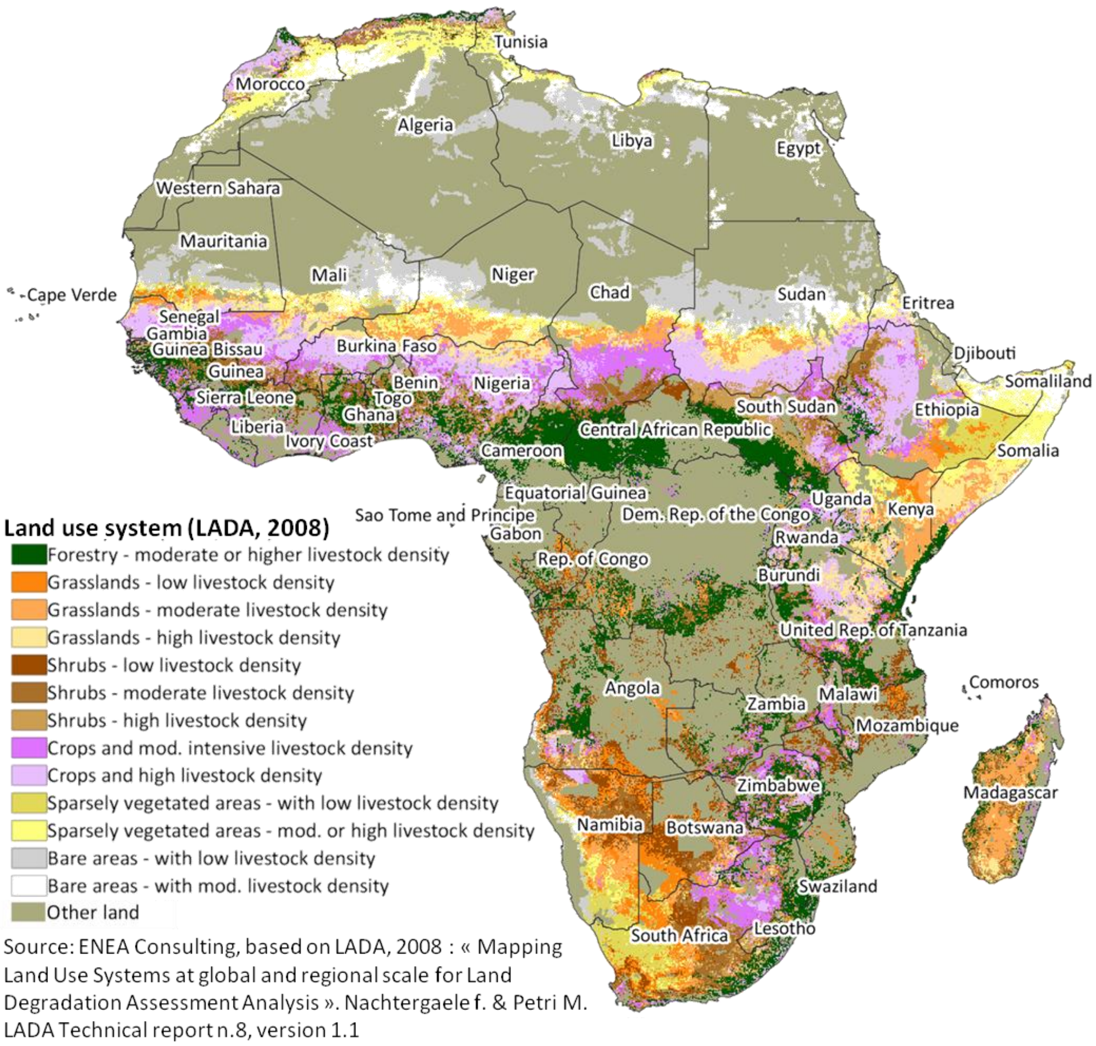
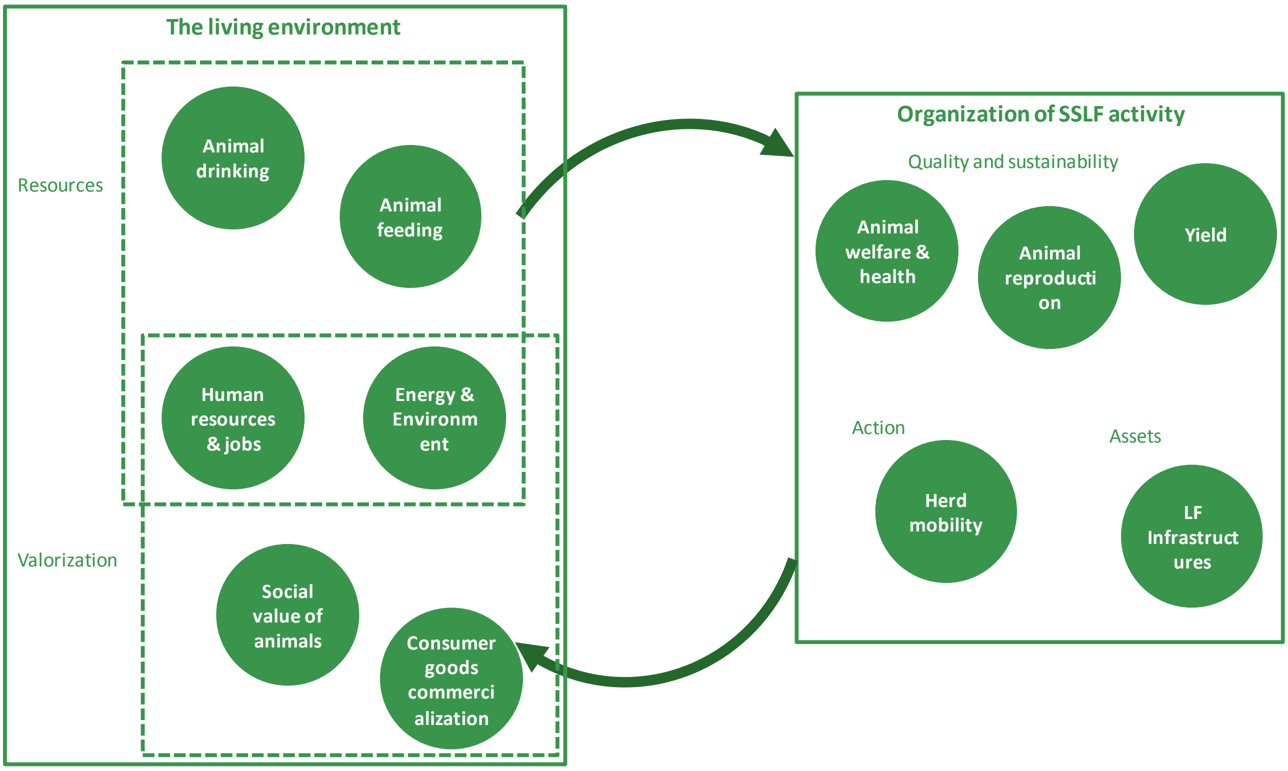


Figure 15 : Land use systems with livestock presence in Africa [35]

Small Scale Livestock Farming should not be seen as limited to the economic valorization of the animal production, but goes beyond, including environmental and social aspects. The megatrends that compose the global Small Scale Livestock Farming activity are mentioned in Figure 16.



Source: ENEA Consulting

Figure 16 : Small Scale Livestock Farming megatrends representation

The SSLF activity is actually closely connected to the surrounding living environment, relying on the following resources:

- Water, for animal drinking;
- Food (grazing), for animal feeding;
- Energy (transportation, use in premises, …);
- Human resources, required in order to take care of the animals and to manage the farm production.

In SSLF, one may note than animal drinking and animal feeding are frequently closely connected, especially via the necessary access to land, providing water and food. LSLF would be less sensitive to the access to land. Besides, the SSLF activity is also directly linked to the living environment when considering the valorization of the activity [13], owing to the following possible valorization options[36]:

- Economic valorization:
  - Direct valorization through commercialization (of the animals themselves, or of their production (milk, meat, eggs, …));
  - Job creation, as SSLF can provide local employments opportunities;
- Valorization through the social value of the animals:
  - Livestock can be either considered, depending on the situation, as a source of food or income, as draught power, as a transportation mean, and/or as a source of manure for fertilizing croplands. "*Livestock is also socially and culturally important in Africa for payment of dowry, celebrations and gifts to family members*" [37]. Lastly, livestock can be considered as a financial placement, sometime safer than a banking system, and easier to cope with for remote livestock farmers;
- Environmental valorization:
  - Production of energy (valorization of by-products, through the production of biogas for instance);
  - Use of lands unsuitable for agriculture, carbon sinks.

[13] 43% of African land is estimated to be valorized through pastoralism (http://bruxellesbrieifings.net ; 22/2/2012)

Keeping in mind that SSLF should be considered within this living environment, SSLF can be described through several megatrends, representative of the various considerations that need to be taken into account when discussing about its "efficiency":

- Animal welfare and health is at the core of SSLF, as the animals are frequently the main possession of the livestock farmers;
- Animal reproduction (meaning, in the context of this study, the herd size: animals destocking/restocking decisions and animals natural reproduction) is also of a major importance;
- Animal "yield" refers to the efficiency of the production (milk, meat, eggs, …). Optimizing these yields is a conjunction of the livestock farmers experience and know-how, and of the scientific community research and conclusions;
- Herd mobility is clearly part of SSLF, as illustrated by pastoralist practices;
- Lastly, SSLF communities can from time to time rely on some infrastructures, aiming at easing the activity. Small barns, shelter (shade structures), enclosure, greenhouses (for mixed crops and livestock systems), small-scale digester (for biogas production), as well as family houses are part of the fixed assets owned by SSLF communities.

As a whole, SSLF activity is consequently rather complex to analyze. Similarly, and as mentioned previously (refer to Box 1), climate change is also hard to predict and to model. The links between both, meaning the impacts of climate change on SSLF and the impacts of SSLF on climate change can however be investigated.

3 Summary of the main climate-change-based threats and opportunities for SSLF

Subject	Threats	Opportunities
Climate change and associated disturbance	Higher risk of damages (financial and physical losses) due to more and more unexpected extreme weather events. Changes in LGP can have negative impacts on agricultural/livestock yield. Higher population migrations are expected. Spread of animal and human diseases (mainly vectorborne diseases), due to the growth of the favorable areas (biotopes).	Some changes in rainfall and temperature patterns may locally have positive impacts on agricultural production. Adaptation practices can lead to living conditions that are better than current ones.
Population	Food sovereignty/security may be threatened by rising demand due to population growth and increase of life level. High unemployment risks due to very young population pyramid. Urbanization may trigger rural exodus.	Pastoral farmers and other small scale livestock farmers can address new markets (rising demand for livestock products). SSLF can provide rural population with employment opportunities. Feeding urban population through periurban SSLF is a coming challenge
Depletion of resources	Increased vulnerability of livestock farmers.	Adaptation strategy may increase resilience of small scale farming systems. SSLF can promote biodiversity by selecting crop/livestock species and adopting relevant agricultural techniques. SSLF could stimulate further reflections on more sustainable livestock farming systems and animal products consumption habits.
Environmental impacts of economic activity	SSLF is responsible for parts of agricultural GHG emissions.	SSLF represents a great potential for carbon sequestration and could pioneer low carbon farming practices (e.g. agroforestry) in Africa.
Geopolitical pressure	New conflicts could arise at the community level if resources get scarcer and/or in case of increasing demand.	SSLF actors could play a role in the prevention of land use ownership related conflicts (optimization of transhumance corridors, integration of livestock and agriculture).

Figure 17 : Climate Change and SSLF: Threats and opportunities

4 Analysis of climate change impacts on small scale livestock farming

4.1 Impacts evaluation

4.1.1 Introduction and methodology

Among the environmental and social megatrends described in section 1, some can be seen as directly or indirectly connected to climate change. Only those megatrends that are the most directly linked to climate change have been considered in the following evaluation. Their impact on SSLF is the subject of this section.

Despite the efforts made to propose a robust segmentation of the environmental and social aspects on the one hand, and of the SSLF aspects on the other hand, one should note however that the megatrends listed are definitely not independent. Only the most straight forward implications are actually indicated in Table 2. The latter should be read in conjunction with Table 1, which explains the meaning of the symbols used.

Symbol used	Meaning
+	The climate change megatrend has an impact on the SSLF megatrend that is necessarily positive, with regards to the sustainability of the SSLF activity.
-	The climate change megatrend has an impact on the SSLF megatrend that is necessarily negative, with regards to the sustainability of the SSLF activity.
+ / -	The climate change megatrend has an impact on the SSLF megatrend that can be either positive or negative, with regards to the sustainability of the SSLF activity, depending on the actual evolution (e.g. temperature increase or temperature decrease).
Key	The climate change megatrend has an impact on the SSLF megatrend that is considered as major, compared to other impacts.
Map	A map is available either in section 1 or hereafter, providing an illustration of the potential impact.

Table 1 : Climate change impacts evaluation methodology

4.1.2 Megatrends interactions

Among the existing interactions in-between the megatrends, the following can be mentioned regarding climatic issues:

- Water scarcity and fertile land availability are likely to be connected to temperature change;
- Water scarcity and fertile land availability would also in some extent be linked to the rainfall patterns;
- Extreme weather events would certainly have negative impacts on water scarcity and fertile land availability, in a more punctual way.

Furthermore, population considerations (demography, urbanization) would also somehow be influenced by climate change, and its associated disturbances. These considerations have some impacts on SSLF that are worth being taken into account, which is the reason why they are included in the "climate change" impacts.

Some interactions between the SSLF megatrends can also be quoted:

- Animal health and welfare actually depends on animal drinking and feeding;
- Similarly, the production yield also falls under the influence of animal drinking and feeding.
- Lastly, in SSLF, animal drinking and animal feeding are closely linked together (while being both closely connected to the access to land).

As a consequence, and in order to keep the analysis understandable and the matrix thereafter readable, only the most straight forward implications are indicated in Table 2, voluntarily neglecting the impacts that could be considered as indirect, or as a second order of magnitude.

4.1.3 Impacts matrix

	Temperature change	Rainfall patterns evolution	Extreme weather events	Water scarcity	Fertile land availability	Demography	Urbanization
Animal drinking	+ / -	+ / -		+ / - Key Map		-	
Animal feeding		+ / - Key Map	- Key		+ / - Key Map	-	-
Animal health/welfare	+ / -	+ / -	-	+ / -	+ / -		
Animal reproduction	+ / -		-	+ / -	+ / -		
Production yield	+ / -			+ / -	+ / -		
Herd mobility			-	+ / -	+ / -	-	-
SSLF Infrastructures	-	-	-	+ / -			+ / -
Commercialization			-			+ Map	+ Map
Animal social value				+ / -		+ / -	
Energy			-				
HR/jobs			-	+ / -		+	-

Table 2 : Climate change impacts on SSLF matrix

Some clarifications are provided thereafter, so as to further explain the information given in Table 2:

- Temperature change:
  - A temperature increase, which is the overall tendency expected in Africa in the midterm (refer to Figure 2), would result in an increase in thirst and thus negatively impact animal drinking.
  - A change in temperature would also impact animal welfare, animal reproduction and production yield, although the correlation is not easy to model.
  - Lastly, a change in temperature might make the existing SSLF infrastructures inadequate. No positive impact is anticipated, whatever the temperature trend.
- Rainfall patterns evolution:
  - The modification of rainfall trends (as illustrated in Figure 3) will impact the Length of Growing Period (presented in Figure 4 and Figure 5), and therefore impact animal feeding primarily.
  - Animal drinking and welfare will also be concerned, with a possible spread of disease.
  - At last, the existing infrastructures may become out of date or insufficient. No positive impact is anticipated, whatever the rainfall trend.
- Extreme weather events
  - Among all the climate change related megatrends, the increased occurrence of extreme weather events is the only one whose effects will systematically be negative.
  - It actually hinders a long run stable activity, owing to the possible damage on infrastructures and energy supply sources. Commercialization could be altered as well, and employment temporarily affected.
  - Herd mobility could become more complicated (in case of flood for instance). So does animal feeding (owing to crop losses for instance).
  - Lastly health issues and animal fatalities could be reported.
- Water scarcity
  - The main and most obvious impact of water scarcity will be on animal drinking
  - Animal feeding will be impacted as well, as water scarcity reduces possibilities to access to pastoral areas (in semi arid and arid regions, the access to pasture (grassland) during the dry season is submitted to water availability).
  - Animal health, animal reproduction and production yield will also be modified depending on the actual water stress.
  - SSLF infrastructures may become inadequate (e.g. wells located in a region that has become more arid).

  - Herd mobility will be modified, because of the new displacements required to find some water and grassland for the animals.
  - Some decisions (destocking for instance, or reduction of dowry) could be taken modifying the social value of the animal.
  - Lastly, the consequence on human resources is more ambiguous. New jobs could become necessary (new wells digging), other could be destroyed.
- Fertile land availability
  - The main and most obvious impact of fertile land availability will be on animal feeding.
  - Animal welfare and production yield will be impacted in turn, as a consequence of the feeding quality.
  - Besides, similarly to water scarcity considerations, herd mobility could be modified, with new displacements routing to more fertile lands.
  - At last, the access to good grazing lands during the dry season and to a strategic feeding complementation has proven to be effective to maintain, and even improve, livestock fertility rates. Reversely, the reduction of grazing lands quality during the dry season has a negative impact on reproduction rate.
- Demography
  - The most significant impact of the expected increased inhabitants in Africa (refer to Figure 8) will be on commercialization, with an increased demand for livestock products.
  - This higher demand could lead to the creation of new jobs in the livestock sector.
  - More controversially, the increased demand for meat could induce decisions modifying the social value of the animals (shift towards an increased “productive” attitude).
  - Furthermore, the population increase would result in a higher demand for water, and thus possibly in a competition for water impacting animal drinking.
  - In arid areas, the demographic growth increases the pressure on access to lands. The increase of cultivated land areas thereby reduces the extent of grazing land.
  - Lastly, herd mobility will be impacted as well. Indeed, the demographic pressure increases the pressure on lands use. Therefore, one may note the actual trend of farmers and livestock producers to settle and turn into “farmer-breeders”. One may add that farmers use more and more lands in order to respond to the increasing food demand.
- Urbanization
  - The most significant impact of the expected increased urbanization in Africa (refer to Figure 10) will be on commercialization, with a probable increased demand for livestock products.
  - Rural-to-urban migration could drain some workforce from rural areas to cities, thereby reducing the number of people available for work in the livestock sector.
  - The growth of the cities is also likely to compete with the current use of lands for animal feeding, to hinder herd mobility, and to make existing SSLF infrastructure no longer available for use. However, this could also been seen as an opportunity to build new and more modern infrastructures elsewhere.

Figure 18 and Figure 19 hereafter are some illustrations of such impacts, analyzed by ENEA Consulting by mixing several sets of data.

Figure 18 makes the connection between water scarcity (represented through the drought severity risk index) and animal welfare and animal reproduction, observed through the density of livestock presence. Regions where drought severity is high or extremely high while being settled by a moderate to high amount of animals (north of Nigeria, south of Sudan for instance) are probably those who require focusing at the utmost on water management related adaptation strategies.

Figure 19 consists in a more prospective analysis, current farming systems being analysis in conjunction with the expected mid-term (2025) water stress. Agro-pastoral and pastoral farming systems happen to be frequently located in regions that are expected to become even more water stressed than they are today (Sahel region, Horn of Africa, Namibia). A more local analysis could help determine whether some adaptations techniques could be worth being implemented in the near future (regional planning, water management …).

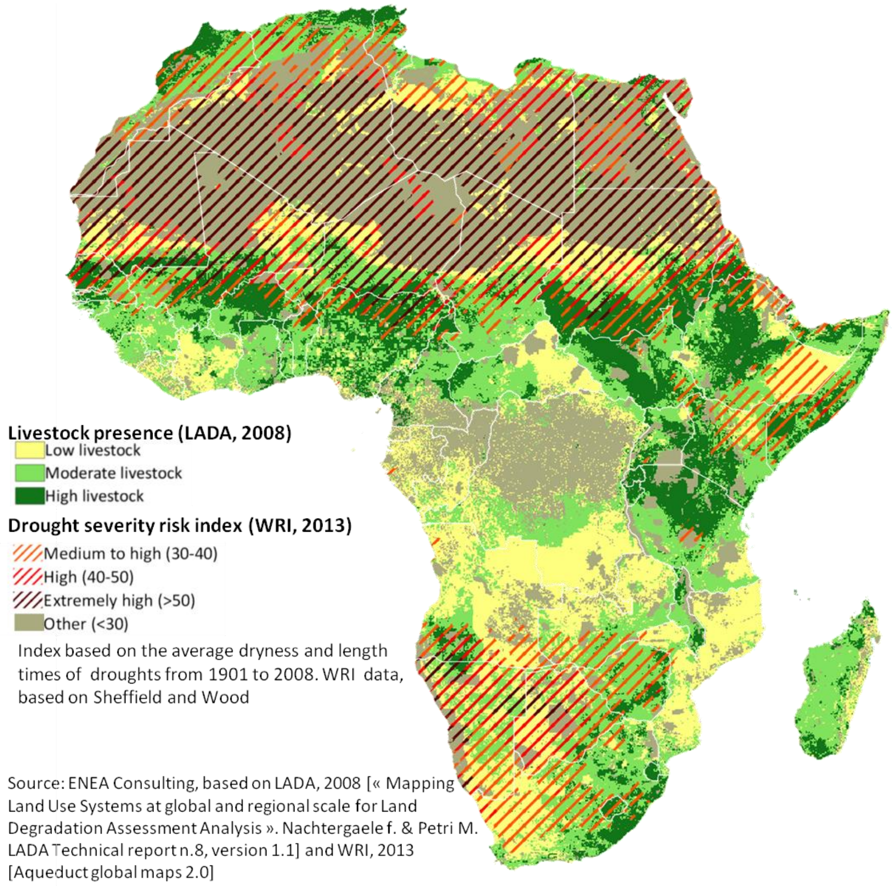
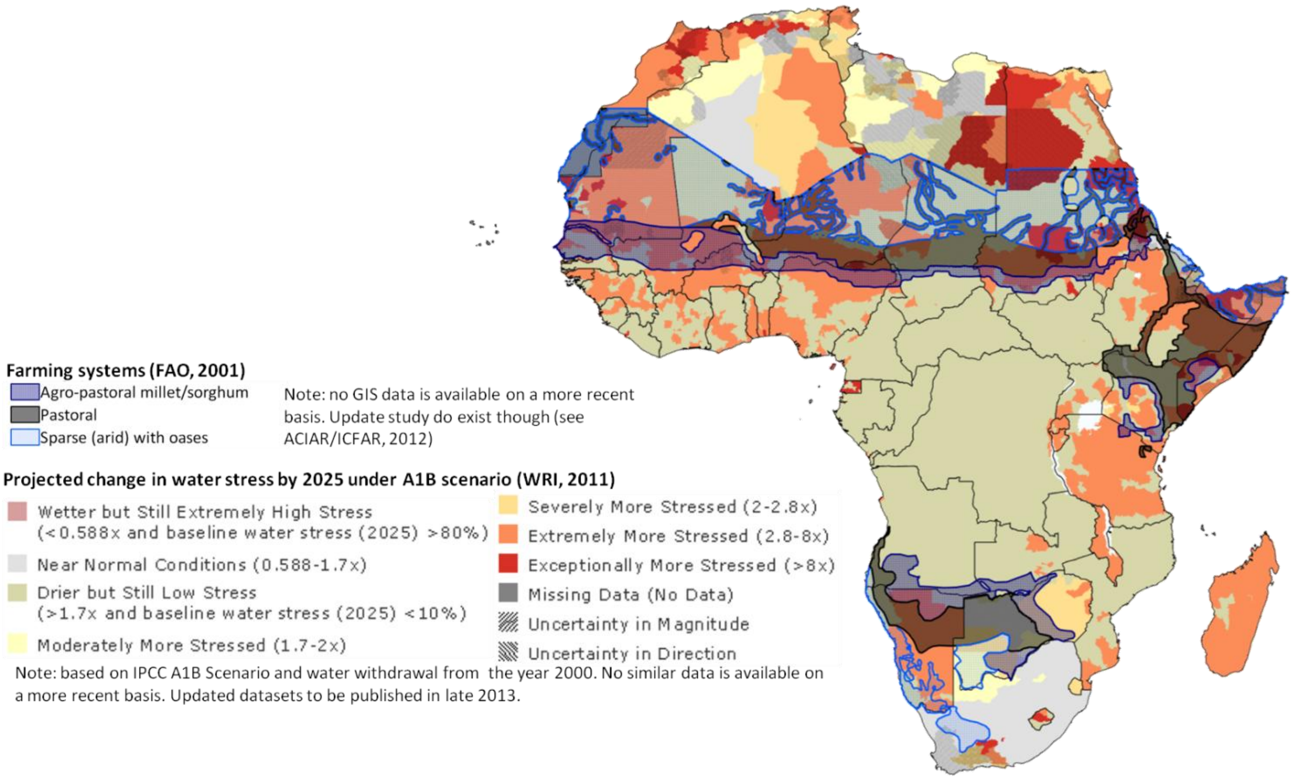


Figure 18 : Livestock presence and drought severity in Africa [38][35]



Source: ENEA Consulting, based on FAO, 2011 [Major farming systems of Sub-Saharan Africa. FAO Geonetwork] and WRI, 2011 [Aqueduct global maps 2.0]

Figure 19 : Projected water stress (2025) and farming systems in Africa [38]

4.2 Towards an adaptation strategy

Adapting to climate change is a process that aims at making human activity, natural ecosystems and goods more resilient to climate evolution either by lowering the damages caused by climate change or by taking advantage of its consequences. It involves long term prospects (adaptation strategies deal with the *effects* of climate change) but can consist of short term actions as well [39].

Some adaptation actions are listed thereafter. This list does not pretend to be exhaustive by any means. Some adaptations options that could be considered as a second order of magnitude in the frame of this analysis have not been taken into account for instance.

Adaptation actions	Associated E&S megatrends	Associated SSLF megatrends	Details of possible actions	Resources
Early warning systems and seasonal forecasting tools	Extreme weather events Water scarcity	Animal drinking Animal feeding Herd mobility SSLF infrastructure	▪ For water scarcity (droughts and precipitations) ▪ For disease spreads ▪ For extreme events	[40]
Regional planning, cooperation & knowledge management	Water scarcity Fertile land availability	Animal drinking Animal feeding Herd mobility	▪ Joint management of grassland to clarify land ownership patterns and avoid conflicts. ▪ Grassland and water resources mapping at a regional scale. E.g. GIS based decision support system for rainwater harvesting, or weather forecast for small scale decisions. ▪ Fodder banks can help farmers to have reliable access to feed. ▪ Support to regional radios. The latter can broadcast useful information on transhumance corridors or water access for instance. ▪ Supranational cooperation can be more efficient than current informal patterns for herd mobility. Indeed, pastoral farmers may have to cross borders in order to face changes in seasonal patterns.	[41][42]
Capacity building	Water scarcity Energy	HR/Jobs Herd mobility	▪ Herd management training ▪ Water management training ▪ Waste management training in order to lower contamination	
Mobility management	Water scarcity Fertile land availability Demography Urbanization	Herd mobility	▪ Transhumance corridors enhance access to resources and grassland preservation but can degrade land (trampling) ▪ Splitting the herd can optimize access to resources while decreasing land degradation	[42]
Financial tools	Extreme weather events	Animal reproduction SSLF Infrastructure HR/Jobs	▪ Microcredit ▪ Financial loans ▪ Animal loans ▪ Crop and livestock micro insurance	[41][40]
Water management	Water scarcity	Animal drinking Animal feeding SSLF Infrastructures HR	▪ Small scale irrigation management: higher water use efficiency through efficient water collection, distribution (flood cropping, stream diversion, pump supply...), storage, and application ▪ Micro irrigation systems with water storage (bucket kits) ▪ Rainwater harvesting ▪ Wells	[40] WOCAT website [43]

Adaptation actions	Associated E&S megatrends	Associated SSLF megatrends	Details of possible actions	Resources
Energy management		Energy Commercialization SSLF Infrastructures Animal social value HR	The following actions enhance autonomy and increase resilience: ▪ Improved cookstoves ▪ On site biogas production ▪ Waste valorization: waste can be used as fodder or fuel ▪ Animal traction avoids fossil fuel consumption ▪ Wind/Solar powered hydraulic pumps	[44]
Land management	Fertile land availability Urbanization	Animal feeding SSLF infrastructure Production yield	▪ Contour cultivation and other cross-slope barriers hinder erosion ▪ Integrated soil fertility management aims at maximizing positive interactions and complementarities at the farm scale ▪ Agroforestry mixes crops and livestock with forestry to enhanced their combined benefits ▪ Tree nurseries enhance reforestation	WOCAT website [43][45]
Animal switch & animal diversification	Extreme weather events Water scarcity Fertile land availability Urbanization	Animal drinking Animal feeding Animal social value Production yield	▪ Promotion of local species: supports biodiversity ▪ Promotion of species more suitable to suburban areas ▪ Animal shift: shift to a more resilient species (often less marketable though) such as camels and goats, which need less water and reduce trampling ▪ Poultry is also widely considered as a cheap and fast-producing species ▪ Keep different types of livestock (species diversification)	[37] [46]
Herd management	Extreme weather events Water scarcity Fertile land availability		▪ Temporarily or permanently migrate to more pasture favorable areas ▪ Split herds into core and satellite herds to share risks ▪ Maintain female dominated herd structure, to avoid long calving intervals ▪ Optimize herd size (stocking/destocking)	[46]
Crop switch & crop diversification	Temperature change Rainfall pattern evolution	Animal feeding SSLF Infrastructure Production yield	▪ Switch from low value to high value (price) ▪ Switch from low yield to high yield ▪ Switch from high water use to low water use ▪ Multipurpose crops with high valorisation standards ▪ Mixed farming (crop and livestock): enhances land fertility	[41][40]
Market oriented diversification	Demography Urbanization	Commercialization	▪ Niche markets: e.g. cane rats, snails... Animal diversification can be an asset to address these markets. ▪ New markets: e.g. Poultry, organic products ▪ New markets: promote dried meat consumption (reduction of preservation constraints) ▪ Nonagricultural income diversification: - Ecotourism - Petty trade - Non-timber forest products	[41][37]
Farming and household infrastructure	Temperature change Rainfall pattern evolution	SSLF Infrastructure Animal reproduction Production yield	▪ Shelter can provide more shade structures ▪ Greenhouses can improve yields	
Animal nutrition	Fertile land availability	Production yield Animal feeding	▪ Fattening techniques ▪ Get inspired from LSLF	
Veterinary medicines		Production yield Animal reproduction Animal health/welfare	▪ A vaccination campaign hinders disease spread but can degrade land (trampling and overgrazing around the centre) ▪ Livestock medical treatments avoid mortality but can hinder biodiversity (genes)	[47]

Table 3 : Adaptation actions listing

5 Analysis of small scale livestock farming impacts on climate change

5.1 Impacts evaluation

5.1.1 Introduction and methodology

Among the environmental and social megatrends described in section 1, some can be seen as directly or indirectly connected to climate change. Only those megatrends that are the most directly linked to climate change have been considered in the following evaluation. The impact of SSLF on those megatrends is the subject of this section.

The impact matrix in Table 5 should be read in conjunction with Table 4, which explains the meaning of the symbols used.

Symbol used	Meaning
+	The SSLF megatrend has an impact on the environment megatrend that is necessarily positive, with regards to the sustainable development.
-	The SSLF megatrend has an impact on the environment megatrend that is necessarily negative, with regards to the sustainable development.
+ / -	The SSLF megatrend has an impact on the environment megatrend that can be either positive or negative, with regards to the sustainable development, depending on the actual evolution (e.g. GHG emission depending on the food given to the animal).
Key	The SSLF megatrend has an impact on the environment megatrend that is considered as major, compared to other impacts.

Table 4 : SSLF impacts evaluation methodology

5.1.2 Megatrends interactions

Despite the efforts made to propose a robust segmentation of the environmental and social aspects on the one hand, and of the SSLF aspects on the other hand, these megatrends can't clearly be considered as independent.

Interactions between the SSLF megatrends has already been discussed in the climate change impacts section.

The interactions between the environmental aspects listed in this analysis are more limited, since only an obvious influence of energy on greenhouse gases emissions can be pointed out.

5.1.3 Impacts matrix

	Biodiversity	Water scarcity	Fertile land availability	Forests	Energy	GHG
Animal drinking		+ / -				
Animal feeding	+ / -			-		+ / -
Animal health/welfare						
Animal reproduction	+					
Production yield						+
Herd mobility	-		+/ -			
SSLF Infrastructures		+			+	+ / -
Commercialization						
Animal social value						+ / -
Energy						
HR/jobs						

Table 5 : SSLF impacts on climate change matrix

Some clarifications are provided thereafter, so as to further explain the information given in Table 5:

- Biodiversity
  - By eating, animals will have an impact on biodiversity.
  - So they will, when moving (herd mobility).
  - Besides, SSLF tends to promote several species for each animal, with a focus on genetic diversity, thereby favoring biodiversity
- Water scarcity
  - Animal drinking can worsen water scarcity.
  - On the opposite, SSLF infrastructures including rainwater harvesting systems can help reduce water scarcity.
- Fertile land availability
  - Herd mobility can negatively impact fertile land availability, due to trampling.
  - On the other side, manure is very important to fertility.
- Forests
  - A negative impact on forests can be observed, should stubble-burning be frequently applied for animal feeding
- Energy
  - Valorizing wastes through methanisation (production of biogas) can help provide an energy source to local communities
- Green house gases emissions
  - This impact is the most widely discussed in the literature, owing to the overall impact of agriculture and livestock farming on GHG emissions. In livestock farming (SSLF and LSLF both included), at a global scale, animal feeding is the prevailing impact on GHG emissions. In the framework of SSLF, one may note that the limited use of fertilizers reduces by the end the N_2O emissions from animal feeding.
  - SSLF infrastructures are also contributors to GHG emissions, through energy consumption. This impact can be limited when special attention is paid to the energy source (solar power for instance). A proper design of infrastructures can help limit energy consumption and thus GHG emissions.
  - Besides, one may note that an increase in production will directly reduce associated GHG emissions (less tons of CO_2-eq emitted per ton or liter produced)
- Lastly, should animals be used as draught power, this can result in a reduction of the GHG emissions originating from transportation.

5.2 Towards a mitigation strategy

Mitigation includes all the actions made in order to reduce the global anthropogenic emissions of GHG. At a global (agriculture and livestock farming both included) and worldwide scale, the main sources of such emissions in the agricultural sector are enteric fermentation (CH_4) and N_2O emissions from fertilized soils [29]. The global contribution of the specific livestock farming sector to GHG emissions worldwide is estimated to be 18% (FAO figures based on data recovered in 2006) [28], with a higher contribution of CH_4 rather than CO_2.

In order to prioritize mitigation actions, one can assess their efficiency by measuring their potential reduction of net GHG emissions[14]. It is estimated that soil carbon sequestration accounts for 89% of the total potential for GHG mitigation in the agricultural sector. On the contrary, methane mitigation (e.g. through improved feeding practices for livestock) only represents 9% of the total potential for GHG mitigation [1]. Besides, one may note that technical capacity of favoring carbon sequestration in grazing land is considered higher than other CH_4 emission mitigation techniques, which allows a classification of the mitigation measures listed thereafter [30].

Some mitigation actions are listed thereafter. This list does not pretend to be exhaustive by any means. Some mitigation options that could be considered as a second order of magnitude in the frame of this analysis have not been taken into account for instance.

[14] Namely, the balance between the gross emissions and the carbon sequestration.

Mitigation actions	Associated E&S megatrends	Associated SSLF megatrends	Details of possible actions	Resources
Regional planning			▪ Supranational cooperation can be efficient (allocation of GHG emissions, dissemination of best practices observed …)	
Financial incentives to GHG reduction	GHG	Commercialization	▪ Carbon trading systems: Programmatic CDM could be considered for small scale projects (e.g. AMS-III.D: Methane recovery in animal manure management systems)	[30] [48]
Reducing soil emissions and enhancing GHG sequestration	Fertile land availability, GHG	Animal feeding, animal welfare	▪ Integration of livestock and agriculture: Traditional mixed farming systems ▪ Switch from conventional tillage to no-till farming ▪ Enhanced crop rotation inclusion: nitrogen-fixing legumes included into rotations ▪ Development of conservative agriculture ▪ Optimization of nutrient management : Introduction of livestock into agriculture through traditional mixed farming systems, so as to reduce chemical fertilizers use (though they are already limited in SSLF) ▪ Optimization of pasture/rangeland management: Stimulation of moderate grazing, or cultivation of deep rooted plant species ▪ Involment in biochar studies that present an interesting potential development in SSLF (fertility, fertilizer efficiency and water holding capacity) in spite of a certain lack of implementation schemes and economic assessments ▪ biochar studies	[29] [30][49]
CO2 sequestration into biomass	Biodiversity, Forests, GHG	Animal feeding, herd mobility	▪ Development of hedge planting ▪ Development of agroforestry practices ▪ Development of sylvopasture ▪ Limitation of stubble burning use	[29]
Mitigating GHG emissions from animals	GHG	Animal feeding, animal welfare, reproduction, production yield, commercialization	▪ Investigation of alternate feeding practices: Inclusion of cereals, concentrated food or condensed tannins in animal diet to reduce methane production. ▪ Manipulation of microbial organisms: Introduction of predatory microbes. Such practice would certainly be before experienced in LSLF. SSLF could share views with LSLF and benefit from the experiments if conclusive. ▪ Prefer non ruminant animal/species : For instance prefer mono-gastric animals (e.g. poultry) compared to ruminants ▪ Reduction of the number of “non economically productive” animals; this approach however tends to be more applicable to LSLF rather than SSLF, where it could be contradictory with social habits of livestock farmers.	[29] [30]
Mitigating GHG emissions from infrastructures	Energy, GHG	SSLF infrastructures, commercialization, HR	▪ Energy efficiency measures in infrastructures: For instance valorization of fat and proteins in slaughterhouse, and production of heat that can be used for hygienisation ▪ Enhanced manure management and biogas or compost production ▪ Use of renewable energy (solar, renewable biomass, possibly wind power)	[29] [30] [50]
Behavioral modifications, to mitigate GHG emissions	GHG	Commercialization	▪ Give access to ecological footprint data (e.g. for meat based products) to consumers ▪ Reduce meat consumptions on an average ▪ Optimize food management globally : Reduce food waste, increase local and seasonal food consumption ▪ Increase insects consumptions	[30]

Mitigation actions	Associated E&S megatrends	Associated SSLF megatrends	Details of possible actions	Resources
Limitation of biodiversity degradation	Biodiversity	Herd mobility, animal reproduction	▪ Optimize transhumance corridors ▪ Herd management ▪ Genetic improvement program	
Improved water-use efficiency	Water scarcity		▪ Minimize water consumption (though options are very limited in the case of SSLF)	

Table 6 : Mitigation actions listing

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HEALTHY ANIMALS,

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Vétérinaires Sans Frontières Belgium is a Belgian NGO, with development programmes in 8 African countries: Mali, Burkina Faso, Niger, DR Congo, Rwanda, Kenya, Uganda and South Sudan. We support pastoralists, agro-livestock keepers and livestock keepers in urban areas who practice small-scale livestock farming.

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In Europe, our activities focus on sensitization, education and lobbying of consumers, livestock professionals and decision makers on the importance of small-scale livestock farming and a sustainable production and consumption model.

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Livestock is part of the family: every animal has a name and the farmer knows their pedigree. Meat, blood and milk from the animals play an important role in family, social and religious celebrations. Livestock is often entrusted to others and promotes mutual solidarity. Livestock also serve as dowries at weddings or else may be given as presents.

Household

Cattle provide transport and draught power. Excrement and urine are used as fertiliser, fuel, building materials, beauty products, and insect-repelling and disinfecting agents. Hides are used to make clothing, sandals and mattresses and as a building material.

Income

By selling or trading livestock or animal products, farmers can afford a balanced diet, clothing, education and healthcare. The animal is a four-legged savings bank and insurance policy, which can be converted into cash quickly whenever the need is greatest.

Food

Milk, eggs and meat are an important source of protein. In East Africa, livestock keepers drink the blood of cows in times of crisis, sometimes blending it with milk.

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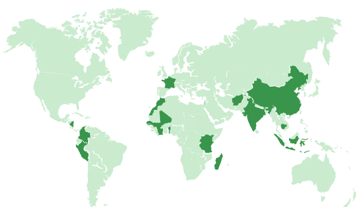

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