Producing Climate Change Scenarios and Risk Assessments for Africa

Strengthening the resilience of ecosystems and populations in four regional hubs in northern Mauritania

Report 3.2 (Part 2 of DELIVERABLE 3)

CRITICAL CLIMATE RISKS IN FOUR REGIONAL HUBS

Delivered by: ARIA Technologies, ACTERRA, AGRER

Date: 08 07 2022

Version: **FINAL**

Table of content

LIST OF ABREVIATIONS AND ACRONYMS

AND (NDA)	Autorité Nationale Désignée (FR) National Designated Authority (EN)
4PRN	Quatre Pôles Régionaux au nord de la Mauritanie
AEP	Approvisionnement en eau potable
ATTM	Agence pour les Travaux de Terrassement en Mauritanie
BATHA	Lit sablonneux en zone de dépression
BCG	Bacille Calmette et Guérin
CDN	Contribution Déterminée au niveau Nationale CN Consultants Nationaux
CMIP	Climate Model Intercomparison Project
CRA	Cellule Régionale d'Appui
DCEV	Direction Climat et Economie Verte
DOTS	Prise en charge des soins gratuits de la tuberculose
DRAS	Direction Régionale à l'Action Sanitaire
DREDD	Délégation Régionale de l'Environnement et Du Développement Durable
DRHA	Direction Régionale de l'Hydraulique et de l'assainissement
ETP	Potential evapotranspiration
FAO	Food and Agriculture Organization of the United Nations
GAVI	Global Alliance for Vaccines and Immunization
GEMBE	Crocodile Zone
GHG	Green house Gas
GRARAA	Zone de dépression en zone accidentée HBT Habitant
HTA	Hypertension artérielle
IEPC	Initiative Elevage, pauvreté et croissance
IPCC	Intergovernmental Panel on Climate Change
IRA	Infections Respiratoires Aigues
MDR	Ministère du Développement Rural
MEDD	Ministère de L'Environnement et du Développement Durable
MHA	Ministère de l'Hydraulique et de l'assainissement
ONG	Organisation non Gouvernementale
ONS	Office Nationale de la Statistique
PDDO	Programme de Développement Durable des Oasis
PNDA	Programme National pour le Développement Agricole
PNDE	Plan national de développement de l'élevage
PPB	Péri Pneumonie Bovine PPR Peste de Petits Ruminants
PR	Precipitation
QCN	Quatrième Communication Nationale
RCP	Representative Concentration Pathways
RGPH	Recensement Général pour la population et l'Habitat
SNDE	Société Nationale de Distribution d'Eau SP Sable et la Prolifération
THI	Temperature-Humidity index
Tmax	Maximum surface air temperature
Tmean	Average surface air temperature
Tmin	Minimum surface air temperature
UNEP	United Nations Environment Programme
UNESCO	Organisation des Nations Unies Pour L'Enfance et L'Education

LIST OF FIGURES

LIST OF TABLES

LIST OF PICTURES

LIST OF BOXES

GLOSSARY

Diéri:	A geographical term associated with dry farming areas (sandy to clayey-sandy) are entirely dependent on rainfall (wintering) and called “rainfed farming” soils. (of Toucouleur origin) which designates the non-floodable land of a river valley, as opposed to the Walo (see Walo).
Hakem:	Authority (Prefect) representing the national government at the moughataa (departments) level.
Moughataa:	The Wilayas are divided into 54 moughataas (departments) that are divided into arrondissements (districts)
Tamourt :	Wetland or Pond or spreading area where the water (rolled by the wadis and which escapes the restraints of dams, dykes) generally sits temporarily for 3 to 6 months. They provide an aquatic habitat for ecosystem-important flora and fauna (sand crocodile) .
Reg :	An area of desert formed by pebbles resulting from the physical disintegration of a material and frequently resting on a more finely disintegrated material.
Wadi:	A valley or ravine, bounded by relatively steep banks, which in the rainy season becomes a watercourse; found primarily in North Africa and the Middle East.
Wali :	He/She represents the central government over the territorial Wilaya; the latter is a deconcentrated administrative entity placed under the authority of a Wali (Governor) .
Walo:	A geographical term designating an area subject to flooding by a natural flood and with clay soil suitable for flood recession crops, in French « cultures de décrues ». The term refers in particular in Mauritania to land along the Senegal River in southern Mauritania (northern Senegal). It is generally contrasted with diéri, areas further away from the river and never flooded (see also Diéri above).
Wilaya:	The territory of the Islamic Republic of Mauritania is organised into 13 wilayas . It is a deconcentrated administrative unit of the country territory placed under the authority of a Wali (Governor)
Region:	Since 2018, the territory of the Islamic Republic of Mauritania is organised in 6 Regions grouping the 13 Wilayas 8 (new organic law).
Zeribas:	From Arabic زَرْب, zarb; in oasian agriculture, this term means a palm grove property unit.

Executive Summary

Objective of this report

The objective of this report '***Climate risk assessment of the four regional hubs'*** is to provide building blocks to finalise the risks assessment of the four selected hubs by characterizing the natural, socio-economic and structural features of the selected territories, namely their exposure and vulnerability to climate change hazards analysed in Deliverable 3.1. The process will allow to obtain risks profiles with the combination of the results of the previous report entitled "*Climate Trends and Projections in the four regional hubs"***,*** namely the key climate change signals, to vulnerability and exposure of the people in this area.

Why those four hubs?

The project focuses on four regional hubs along the strip of the country in the Sahelian region, which is fertile but very fragile, receiving with between 150 and 400mm annual rainfall but where the desertification process is severe. The hubs are located around **Néma** in the Wilaya of Hodh El Chargui**;** around **Tamchekett** in the Wilaya of Hodh El Gharbi; around **Rachid** in the Wilaya of Tagant and around **Aoujeft** in the Wilaya of Adrar. Stopping desertification in those areas is strategic, precisely because the hubs are geographically situated between the valley of the Senegal river (in the South of the country) and the Northern/Eastern part of the country which is entirely classified as a desertic zone. Those four hubs are at the forefront of the current desertification line, therefore strategies promoting resilience to climate change successfully implemented, will constitute a strip **acting as a vital protective zone** for the rest of the country against the progress of desertification exacerbated by climate change related hazards.

What are the key climate related risks facing the regional hubs?

Mauritania located in the African Sahel, is mostly affected by recurrent droughts since 1968. The resulting desertification is the most pronounced effect of the climate change, combined with human action, had direct consequences on an already very precarious environment. Mauritania has one of the highest water deficits, with only ***0.5% of the total surface of the country considered arable*** and an estimated ***60% of the territory is considered as severely or very severely degraded*** which is caused by a combination of natural and anthropogenic factors.

What makes those four hubs vulnerable to climate change?

The climate change simulations carried out for these hubs clearly show a very strong increase of two hazards, namely drought / dry spells and water balance deficit in the four hubs (to a lesser extend in Aoujeft). Heat waves are a very high projected hazard by 2050 under scenario 8.5 in the four hubs and in Rachid even under scenario 4.5. Flood are projected to decrease because of lower values for heavy rain in the four hubs but the risks remain there in the current situation. Combining the vulnerability and the exposure to the projected climate risks identified in Report 3.1, allowed to determine that the four hubs are highly vulnerable to climate change conditions and need a rapid and set of interventions to protect the survival of the people in those areas. Climate change impacts do not affect all sectors equally but they all are highly vulnerable to rising temperatures combined simultaneously to a decrease in precipitation. Climate impacts are combined to a range of social and economic factors described in Section 3 of this report. The adaptation actions described in the final table to respond to identify risks are focussing on building more resilient systems overall, to reduce vulnerability and develop specific system capacities that address key priority risks identified.

1. Introduction

1.1 Objective of this report

The objective of this report is to provide building blocks to finalise the risks assessment of the four selected hubs by characterizing the natural, socio-economic and structural features of the selected territories, namely their exposure and vulnerability to climate change hazards analysed in Deliverable 3.1. The process allowed to obtain risks profiles by combining the results of the previous report entitled "*Climate Trends and Projections in the four regional hubs"*, namely the key climate change signals, to vulnerability and exposure of the people in the four hubs

1.2 The conceptual framework

The tool used by the project allows the identification of risks through the definition of cause-effect chain. A as described in the IPCC AR5 methodology (IPCC, 2014), (GIZ, 2018), a risk chain shows the interaction between 1) climate hazards, 2) vulnerability and 3) exposure to calculate the level of risk (see Box 1 and Figure 1 below).

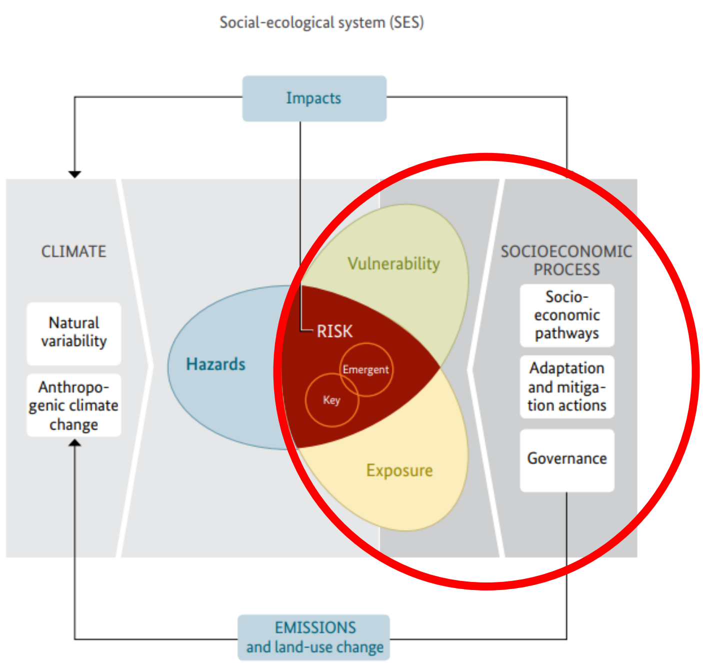


Figure 1 : Illustration of the risk concept of ecological systems

Source: IPCC, 2014 in GIZ 2018 - Element circled in red are analyses in this report and combined to the results about hazards from the report 3.1.

Box 1

***Hazard (probability and severity)* x**

vulnerability* x *exposure = RISK

Where,

- **Hazard** is the potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources, (see Report 3.1);
- **Vulnerability** is the propensity or predisposition to be adversely affected, and
- **Exposure** is the presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected.

This framework includes:

- Climate signals for the climatic hazard component: those elements were analysed in Report 3.1 using IPCC scenarios. They included into the calculation of the risk assessment score grid of this report 3.2.
- Non-climatic information such as secondary impacts, sensitivity and adaptive capacity for the vulnerability component defined in this report.
- One or more exposure factors for the exposure component defined in this report.

These last two set of information are analysed in this study in combination with the results provided under the 3.1 Climate Assessment Report to generate the final risk assessment rating of each hub.

1.3 Methodology of the risk chains development

Sufficient data (time series) were not available to run socio-economic impacts modelling in the four hubs, therefore the risk chain approach, as described in the IPCC AR5 methodology, was chosen to allow a broad social-ecological system assessments which were combined to climate hazards results to define risks. First, a generic risk chain model was used to develop several other thematic chains designed on bibliographical research and focussed on key issues identified in the concept note : surface water flows, land degradation and sand movements, forest productivity, water storage capacities, flood events and heat stress events, crop production and livestock productivity.

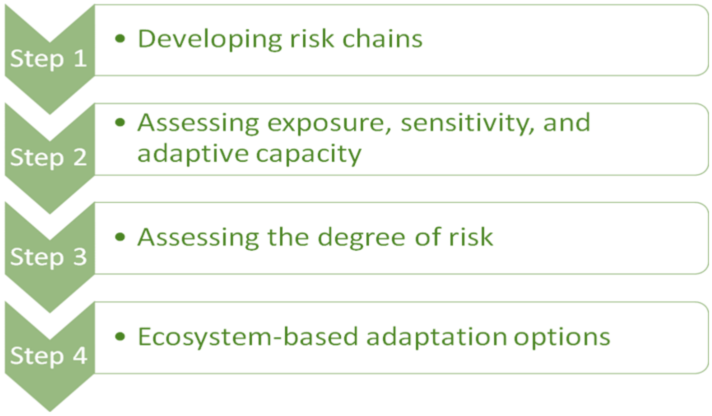


Figure 2 : Steps of risk assessment

These chains facilitated a comprehensive overview to identify ***vulnerability, exposure, and risks*** (see figure 2 for the description of the full process). The consortium team worked with a group of national experts to refine and narrow down the number of chains to be considered with the goal to focus on the priority risks and to adapt risks chains to local conditions based on national experts' knowledge and time available under six broad sectors draft risk chains have been shared with several many times to ensure full ownership of the coproduction**.** Details on the AR5 methodology (IPCC, 2014) were used to develop risk chains: their development process is presented in the inception report (Deliverable 3.1) and in the trend analysis report (Deliverable 3.2). Risk chains have been updated after the submission of Deliverable 3.2 based on the national experts' report a focus group with national experts to assess the reality on the ground.

Six risk sectors emerged on ecosystem degradation, degradation of water resources, reduced crop production, reduced livestock productivity, loss of life and property due to flood and human health. Six corresponding risk chains were finalized with each primary sector streamlined into one chain. The final results generated are presented at the end of each sector analysed.

- ⇨ The **risk chains** also include 'secondary impacts' of climate hazards, related consequences to understand the cause-effect chain leading to the risk. Risk chain include all its components, factors, and indicators. Indicators are set to quantify the factors determining the risk. Secondary impacts are not a risk factor as such, therefore not quantified but they allow to grasp the cause-effect chain leading to the definition of the risks. Impacts link hazards and risk and depend on vulnerability, defined as consequences, ranging from direct physical impacts of a hazard to indirect consequences for society (GIZ, 2018).
- ⇨ **The three elements of the risk equation : hazard defined by climate data modelling, vulnerability and are scored from 0 to 5 using the scoring grid presented in section 4.1**. As described in details in the Inception Report, climate hazard was scored from the climatic data developed and imported from the report 3.1. National experts assessed exposure and vulnerability scoring in a focus group (see the following section 1.4 for more details). Scores are given and justified for each of the four hubs for each element.
- ⇨ **Scores are aggregated by sector** into an average score : climate hazard, exposure, and vulnerability. The geometric mean of the scores per component gives the final risk score. Risk score is assessed for current risk and future risk (2050 horizon for RCP 4.5 and RCP 8.5). Each risk can be compared from one hub to another but also between the current period and the mid-century horizon (RCP 4.5 and RCP 8.5 scenarios). In addition, the

graphical representation of the results makes it possible to assess which components best explain the level of risk.

⇨ Finally, based on the priority risks identified and ranked in this report, a set of **adaption options** was formulated and discussed with national experts and local people. This work is presented in the last report, Deliverable 4.

1.4 Assumptions and limitations

These risk analyses were designed to inform the forthcoming formulation of the GCF Feasibility Study entitled : "Strengthening the resilience of ecosystems and population in four regional hubs in Northern Mauritania". Because of a deficit of statistics and other systematic socio-economic data collection with relevant time series at the local level of each hub, elements to assess the vulnerability and the exposure were drawn from publicly available information, consultations, and interviews carried out by experts from Mauritania. Detailed analyses were conducted at localized scales in order to define the specific suite of actions that should be implemented to safeguard the sector actors that are locally and culturally relevant. The key steps of this process are described in the National Experts report[1].

The mission team was composed of five highly experienced national experts:

- ***Ould Cheikh El Houssein Sid Ahmed Lehbib***, MS Rural & Tropical Forestry, Head of Mission, retired civil servant, former Director of Rural Engineering directorate, MS Forestry engineer ; consultant.
- ***Djibril Sarr***, Hydraulic Engineer, retired civil servant; former Deputy director of Rural Engineering directorate; MS Hydrologist; consultant
- ***Mohamed Ould Sidi Bollé***, MS Agricultural Engineer; Deputy Director of agricultural value chains and freelance consultant
- ***Moussa Keita***, Socio-economist, University professor in sociology and freelance consultant
- ***Oumar Fall***, Technical Advisor, MSc in Agricultural Economist, MSU USA Retired Civil Servant; international Consultant

The analysis tools described in the project's framework note (reflecting the well-established methodological tools of the IPCC, CARE, GIZ etc…) were submitted to the local resource persons invited to participate in the sessions and were systematically used during the interviews conducted from 24 March to 5 April 2021 in the four hubs and until early 2022 to finalise the outputs in a systematic manner. The approach consisted of collecting reliable information on the four poles, through literature and interviews with resource persons. Two sources of information were selected:

- Documentary sources: national communications on CC, monographs, statistical data published by the ONS, the MDR and other departments, project studies or communications from colloquia and seminars.
- The central and regional technical services, but also the decentralised structures (communes, civil society associations) which have contributed to the extent of the means available.

To these sources of information should be added tools such as the focus group guide, semi-structured and semi-direct interviews that we used for the field mission.

[1] Rapport Analyse du risque climatique (French) 97 pages, April 28, 2021.

TABLE 1 : TOOLS USED DURING THE FOCUS GROUP SESSIONS

Tools	OBJECTIVE
Hazard mapping	To become familiar with the community and how the place is perceived by different groups in the community; Identify important resources in and around the community; Begin to identify hazards (climatic or otherwise) that affect the community
Timeline	Obtain information about the nature, intensity and evolution of observed and experienced hazards and changes; Raise awareness of these trends and changes over time; Document community observations of changing hazard and resource trends
Seasonal calendars	Analyse the nature of activities in relation to the seasons and identify periods of crisis, stress or shortages; Identify important livelihood activities for the community; Gather perceptions of community members on changing trends
Impact chains	Analyse the direct and indirect impacts of climate change on the target community
Vulnerability matrix	Identify key resources and the hazards that threaten them; Analyse the level of impact of hazards and climate change on key resources.
Adaptation options/prioritisation of adaptation strategies	Define adaptation options to the identified climate change impacts Prioritise and rank adaptation options for each area

The interviews and data collection mission took place in the four poles as follows. The number of local experts indicated for each hub does not include the population of the focus groups, seasonal map plots, focus group discussions, and individual interviews which exceed 100 in each Hub.

NEMA HUB in the Wilaya of Hodh Ech Charghi, 03 to 05 April 2021

MEETINGS: *The Wali of Hodh El Charghi region, delegates and a group of local resources people in addition to the four project team members.*

Number of local experts	*Male*	*Female*
5	*5*	*0*

The authorities understood the objective of the mission and proposed the list of villages to be visited. All the collection tools were submitted to the participants and resource persons for their feedback.

FIELD VISITS: the Cheikh Tourad dam, the Leghligue palm groves, the pastoral wells in the basin, the silting up of the palm trees; the pastoral areas of Achemim and Djaguenaye.

PRELIMINARY FINDINGS : Degradation of the environment and living conditions of the population lead to a massive exodus from this area to the country's major urban centres and abroad. The greatest pockets of poverty in Mauritania (Aftout, Affolé, the border with Mali, etc.) lie in this area. The limitation of access to dams to nationals of communities traditionally using the land, causes frequent land conflicts. Very low level of cultivation techniques (non-compliance with technical itineraries prescribed by research) and rangeland management is recurrent. Insufficient development of agriculture associated with the protection of fragile soils and conservation of its moisture with a low level of advisory support to farmers and supply of agricultural inputs and equipment.

TAMCHEKETT HUB the Wilaya of Hodh El Gharbi, 31 March to 03 April 2021

MEETINGS: *Mayor of Tamchekett and the Hakem of Hodh El Gharbi and a series of technical services in addition to the four project team members.*

Number of local experts	*Male*	*Female*
8	*5*	*2*

The authorities assured that they would spare no effort to ensure that the mission would take place in the best possible conditions. All the collection tools were submitted to the participants and resource persons.

FIELD VISITS: Visits were organized to the ponds, boreholes and the Toueïmirit dam, the women's market garden; the project "Improving community resilience and food security to the adverse effects of climate change in Mauritania" (PARSACC) doing capacity building with the women of Tamchekett (Focus Group Women of Tamchekett), the Médina borehole, the Toueïmirit dam and the crocodile pond.

PICTURE 2 : WORK WITH LOCAL STAKEHOLDERS IN TAMCHEKETT

PRELIMINARY FINDINGS: There are many problems related to climate change (heat waves etc.) however, rising salinity and silting up are the most acute and most often mentioned.

RACHID HUB in the Wilaya of Tagant, 27 to 31 March 2021

MEEETINGS

- *In the rural commune of Rachid: The Chef d'arrondissement' (district) of Rachid in the presence of the Secretary General of the commune and the First Deputy Mayor, the hakem and local elected officials who facilitated the collection of information in the best conditions.*
- *In agricultural urban commune of Tidjikja: The Wali of Tidjikja, a panel of technical services: DREDD of Tidjikja. Delegate of the MEDD, DRHA/MHA, CRA/PDDODRA, DRAS, DR/MDR in addition to the four project team members.*

Number of local experts	*Male*	*Female*
15	*13*	*2*

PICTURE 3 : COMMUNE OF RACHID IN THE MOUNTAINS

The Deputy Mayor stated that the collection of qualitative and quantitative data deserves special attention and asked the heads of the respective technical services present at the meeting to provide them and to accompany the national experts to fulfil their mission. All participants were interviewed individually and documents and information were collected and semi-structured interviews were organized with the focus groups. All data collection tools were submitted to the population and resources persons.

FIELD VISITS:
Site visits were organized with the populations to assess the impacts of climate change in the oases of Oued de Rachid, Dakhlet Mabrouk, Voum daar, Iriji, the palm groves of Taoujeft, Hadi El Rassoul, Tweimiritt, Tarva and Ajar. The team visited the market garden of the Rachid cooperative and recycling activities as well as the ruines of the previous city of Rachid.

PRELIMINATIRY FINDINGS : Oases dried up by lack of water and advancing sand dunes are the key climate related hazard impacting their development.

PICTURE 4: DISCUSSION BETWEEN THE DREDD/MEDD OF TIDJIKJA AND THE TEAM OF EXPERTS.

AOUJEFT HUB in the Wilaya of Adrar , 24 to 26 March 2021

MEETINGS: *Wali of Adrar, A panel of technical services: Delegate of the MEDD, DRHA/MHA, CRA/PDDODRA, DRAS, DR/MDR , Legal advisor to the wali; hakem of Aoujeft, the Deputy Mayor, representative of the civil* *registry, representatives of , representatives of NGOs; farmers and stockbreeders in the palm groves, head doctor of the Aoujeft health center, the deputy mayor of the commune in addition to the four project team members.*

Number of local experts	*Male*	*Female*
27	*20*	*7*

DISCUSSIONS: Plenary session with representatives of the technical directorates and local authorities to capitalize on this information. The wali considered this collection to be of paramount importance and urged the technical directorates to provide the necessary information for the data collection. Interviews which provided ample information on the various indicators to be reported. The hakem gave instructions to facilitate the data collection, making the meeting room of the commune available.

FIELD VISITS: Seguelil dam site. Field identification of the problems of the palm groves and market gardening areas, of the Seguellil wadi and of potential sites for intervention; the Graraa and exchanges with the inhabitants. Visit of palm groves and exchange with farmers and stockbreeders, manual motor pumps, wells and oases in danger of disappearing due to silting.

PICTURE 5 : RESOURCES MAPPING OF THE HUB WITH REPRESENTATIVES OF THE COMMUNITIES IN AOUJEFT

PRELIMINARY FINDINGS: Local stakeholders stressed that the major problem is silting and food security. A sand removal team for the new road linking Adrar to Tagant, which is constantly sinking, is the manifestation of this key problem for the Adrar region. This unbridled silting, the disappearance of certain plant species, the scarcity of water, the maintenance of dams such as that of Séguelil, the loss of significant natural surfaces, date palm groves and the problems of animal and human health related to climate change.

INPUTS TO THE VULNERABILITY AND EXPOSURE ANALYSIS

Data collected during these missions and further literature reviews (mostly authored by the Government of Mauritania such as the National Communication to the UNFCCC, the National Adaptation Plan, the National Determined Contribution etc.) were used to produce the analysis provided in this section. A full bibliography was collected and is displayed in chapter 8. Several meetings (and multiple conference calls) were then held between the national experts and the international projet staff to jointly review and harmonize the data and information provided to finalize the risks assessments report and further develop the adaptation options.

2. Overview

2.1 Geography of the hubs

The project focuses on four hubs along the strip of the country where the desertification process is more severe and stopping it more strategic. This chapter provides basic information on those four hubs : the centres of the hub, it radius in km2, the number of communes and its population. In each of these hubs, the project considers the urban and rural areas, focusing mostly on the latter. The areas defining these hubs are smaller than the size of a wilaya region (with a radius of 100 to 200 km around the selected localities) to take into account, the ecosystems exploited by the population (transhumance, etc.) and to better understand the climatic phenomena at stake.

1. The hub around Néma (Wilaya of Hodh Ech Chargui) includes 10 communes in an area of 80 km2.
2. The hub around Tamchekett (Wilaya of Hodh El Gharbi) includes 5 communes in an area of 85 km2.
3. The hub around Rachid (Wilaya of Tagant) includes 3 communes in an area of 80 km2.
4. The hub around Aoujeft (Wilaya of Adrar) includes 6 communes in an area of 80 km2.

The hubs, defined as a strategic approach to fight against climate change impacts, are **conceived to follow the lines of the worse climate impacts of the borderline between the Sahelian and the Saharan zones and do not correspond to administrative (and statistical) boundaries per se.** The administrative locations of the hubs are further detailed in figure 4. The table below provides the list of the project hubs with their population, the names of the Wilayas (and their capitals) as well as the chief towns of the Moughataas where they are located.

HUB	MAIN URBAN COMMUNE OF THE HUB	POPULATION	LOCATED IN THE WILAYA OF	Capital of the Wilaya	Chief town of the Moughataa
1	NEMA	99,620	HODH ECH CHARGUI	Néma	Néma
2	TAMCHEKETT	43,282	HODH EL GHARBI	Aioun	Tamchekett
3	RACHID	25,626	TAGANT	Tidjikdja	Tidjikdja
4	AJOUJEFT	35,643	ADRAR	Atar	Ajoujeft

It is worth noting that the name of the commune of Néma is the name of Hub 1, and also of the name of the moughataa (department) chief town (chef lieu) and of the Wilaya capital. For Hub 2 and 4, the main urban communes of the hubs, Tamchekett and Ajoueft are also the chief town of the moughataas; for Hub 3 the main administrative locations are different from the name of the Hub called Rachid. The hubs are further detailed in the following tables providing key socio-economic and environmental information collected during the field trips. Information is mostly provided at the regional level which is the normal procedure of collecting data.

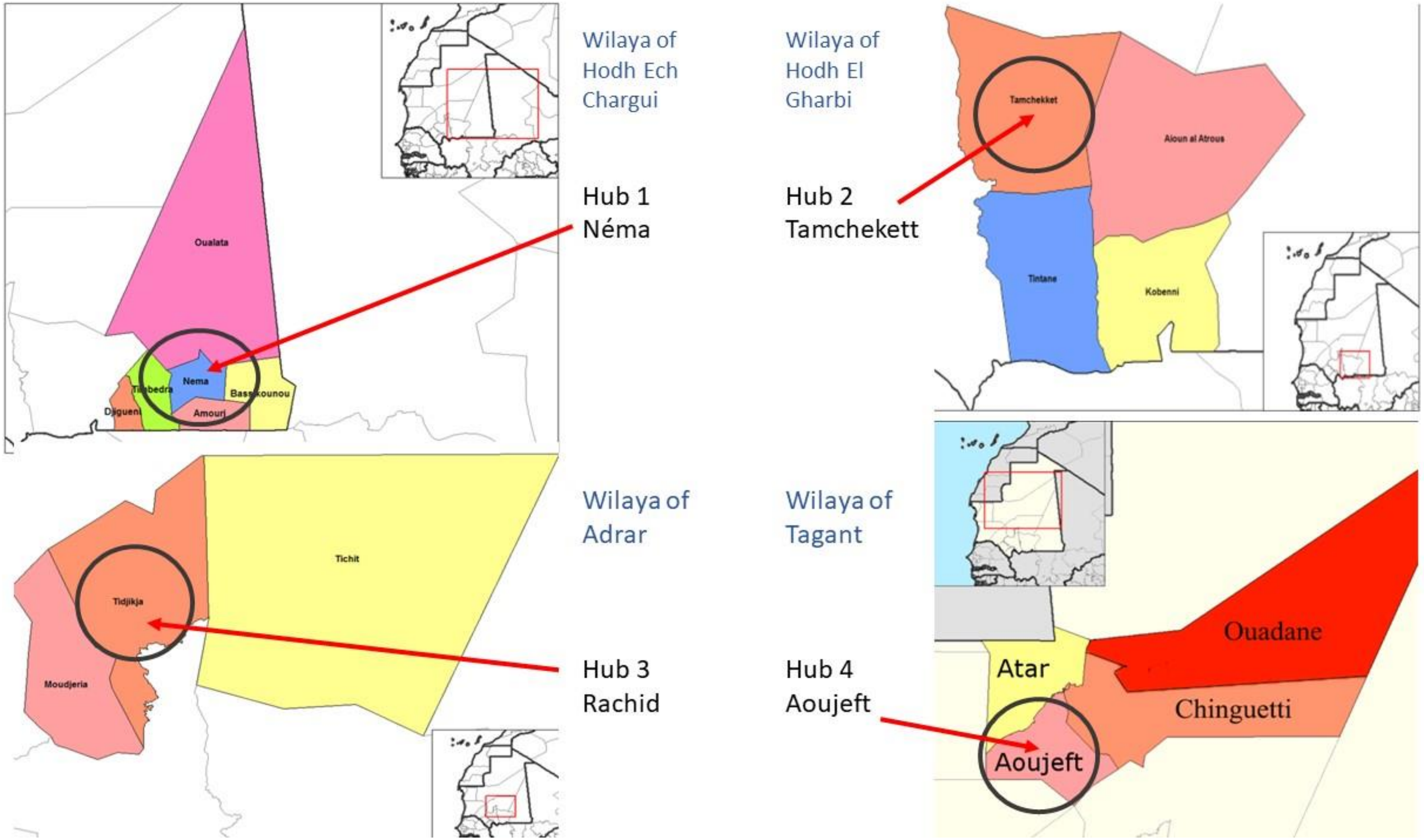


FIGURE 3 : LOCATIONS OF THE HUBS IN THEIR ADMINISTRATIVE BOUNDARIES

source : https://upload.wikimedia.org/wikipedia/commons/e/ef/Mauritania_location_map.svg

2.2 Socio-ecological information collected in the four hubs

One of the main challenges identified in the project intervention area was the deficit of departmental or local data, which are scarce, if not inexistent but definitively not collected at the 'hub' level. Thus, this analysis is based on data available to reflect the reality of the situation of interest in the hub.

HUB 1 AROUND NÉMA

<table>
<tr><th></th><th>Sector</th><th>Description</th></tr>
<tr><td>Administ rative and</td><td>General</td><td>Néma is the most important urban commune in south-eastern Mauritania, capital of the Hodh Chargui Wilaya and of the Moughataa of Néma.
The "Néma hub" includes 10 communes : Néma, Achemim, Jreif, Banguou, Hassi Etila, Oum Avnadech, El Mabrouk, Beribavat, Noual and Agoueinit.</td></tr>
<tr><td rowspan="3">Environmental description</td><td>Climate</td><td>Three types of climates cross the wilaya (region) and give rise to three distinct ecological zones:
14% is in the Sudano-Sahelian zone;
19% is in the typical Sahelian zone;
67% is in the desert domain.
These three areas are commonly known as El Kouch, Aoukar and Dhar.</td></tr>
<tr><td>Vegetation</td><td>Three types of vegetation formation in the area according to the nature of the soils:
Sandy peneplains,
Hydromorphic soils
Hills. (Basins and its ecosystem, published by the MEDD September 2016).</td></tr>
<tr><td>Water resources</td><td>The wilaya's of Hodh Ech Chargui's hydrographic network is composed of numerous wadis (Bourjemane, Kraa Ould Zeyane, Bat'ha N'Gady, Ajar Néma, Bat'ha Néma, Kraa Bouzeyane, Agoueïnit, etc.). These wadis feed many essential Tamourts (215 in the region) for the watering of livestock. The water is concentrated in numerous depressions favourable to crops. The region has dams, notably those of Cheikh Tourad and Béribavat. Underground water resources are unevenly distributed in this region. Some areas are home to continuous aquifers with significant water resources such as the Dhar de Néma aquifer (reserves estimated at 10 billion m3) and the Aouker aquifer (excellent freshwater reservoirs due to the thickness of the sands covering this aquifer). Finally, there are also barren areas that can only be exploited thanks to a few pastoral wells with difficult access.

Water infrastructure in the Wilaya (Region) of Hodh Ech Chargui - Drinking water supply by Moughataa
<table>
<tr><th>Moughataas (Departements)</th><th>Water fountain bollard</th><th>Wells</th><th>Drilling</th></tr>
<tr><td>1. Amourj</td><td>15</td><td>745</td><td>2</td></tr>
<tr><td>2. Basseknou</td><td>22</td><td>82</td><td>2</td></tr>
<tr><td>3. Djiguenni</td><td>16</td><td>366</td><td>3</td></tr>
<tr><td>4. Néma</td><td>34</td><td>392</td><td>14</td></tr>
<tr><td>5. Oualata</td><td>3</td><td>51</td><td>0</td></tr>
<tr><td>6. Timbedra</td><td>9</td><td>1 489</td><td>16</td></tr>
<tr><td>Total</td><td>105</td><td>3 157</td><td>41</td></tr>
</table>
Source ONS : RGPH 2013
The table above shows that 96% of drinking water was supplied by wells in 2013 in the 6 departments of the Wilaya. The distribution of households according to the source of drinking water supply shows that 6.1% of households obtain their drinking water most often from the tap in the yard/parcel, 4.8% from the tap in the dwelling. As for households without access to drinking water, the majority get water from uncovered wells (47.6%).</td></tr>
<tr><td>Socio-economic description</td><td>Population</td><td>The total population of the Néma Hub is estimated to be 99,620 habitants, with a population of 21,979 in the commune of Néma itself.
Population growth rate of the Hodh Ech Chargui Wilaya is larger than the national average with 281,600 inhabitants in 2000 to reach 421,808 in 2013 (see table below) with a higher proportion of female gender (52,4%). The density of 2.4 inhabitants/km² in the Wilaya.</td></tr>
</table>

Sector	Description

Moughataas of the Wilaya of **Hodh Ech Chargui**	Male	Female	Total
1. Amourj	43.803	50.751	94.554
2. Bassiknou	43.052	45.380	88.432
3. Djigueni	27.891	31.723	59.614
4. Néma	**41.656**	**45.392**	**87.048**
5. Oualata	6.592	6.494	13.086
6. Tembedra	37.846	41.223	79.069
Total	200.840	220.963	**421.803**

Source : RGPH, 2013

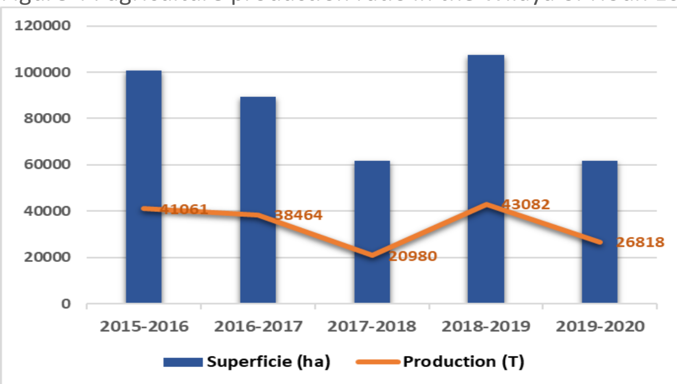
Living conditions

Active population : 44.3% of the population of working age in the Wilaya.
Only 5% of households have tap water. 66% of households access water through a public fountain, a tap in the yard or a well, in particular via uncovered wells (48%). The rest of the population (29%) has no direct access to water.
The Wilaya has one hospital and eleven health centres.

Agriculture

Dominated by two types of crops: rainfed crops (sorghum, millet and maize) and lowland (dam and recession) crops (sorghum, maize, wheat and barley). Traditional cereals are grown on the sandy soils of the diéri (non-flooded cultivated land in a valley) which are directly dependent on rainfall, as well as on recession land (natural and controlled), including lowland areas and those behind dams which provide a better income. The area under diéri represents about 72% of the total land cultivated with traditional cereals. Land behind dams represents 4.7% of the total area cultivated but provides higher yields.

Figure 4 : agriculture production ratio in the Wilaya of Hodh Ech Chargui



Livestock

The livestock farming system in the wilaya is mainly extensive and transhumant, with the emergence of peri-urban livestock farming. The contribution of livestock production to the economy of the wilaya is significant, and it contributes substantially to the added value of the rural sector. Livestock production plays a major role in household food security, generally through the self-consumption of milk and meat. Statistics on livestock numbers are presented in Figure 6

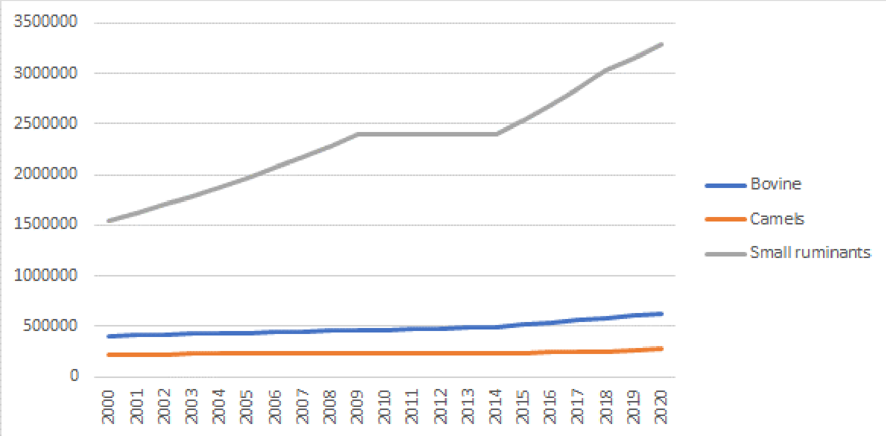
Sector	Description
	

Figure 5 : livestock evolution in the Wilaya of Hodh Ech Chargui

There has been a growth in the size of the population of the different livestock, particularly of small ruminants, possibly explained by the rainfall of the last few years.

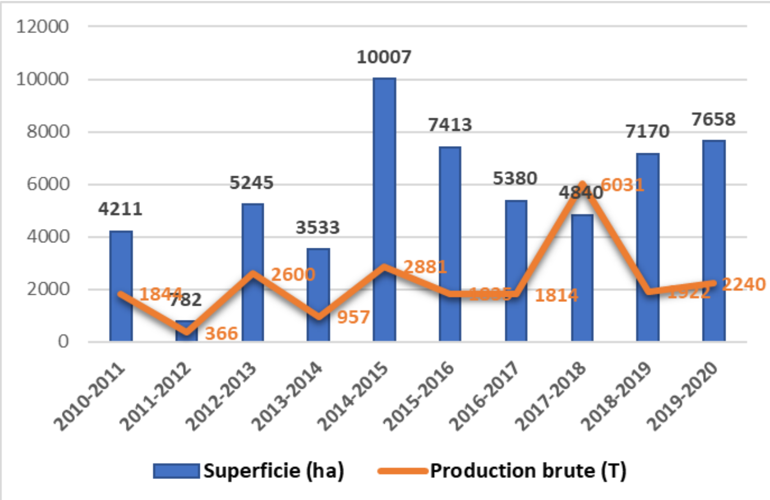
HUB 2 AROUND TAMCHEKETT

	Sector	Description
Administ rative	General	**Tamchekett** is an agricultural urban commune located in the Moughataa of Tamchekett, and one of the chief towns of the Wilaya of Hodh El Gharbi. The **Tamchekett hub** includes five communes : Tamchekett, El Mabrouk, Radhi, Gueate-Teidoume and Sava.
Environmental description	Climate	Tamchekett is located in the Sahelo-Saharan ecological zone which is characterised by the presence of three seasons: • A winter season (5 to 6 months) is cool and dry (the lowest temperatures are recorded during this period). • A summer season (4 to 5 months) is hot and dry (the highest temperatures are recorded during this period). • A rainy season (1 to 2 months) hot and humid (rains are recorded during this period).
	Vegetation	Three types of vegetation formation in the area depending of the nature of the soils: Sandy peneplains; Hydromorphic soils; Hills (Source: Basins and its ecosystem, published by the MEDD September 2016).
	Water resources	The Wilaya receives water from the El Aguer and R'Kiz hills. The hydrographic network is relatively developed with numerous wadis and tamourts (pits where water accumulates). The Wilaya also has 88 days or reservoirs. The aquifers in the area are (UNICEF, sad): • Assaba sandstones and the Aouker sands (low productivity). • Aïoun sandstones (heterogeneous productivity, low salinity water). • Hodh pelites (heterogeneous productivity). • The El Aguer plateau in the commune of Radhi causes significant water run-off each year, which has led to a lot of retention works in the area, but also a good part of it is lost to the Senegal River via the Karakoro. Precipitations are important every year. These quantities of water could help solve the Hub's water shortage problems.

Status of dams, dykes, embankments and other water reservoirs built until 2014 - Wilaya of Hodh El Gharbi

Inventory of water reservoirs (year 2008)				Dams built from 2009 to 2014 (DAR+ PDDO)		TOTAL UNTIL 2014	
Total number			Area (ha)				
	Reservoirs without identified area	Reservoirs with identified area		Number	Area (ha)	Number	Area (ha)
138	54	84	6 991	4	475	88	7 466

<table>
<tr><td rowspan="4">Socio-economic description</td><td>Population</td><td>In 2007, the total population of the Tamchekett Hub is estimated to be 43,282 with 2,792 inhabitants in the commune of Tamchekett itself and the rest of this number spread between 4 other rural communes.
Back in 2000, the total population of the Moughataa of Tamchekett was 30,760 inhabitants: 14,669 men (47,68%) and 16,091 women (52,3%).
The population of the Wilaya of Hodh El Gharbi was 294,109 inhabitants in 2013 with an average population density of 5.5 inhabitants/km².The population is young, with almost half (48%) under 15 years old.</td></tr>
<tr><td>Living conditions</td><td>75% of the households in the Wilaya are poor (compared to 42% nationally).
Unemployment is high, with 38% of the working-age population employed.
7% of households have tap water and 83% of households access water through a public fountain, a tap in the yard or a well (in particular via uncovered wells (43%)). The rest of the population (10%) has no direct access to water.
Access to health services is limited with only one hospital in the Wilaya and ten health centres.</td></tr>
<tr><td>Agriculture</td><td>This sector provides 13% of employment in the Wilaya; dominated by two types of crops: rainfed crops (sorghum, millet and maize) and lowland/oasis/wetland crops (dams and recession) (sorghum, maize, wheat and barley), highly dependent on rainfall.
The average gross production (2009/2011 -2019/2020) is of the order of 16,613 T. It is distributed, by typology, as follows (see summary table 6):
- Crops grown under the rains or Diéri (Sorghum, millet and maize
- Crops grown behind dams (Sorghum, maize, wheat and barley):
- Recessional crops (Sorghum, maize).
Oasis crops in Hodh El Gharbi are mainly market gardening and date palms. Market gardening has developed significantly since the drought cycles of the 1970s, encouraged by sedentarization. Phoeniciculture was first introduced in Hodh El Gharbi and has developed considerably. The Wilaya of Hodh El Gharbi is the fourth in production at the national level after Adrar (1st) and Tagant (2nd).

Figure 6 : Agriculture production ratio in the Wilaya of Hodh El Gharbi

</td></tr>
<tr><td>Livestock</td><td>Livestock farming accounts for 37% of rural jobs in the Wilaya. It is extensive and depends on natural conditions (rainfall, pastures, plant cover, water). Despite the unpredictable climatic conditions, the fodder potential of the Wilaya makes it an important refuge for herds from neighbouring zone. Estimates of the number of animals are given in Figure 7.</td></tr>
</table>

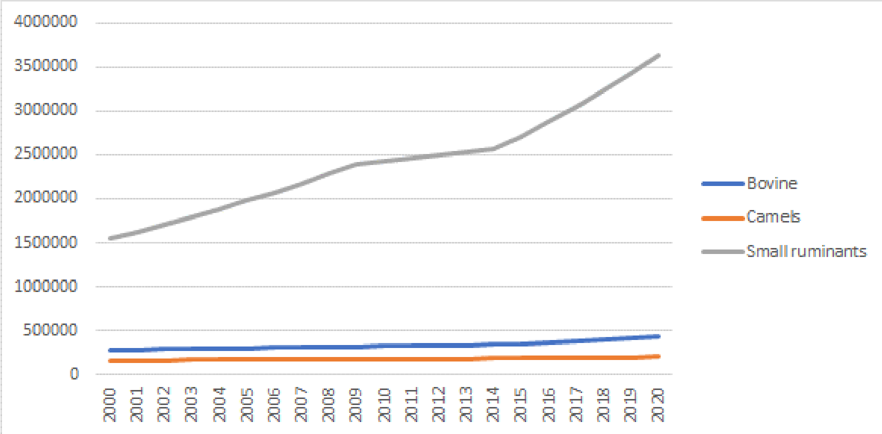


FIGURE 7 : LIVESTOCK EVOLUTION IN HODH EL GHARBI

There has been a growth in the size of the population of the different livestock, particularly significant for small ruminants possibly explained by the rainfalls of the last few years.

HUB 3 AROUND RACHID

	Sector	Description
Administrative description	General	**Rachid is a rural commune and a district (arrondissement) in south-central Mauritania in the Tidjikja Moughataa, located in the Wilaya of Tagant** at the foot of the Tagant Plateau. The "Rachid hub" includes the commune of Rachid El Wahat, the agricultural urban commune of Tidjikja (also chief town of the Moughataa, located 39 km away) and Tensigh. 
Environmental description	Water resources	Main rivers running through the **Wilaya of Tagant:** • Oued of Tamourt-en-Naaj (main watercourse) and the Oued El Abiod (secondary watercourse) which confluence downstream from N'Beïka and flow into Lake Gabou. • Depression of El Khatt receiving the flows of the Oued Iziv, the Oued Anzak, the Oued Tidjikja and the Oued Rachid. • The waters of the Achram wadi and part of the waters of the Tagant Plateau flow into the Gorgol. The Tagant has the following types of aquifers: • Discontinuous sandstone and limestone aquifers (not very productive). • The continuous aquifer of the N'Beika plain (very productive). The surface hydraulic infrastructures (dams, dykes) are summarised in the table below. Since the drought of 1970s, an explosion of small rags (embankments of less than 1 meter high) developed in Achram Commune and along the paved road of the "Route de l'Espoir" by landless smallholders. Status of dams, dykes, embankments and other water reservoirs built until 2014 - Wilaya of Tagant

Inventory of water reservoirs (year 2008)		Dams built from 2009 to 2014 (DAR+ PDDO)	TOTAL UNTIL 2014
Total number	Area (ha)		

	Reservoirs without identified area	Reservoirs with identified area		Number	Area (ha)	Number	Area (ha)
141	25	116	11 384	14	2 540	130	13 924

Source : MA/PNDA.

Socio-economic description

Population

The estimated total population of the **Rachid Hub** is 25,626 for the 3 communes which include 13 532 hab. for Tidjikja (population details for the 2 other communes are unknown).
The population of the **Wilaya of Tagant** is estimated to be 85,819 inhabitants in 2010, i.e. a density of 0.9 inhabitants/km2 (0.78 inhabitants/km2 in 2000).
The female number is slightly higher with 47,575 compared to 38,244 for the male number. The population is young, with almost 45% of the inhabitants under 15 years old.

Living conditions

In 2013, almost 34% of the population aged 6 years or older had received no education at all in the Wilaya and **39% of the population was illiterate**.
Only 4.4% of dwellings are equipped with a water tap. 77% of households access water through a public fountain, a tap in the yard or a well. The rest of the population (19%) has no direct access to water.
61% of households in the Wilaya are considered poor compared to 42% nationally. Approximately 47% of the working age population is active, which reflects a high unemployment rate.
According to the Regional Director for Health Action in Tagant, there is a **direct link between climate change and health** with an increase in the number of sick people and cases of malnutrition, often leading to a rural exodus.

Agriculture

Agriculture represents more than 23% of the jobs in Tagant but it characterized by the ancient oasis tradition where the knowledge of phoeniculture is well established. The agriculture practised in the Wilaya of Tagant is characterised by the cultivation of date palms with sub-stages of cereal crops (sorghum, wheat, barley, cowpeas), vegetable crops (potatoes, onions, melon, carrots, tomatoes, cabbage, etc.) and fodder crops (alfalfa) and henna shrubs (Lawsonia alba).

Oasis	Number of producers	Total number of dates palm trees	Productive dates palm trees	Production of dates (Tonnes)	Area (Ha)
Tagant	10045	684045	455179	3 831,75	3 042,56

Traditional cereals are the main products of rainfed cultivation, sometimes coupled with small-scale market gardening, generally carried out by women's cooperatives. The resulting production depends essentially on rainfall and its spatio-temporal distribution. (See Figure 8).

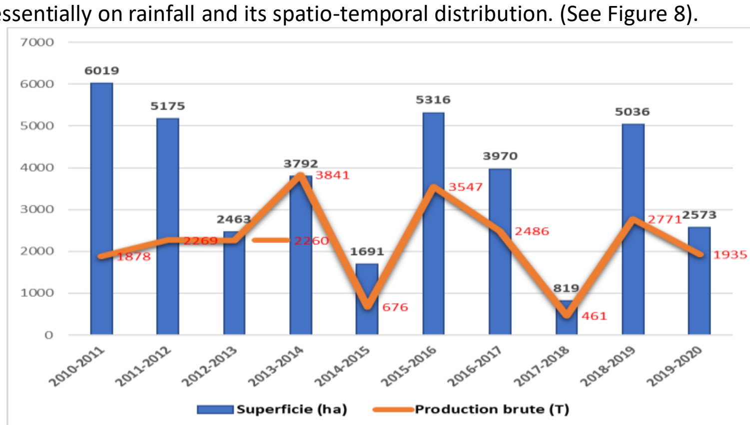


FIGURE 8 : AGRICULTURE PRODUCTION RATIO IN THE WILAYA OF TAGANT

Livestock

Livestock farming accounts for almost **29% of jobs** in Tagant although a distinction is made between

- villages or **sedentary livestock farming** system that exploits the space around the village that can be associated with oasis agriculture in which animals graze crop by-products;
- a **transhumant livestock farming** system on the grazing lands.

In the absence of reliable statistics, livestock technicians in Tagant, based on various estimates, provided the figures summarised below in Figure 9.

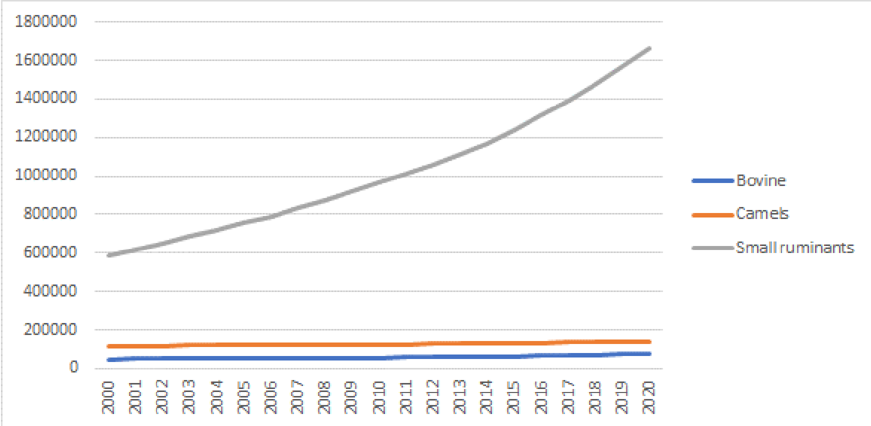


Figure 9 : Livestock evolution in Tagant

There has been strong growth in livestock (small ruminants) numbers in recent years possibly explained by the rainfalls of the last few years and State investments in infrastructures, institutional establishments promoting the sector value-chains since year 2020 (Timbedra Fair, 2020).

HUB 4 AROUND AOUJEFT

	Sector	Description
Administrative	General	**Aoujeft** is one of the four moughataas of the Wilaya of Adrar, and the chief commune of the moughataa of the same name. The **Aoujeft hub** includes five communes: the agricultural urban commune of Aoujeft, and four rural communes : Maeden, N'Teirguent, El Medah and Tenmewend.
Biophysical description	Geography And Water Resources	The Wilaya of Adrar where Aoujeft is located is criss-crossed by plateaus and peaks reaching 815m in altitude. In terms of hydrography, the Wilaya of Adrar has several watercourses but all are endoreic. The most important of these are the Séguelil wadi and the El Abiod wadi, which confluence in the Aïn Ehel Taya area and flow into the large Yagref floodplain, the bottom of which is at an altitude of 110m on the Atar topographic map. Most of them are threatened by the formation of sand dunes. Floods are becoming rare but devastating. The surface hydraulic infrastructures (dams, dikes, dykes) are summarised in the table below.

Status of dams, dykes, embankments and other water reservoirs built until 2014 in the Wilaya of Adrar

Inventory of water reservoirs (year 2008)				Dams built from 2009 to 2014 (DAR+ PDDO)		TOTAL UNTIL 2014	
Total number			Area (ha)				
	Reservoirs without identified area	Reservoirs with identified area		Number	Area (ha)	Number	Area (ha)
45	5	40	3 749	4	490	44	4 239

Source : MA/PNDA, 2016

The sources of water supply in the Wilaya are 11.7% in AEP networks; 3.12% in public fountains; 24.63% in total 39.45% and the rest 60.55% unidentified.

Water source	Adrar	National
	Rate (%)	Rate (%)
AEP Network	11.7	15,0
Public fountain	3.12	25,7
Well	24.63	37,3
River-spring	0	13,0
Other	…	9,0
Total	100,0	100,0

Source : RGPH 2013-ONS

Socio-economic description		
	Population	The population of the moughataa of **Aoujeft** is estimated to be 12 997 inhabitants (2013 census) and 35 643 by 2017 (ONS). The **Aoujeft hub** includes the agricultural urban commune of Aoujeft itself, with a population of 6,019 inhabitants, and 5 other rural communes (population details unknown). Population density of the Wilaya of Adrar is about **0.3 inhabitants per km²** compared to 3.34 national level.

Wilaya of Adrar	1988	2000	2013
Aoujeft moughataa	16 217	20 181	**12 997**
Atar	35 317	38 962	38 877
Chinguitti	63 27	6 704	6 810
Ouadane	3 186	39 395	3 974
Total	61 047	69 542	62 658

Source RGPH/ONS : 1988, 2000 et 2013

The monograph on the Wilaya of Adrar drawn up by the National Statistics Office (ONS) in 2017 **revealed a change in the population numbers** for the whole of the Wilaya of Adrar, with a remarkable variation at the level of the moughataas : the population of the Wilaya is young with approximately 45.45% of the population is under 15 years old, compared to 59.46% for the active age group (15-64 years).

This population is dominated by the **female gender, as about 53%** of the total population of the Wilaya are women, compared to 47% of the male population.

Data collected in the 2013 Census at the Wilaya level reveals that more than 19.7% of the population aged 6 years and above have no education and that about one in four of the population of the Wilaya aged 10 years and above is literate (25%): men (22%) women (27%).

Living conditions

Only 12% of the population is directly connected to the water supply network. 27% of the population can access water with public fountains and wells. The remaining 61% have no immediate access to water. The development of roads has made it possible to partially open up this territory. The school **enrolment rate is low** as the gross enrolment rate in primary school is only 63%. At the secondary level this rate falls to 20%.

Access to health services is very limited, with only one hospital, five health centres and eighteen health posts in the Wilaya of Adrar.

Agriculture

The Wilaya of Adrar is an area with an **ancient oasis tradition** and proven know-how in date production. It is considered the country's leading date-growing zone, currently accounting for about 45% of national production. The average **annual production of dates fluctuates according to climatic conditions**, varieties and the quality of cultivation techniques. Date palms in Adrar are generally not very productive with average yields of 15-20 kg per plant without irrigation (30-50 kg per plant with irrigation) (PNDA, 2016, STM, 2019 and PDDO, 2020).

EVOLUTION DES SUPERFICIES MISES EN VALEUR EN PHOENICULTURE

Wilaya	Year	Number of palm trees	Surface area (ha)	Number of exploitations
ADRAR	**1984**	386 017	2 187	2 876
	1993	883 060	1 876	6 590
	2020	1 212 876	5 759	10 211

Source (projet Oasis et PDDO)

In Adrar, **market gardening is an occupation and an income-generating activity**, especially for women and young people. Annual production varies from year to year depending on climatic conditions.

Since 2019, a date and vegetable packaging factory located 80 km from Aoujeft, is improving the economic activity of the population in the oases exploiting the local products to make the most of it. However, transport is carried out in poor conditions, without considering the perishability of market garden produce.

Livestock

Livestock breeding is a very important economic activity in the Wilaya. It is essentially composed of small ruminants and camels (Figure 10). The livestock population has grown strongly over the last 20 years. The abundant rainfall of the last few years seems to have allowed an overall reconstitution of the herd.

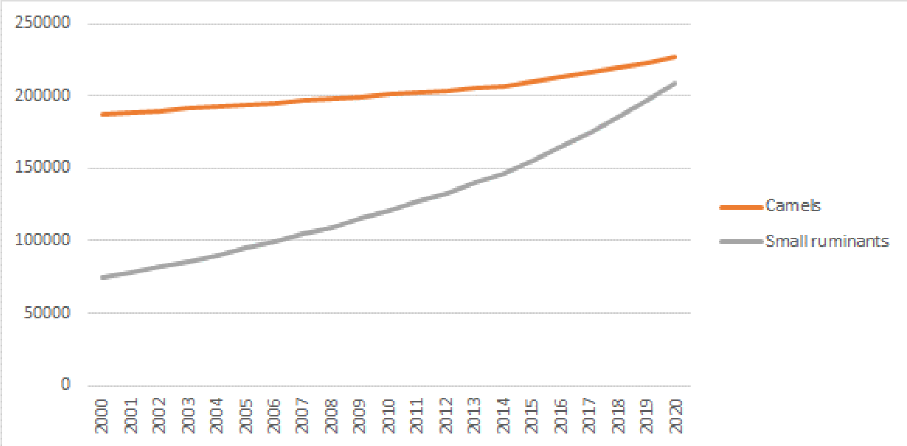


FIGURE 10 : LIVESTOCK EVOLUTION IN THE WILAYA OF ADRAR

In Adrar, as in the rest of the country, individual consumption of milk and milk products is high. Part of this need is covered by local production, in particular goat and camel milk with traditional processing and conservation methods.

The existing livestock system in the wilaya is mainly extensive and transhumant with the emergence of the peri-urban livestock system with rich pastures. It is a transit and transhumance area for herds of small ruminants and camels from several wilayas in the country, depending on the state of wintering and the abundance of pastures. With the introduction of crops under palm trees and fodder crops, some breeders have started to supplement their feed.

Tourism	The geographical situation of the Wilaya of Aoujeft, its relief and its landscape (sand dunes, plateaux, and the historical cities of Chinguitti and Ouadane) constitute a real tourist, cultural and historical asset which places it at the first tourist choice of the country.

2.3 Local knowledge and perception of climate change in the four hubs

The participatory process that has driven the implementation of the study allowed to gather the most important events about climate change as expressed by the people during the site visits. Discussion with relevant focus groups provided elements to draw a mapping of the resources and climate risks for each hub (see Annex 2). These milestones (with an orange line indicating ongoing or recurrent events) in the chronological sequence below, includes major events about the nature, intensity and evolution of hazards and changes observed or experienced.

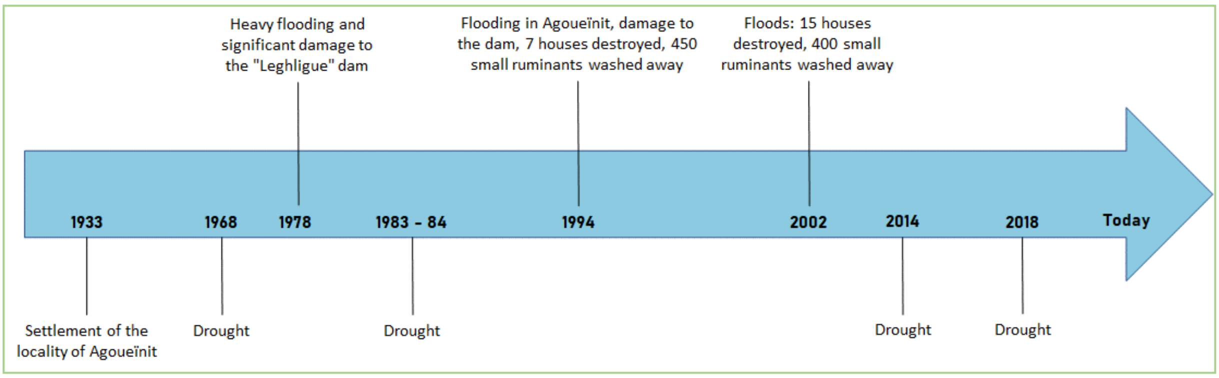
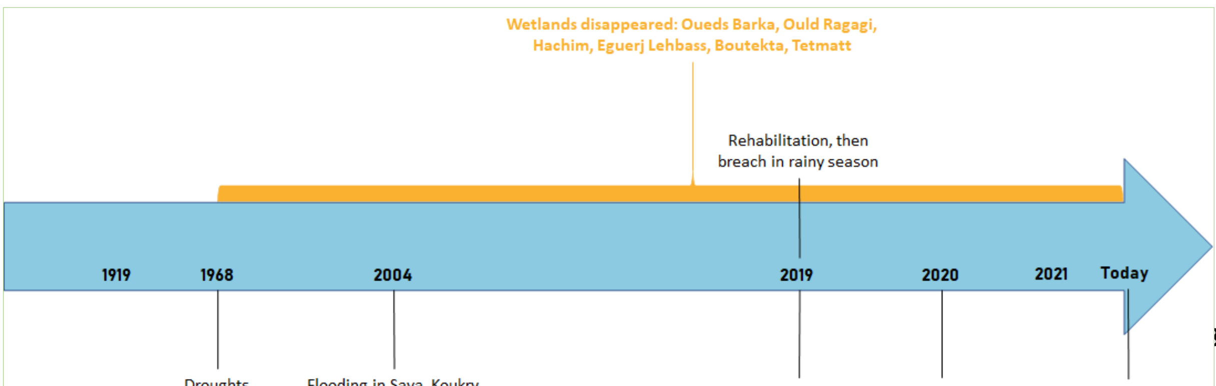


FIGURE 12 : HISTORICAL CLIMATE CHANGE TIMELINE IN NÉMA



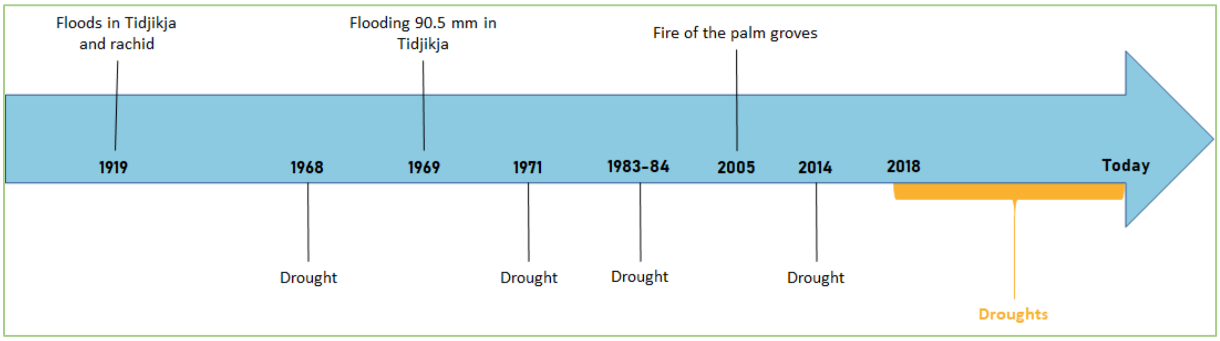


FIGURE 13 : HISTORICAL CLIMATE CHANGE TIMELINE IN RACHID

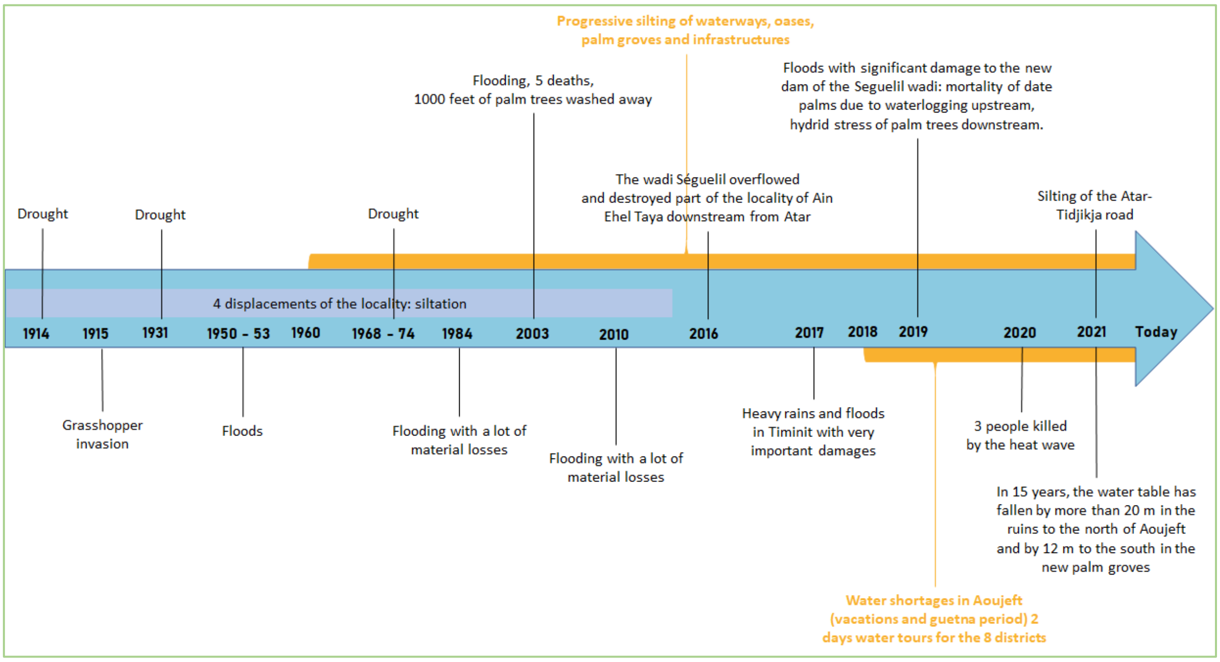


FIGURE 14 : HISTORICAL CLIMATE CHANGE TIMELINE OF AOUJEFT

These participatory exercises allowed to raise awareness on the trends hazards over time and to document community observations of changing resource trends. Most importantly, as highlighted with those detailed timeline, it how the population has been struggling with repeated and serious climate hazards over the past 100 years in the four hubs.

3. Impacts of climate change

***Information** collected during the 2021 mission and further literature reviews of publications produced by the Government of Mauritania such as National Communications, the National Adaptation Plan, the National Determined Contribution etc. were used to analyze the impacts of climate change. A **bibliography** is available under chapter 8. Several meetings (and multiple conference calls) were then held between the national experts and international projet staff to jointly review and harmonize the data to ensure their consistency and information provided to finalize the risks assessments report and further develop the adaptation options.*

3.1 Impacts on ecosystems

The Fourth National Communication (July 2019) reports that *'the chronic droughts and human pressure will destroy the woody vegetation cover, accentuate desertification, affect biological diversity and reduce pastoral potential thus provoking a massive rural exodus towards the large urban centres. Conflicts over access to these resources, which have marked the history of the Guidimakha Wilaya since the first droughts, are likely to intensify* [and expand] *as a result of the growing demand for food, fibre and energy, and the loss and degradation of productive land. They will be further exacerbated by changing agricultural conditions, increased water shortages, loss of biodiversity and reduced grazing land and its poverty.*

As far as biodiversity (fauna and flora) is concerned, field visits and literature reviewed allowed to collect the following information. (See also Annex 3: Endangered and extinct species in the four hubs). The reduction of agro-sylvo-pastoral main eco-systems is indeed the source of conflicts in rural oases, particularly between farmers and herders (transhumant or sedentary herders and sedentary farmers) as confirmed during the field visits.

Key findings on ecosystem climate induced changes

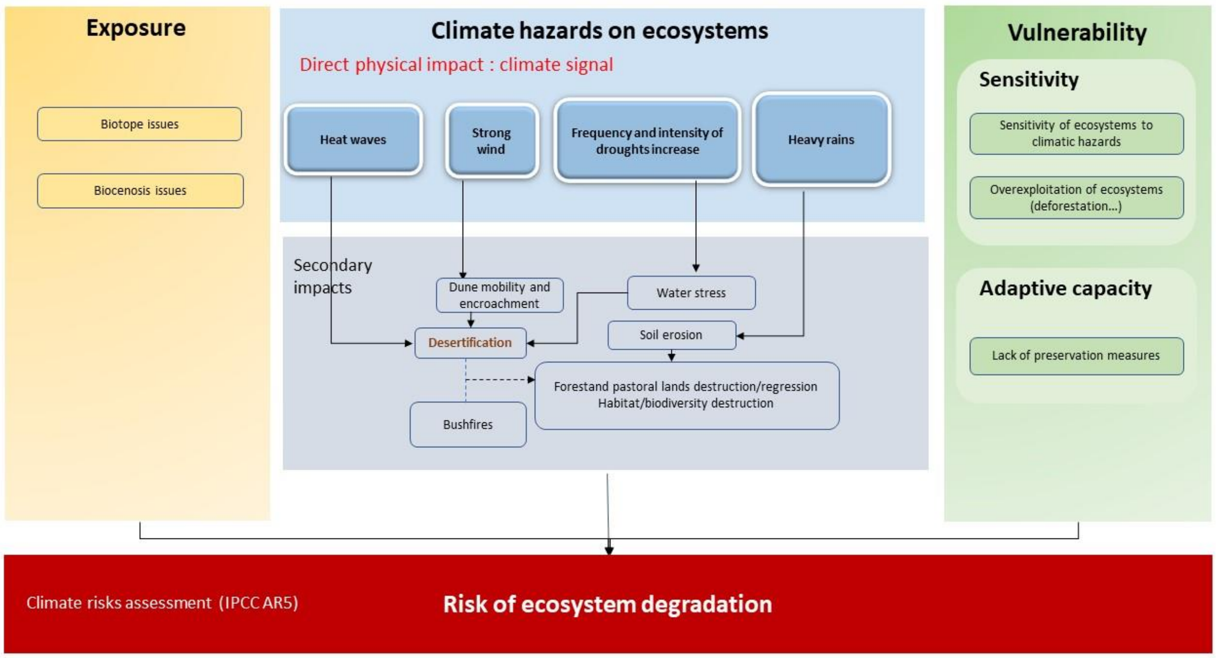
- **Néma hub**, Some infrastructures are completely buried by silting up and this generates various impacts such as i) leading to rural exodus to the big cities, ii) causing displacement of populations and iii) the reduction of agricultural areas. Communities observe that "*The droughts of the 1970s and 1980s led to a sharp decline in livestock numbers, with a dramatic acceleration in the rural exodus and a tendency for herds to be concentrated in the hands of large urban owners. The improvement of rainfall during the recent years seems to have allowed an overall reconstitution of the herd. The last few decades have also been marked by a strong movement towards the settling of livestock breeders, which has led to profound changes in production systems (in particular: regression of nomadic systems, spatial and temporal reduction of transhumance) and increased competition over pastoral resources.*" (OSS, 2015).
- **Tamchekett hub** is characterized by hydromorphic sandy-clay soils. This type of formation is found around wetlands (wadis and tamourts) and is clearly dominated by Acacia nilotica (Amour en Hassanya) associated with Ziziphus mauritiana (jujube tree). The classified forest of Tamchekett corresponds to this type of plant formation. However, this forest is nowadays in the state of a relic since there is no trace of regeneration of the above-mentioned species.
- **Rachid hub :** conflicts generally arise as a result of livestock roaming in the oasis area, but more generally in the peri-oasis area, for example affecting flood recession crops, which are less easy to protect than the "zeribas" (palm grove property unit). The climate hazards impacts on livestock are worsening in the current situation, marked by the degradation of livestock productivity induced by recurrent droughts, the scarcity and the remoteness of pastoral areas and water points. The lack of availability of pastures will

increase transhumance distance and duration all year round, and potentially increase social conflicts. The peri-urban development and the implementation of breed improvement programmes simultaneously to the lack of availability of pastures (leading to increasing transhumance) is affecting the entire livestock sector, in particular the way in which the herds are run.

- **In the Aoujeft hub,** the wilaya of Adrar shelters rich pastures. It is a transit and transhumance area for herds of small ruminants and camels from several wilayas in the country, depending on the state of wintering and the abundance of pasture. The fodder balance is dependent on rainfall and therefore varies from one year to the next. The existing livestock system in the wilaya is mainly extensive and transhumant, with the emergence of the peri-urban livestock system and home-based livestock farming for the goat species (Toumza). With the ***introduction of fodder crops under palm trees,*** some breeders have begun to provide food supplements, to hut farms in the large towns and to the dairy camels. Based on focus group discussions, climate change has a significant impact on oasis livestock. Its influence is reflected in the reduction of woody and herbaceous cover, abortion, the reduction of the most appetizing plant species, the reduction of the duration of lactation and the decrease in productivity due to the pasture availability that can lead to food insecurity. The herders met said that currently the ***density of trees in the oasis areas is lower than before the drought of the 1970s***.

Figure 15 provides a summary of the risks chain leading to ecosystem degradation : it describes exposure issues, climate hazards (direct physical impacts) and vulnerability that were jointly defined by the Focus groups and the team of experts. These elements (measured on a series of indicators listed below) are rated and ranked in the following section. The secondary impacts were simply used to guide the discussion on exposure and vulnerability.

FIGURE 15 : CHAIN OF RISKS FOR ECOSYSTEM DEGRADATION



3.2 Impacts on water resources

Mauritania is one of the most water deficit countries with only 0.5% of the total surface considered arable. An estimated 60% is considered as severely or very severely degraded, which is being caused by a combination of natural and anthropogenic factors. The major environmental problem the country is currently facing is the temporally and spatially erratic character of rainfall, frequently leading to general or local droughts since the late-1960s with subsequent increase of human pressure on the natural resource base and degradation. Mauritania lies almost entirely within the Sahara desert, with very low rainfall and water-poor.

Only the coastal zone sees any significant seasonal rainfall and the only perennial river in the country is the Senegal River, which forms its southern border (See Figure 16 and 17) on the water resources decrease in runoff of about 10% between 2000. The country is dependent on groundwater for virtually all its water supply. The overall impacts on water resources are significant and reflected in a general decrease in rainfall of around 10 to 15% with foreseeable consequences for agriculture, health and the well-being of the population[2]. In addition, a delay of rainy season onset associated and with intensity of rainfall, temperature increasing is noted with direct impact on the water table and surface water resources.

A part from drought and its impacts like the drying up and disappearance of rivers and wells, it will be difficult to find other socio-economic factors that might play such an important role. In general, local consultations reported by national experts during the field visit described a decrease in runoff of about 10% between 2000 and 2020 which is confirmed in the National Communication (*République Islamique de Mauritanie*, 2019), associated with an increase in evapotranspiration therefore the degradation of water quality, including the regression of woody and herbaceous plant cover. A drop in piezometric levels and a disruption of the wadi regime, associated with a reduction in the storage capacity of dams due to concentrated rainfall and accelerated silting by water erosion in heavily denuded catchment areas (Freidel et al, 2012[3]). It's reported warmer and less aerated surface waters, with reduced flow rates and therefore a reduction in their power of dilution and biodegradation of certain pollutants.

The geological mapping of the water resources in Mauritania clearly show that the "**hub of Tamchekett only** is located in a geological zone where ***the aquifers do not present major risks for their exploitation***".

[2] *Fourth National Communication République Islamique de Mauritanie*, 2019, p.61.

[3] Friedel M. J., Finn C. A., Horton J., 2012. Synthèse des données hydrologiques, 27p.

FIGURE 16 : HYDROLOGY OF MAURITANIA (INTERMITTENT RIVERS) SOURCE : AQUASTAT, 2005

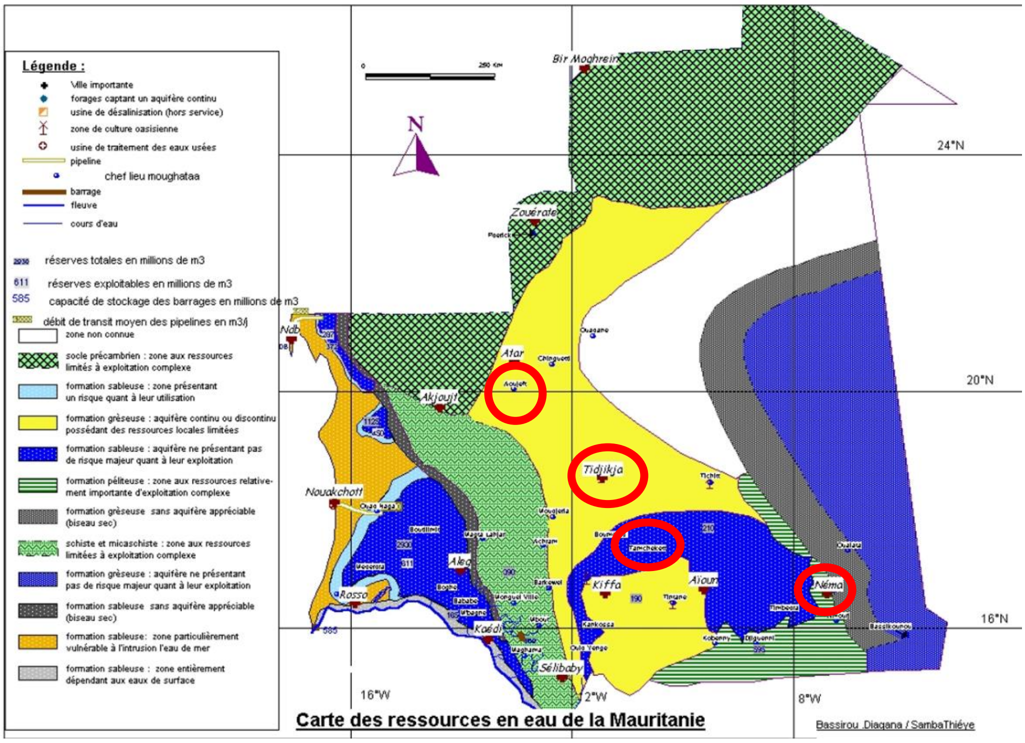


FIGURE 17 : WATER RESOURCES IN MAURITANIA - *Source :* Bassirou Diagana (2007)

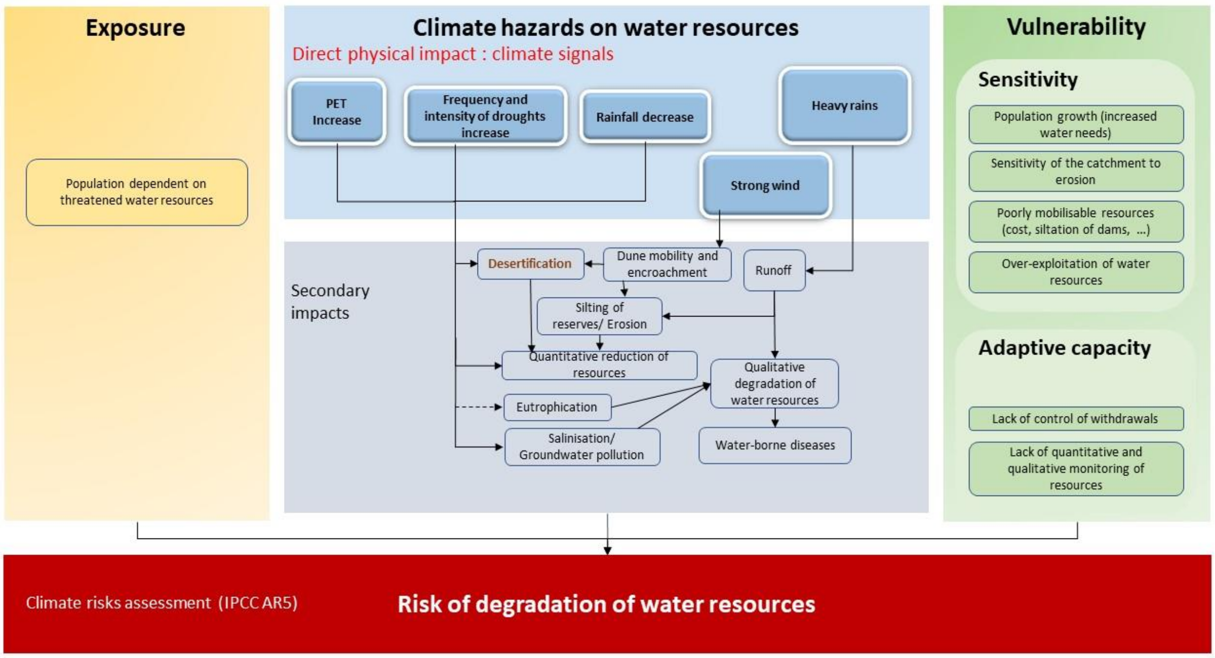
Key findings on water resources issues

- In the Néma hub, three water points disappeared during the 1960's droughts; they are located in Tichilit Talh, Oum Ettemay and Temachmarit. In general, local consultations reported by national experts during the field visit described a ***decrease in runoff of about 10% between 2000 and 2020 associated with an increase in evapotranspiration and a degradation of water quality***; a drop in piezometric levels and a disruption of the wadi regime, associated with a reduction in the storage capacity of dams due to concentrated rainfall and accelerated silting by water erosion in heavily denuded catchment areas[4]. It is reported warmer and less aerated surface waters, with reduced flow rates and therefore a reduction in their powers of dilution and biodegradation of certain pollutants, etc.
- In the Tamchekett hub, rivers or streams are in danger of extinction: Taletfal (Tahourat) with a proportion of 2/3, Telmeden, Guelta Touzelat, Arereji, Taymsett and Iriji. Like in the others hubs, some ***traditional wells have already disappeared since the droughts*** occurred during the 1960's: the Majhar, Iriji Oum Lemhar, Tegwa, Aïn Ajhaniya, Legreywa, El Mbeydih, Le Mbeyha, Aguemoun and Lebyadh.
- In the Rachid hub, the same observations can be made. Due the ***drought during the 1960's, the streams disappeared by silting up*** are Oum Larjan, Telmeden (guelta), Guelta Touzelat, Taoujeft, Arereji, Taymsett, Iriji, Legleïb and Tarf. Before 1960, communities said that five (05) wells disappeared (Aghmachanet, Toum Wersukel, Khatt, Foum Ajar and Dhaya). A part from draught and its ***impacts like the drying up and disappearance of rivers and wells, it will*** be very tough to find other socio-economic factors that might be play any other role. Concerning the drying up of wells, communities mentioned in Rachid that it's noticed in Gagni, Toum Jeyj, M'Balla, Aghnemtit, Acharim (2 wells have dried up). Even traditional dry-stone wells and cemented wells are ***affected by the scarcity of water resources*** (Dakhla, Rachid).
- ***In the Aoujeft hub,*** communities reported that before 1960 that three water points disappeared by silting up and since that draught occurred at the end 1960's, in addition seven water points have disappeared (Oum Chenad, Ten Mour, Timoline, Timitine, Ijichane, Aïn Lebgar and Tiroutène).

Figure 18 provides a summary of the risks chain leading to the degradation of water resources : it describes exposure issues, climate hazards (direct physical impacts) and vulnerability that were jointly defined by the Focus groups and the team of experts. These elements (measured on a series of indicators listed below) are rated and ranked in the following section. The secondary impacts were simply used to guide the discussion on exposure and vulnerability.

[4] Friedel M. J., Finn C. A., Horton J., 2012. Synthèse des données hydrologiques, 27p.

FIGURE 18 : CHAIN OF RISKS FOR THE DEGRADATION OF WATER RESOURCES (QUALITY AND QUANTITY)



3.3 Impacts on agriculture and forests

The WFP (2015a[5]), mentioned that *"It is now estimated that 974,000 Mauritanians- one in four- live in food insecurity; including 231,000 in severe food insecurity and in urgent need of assistance"*. The World Health Organisation emergency threshold of 15 percent is surpassed in six Wilayas namely, Hodh El Gharbi, Assaba, Gorgol, Brakna, Tagant and Guidimagha; local communities mentioned this occurred in Oued Nkhal Agouenit (palm grove and wells are impacted), Tichilit Talh (rainfed agriculture is impacted), Zangra and Bamoira (wells are impacted) and Oued Tatrart.

The overall rate of change in land use and land cover accelerated from 0.4 per cent per year between 1975 and 2000 to 0.7 per cent per year between 2000 and 2013. As a result, in 2013, less than **1 per cent of the country was agricultural land**. This makes Mauritania the least cultivated country of the 17 West African countries. Likewise, other "bio productive" land cover types - forest, gallery forest and swamp forest - make up only tiny fractions of the land area (Figure 19).

Classified forests and wildlife reserves

Zone	Name	Area in (ha)
Rachid hub (Tagant)	Forest : El Mechrae	540
	Forest : Legdam	550
	Drill: Tintane	4.495
Tamchekett hub (Hodh El Gharbi)	Forest: Tamchekett	1650
	El Aguer Wild Life Reserve	270 000

[5] WFP, 2015a. WFP Mauritania Brief, 2p.

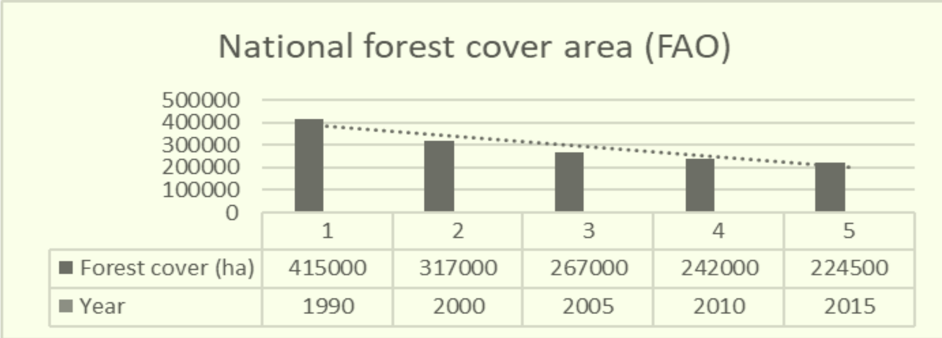


FIGURE 19 : NATIONAL FOREST COVER AREA IN MAURITANIA *(SOURCE: FAO 2014)*

Key findings on agriculture and forest issues

Climate hazards will result in a significant loss of seedlings and harvests, a drop in productivity and production, water stress on plants and land degradation and erosion, as well as an extension of the arid zone towards the south of the country. The rain-fed system and crops grown behind dams is already strongly affected, often resulting in the appearance of ***devastating crop pests and enemies.*** This will imperil food security with impacts on health and the well-being of communities of the project hubs. The **irregularity of the rains,** their poor spatial and temporal distribution concern also natural resources, including the regression of woody and herbaceous plant cover***, under the effect of chronic droughts and anthropic pressure (deforestation or abusive cutting***) probably not directly linked to climate change, the accentuation of desertification, the loss of biodiversity species and the reduction of pastoral potential for livestock, thus leading a massive rural exodus towards the large urban centres. ***The irregularity of the rains, their poor spatial and temporal distribution, and the high frequency of long dry spells (see report 3.1)*** at the beginning of the season are now the main causes of sowing failures, the abandonment of dry sowing, and the increase in the number of seeds per sowing plot and the density of sowing.

It is also worth noting that average yields for *Diéri*[6] oscillate around 547 kg/ha (with variations depending on the year of drought), that can exceed 70% loss. It should be noted that average yields oscillate around 547 kg/ha for *Diéri* (with variations, depending on the year of drought) that can exceed 70% loss. *Diéri* production depends exclusively on rainfall and is therefore very uncertain. It is common to find a yield of 200 kg/ha when growing sesame (PNDA, 2016). Because of the partial control of water, the flood recession cropping system, although dependent on rainfall, is less random than the *Diéri*. The farmers interviewed estimate **a 90% loss in a drought year and 30% in a hot year.** In the context of the oases, the major problem is the **scarcity of water and the difficulty of mobilising it.**

Rainfed agriculture is closely linked to rainfall, which inevitably subjects it to the adverse effects of climate variability and change (reduced and random rainfall, shorter season length, increased frequency and intensity of dry spells, etc.). Long dry spells during the sensitive phases of the plant (vegetative and reproductive phases) can lead to loss of productivity and crop yield. Traditional cereal growing (millet, sorghum, and maize) is dominated by small family farms with rudimentary agricultural practices and a self-subsistence orientation. It has not yet improved enough to make a greater contribution to improving food security and reducing rural poverty. Table 2 shows that the greatest pastoral potential is in Hodh Chargui (Néma hub) with a capacity equivalent to 30% of the national fodder potential. This is due both to the size of this Wilaya and the relatively good rainfall (***242 mm)*** compared to other Wilaya.

6- *Diéri* is a geographical term (of Toucouleur origin) which designates the non-floodable land of a river valley, as opposed to the *Walo*.

The irregularity of the rains, their poor spatial and temporal distribution, and the high frequency of long dry spells (see report 3.1) at the beginning of the season are now the main causes of sowing failures, the abandonment of dry sowing, and the increase in the number of seeds per sowing plot and the density of sowing. It is worth noting that average yields for *Diéri* oscillate around 547 kg/ha, with variations, depending on the year of drought, that can exceed 70% loss. It should be noted that average yields oscillate around 547 kg/ha for *Diéri*, with variations, depending on the year of drought, that can exceed 70% loss. *Diéri* production depends exclusively on rainfall and is therefore very uncertain. It is common to find a yield of 200 kg/ha when growing sesame (PNDA, 2016). Because of the partial control of water, the flood recession cropping system, although dependent on rainfall, is less random than the *Diéri*. The farmers interviewed estimate **a 90% loss in a drought year and 30% in a hot year.** In the context of the oases, the major problem is the **scarcity of water and the difficulty of mobilising it.**

According to most of the farmers met, the level of the water table has fallen sharply since the droughts. According to the focus group in Aoujeft, this level has gone from a depth of **6 m to a depth of at least 12 m**. The **lowering of the water table** as a result of the **drought and the overexploitation of water resources** are reflected in the oases by a **progressive degradation of the soil through salinization**. During our discussions with farmers, it became clear that the quality of groundwater has deteriorated significantly. Indeed, the drought of the 1970s and 80s in the oasis areas has led to **salinization of the water** in some places. This issue of salinization should not be put only in relation with climate change, but probably with agricultural bad practices even if in some cases, in relation with the **rise of the salt-water wedge**. The focus group interviews reveal a degradation of the palm groves caused by **drought and silting**. Due to drought, there is **not sufficient water** and palm groves have considerable problems to satisfy their water needs. This major constraint is associated at the same time with silting, that covers large parts of the palm groves and in some cases the **height of the dunes** can completely bury the palm trees.

Wind erosion is a major threat to the oases. The effects of drought have led to the gradual disappearance of the vegetation cover. The fine elements of the soil are uprooted and transported, leaving coarse sand which is carried away by the wind to bury the palm groves. During the recent years, water erosion is mainly due to the effect of **heavy rains concentrated over a short period of time**, which results in the formation of gullies and ravines in the palm groves. Water erosion scours the surface layers of the soil, which are conducive to the development of crops, and causes gullies that transport heavier elements from the soil and also destabilise the banks of watercourses and their vegetation. According to the technical services and the focus group (Aoujeft), the main constraints of date palm tree are the scarcity of irrigation water and the high cost of water extraction due to the depth of water table in the oases.

Drought conditions and high temperatures have also generated the outbreak of **bushfires**, devastating rangelands, and other ecosystems. While fires are largely favoured by dry weather conditions (heat waves, droughts), they are **often started by humans**. The causes can be multiple: ash throwing, uncontrolled burning, etc.; two hubs are particularly prone to these impacts: an average of 410 km² went up in flames each year between 2017 and 2020 in the Wilaya of Hodh Echargui (Nema hub) and 19 fires were reported in Hodh El Gharbi (Tamchekett hub) (Table 2). Data collected however have an insufficient historical span to show a meaningful trend[7].

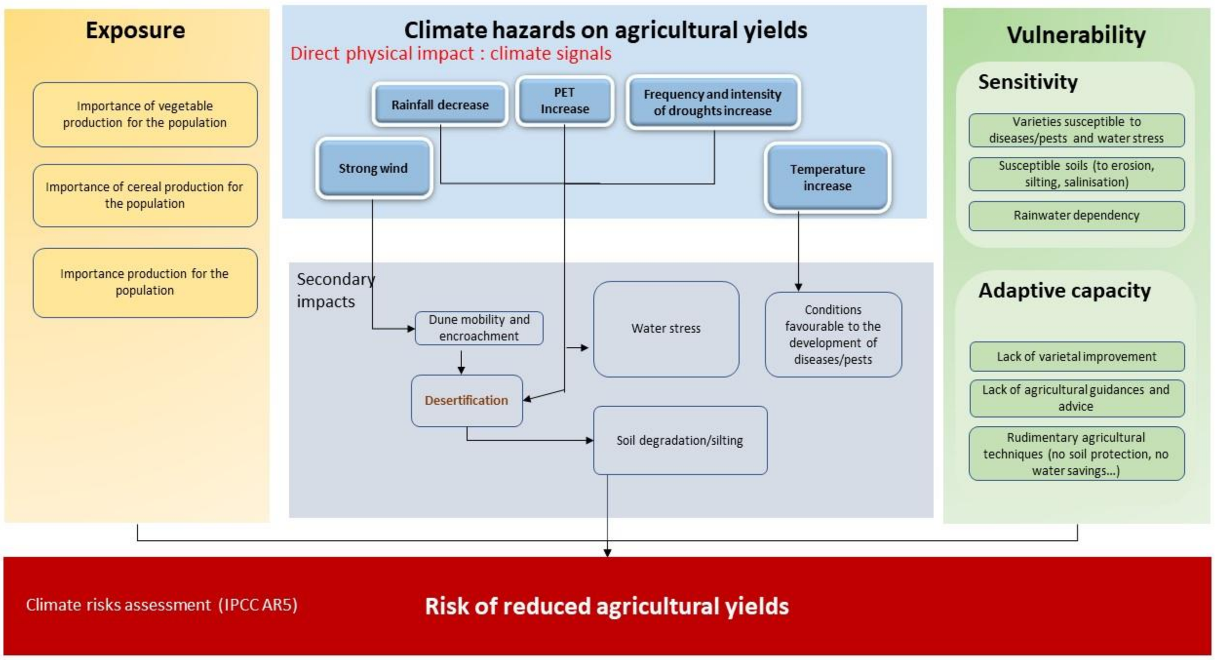
[7] Strengthening the resilience of ecosystems and populations in four regional hubs in northern Mauritania, Trends analysis, Eco solutions.

TABLE 2 : TOTAL AREA OF LAND BURNT BETWEEN 2016 AND 2019 IN NÉMA AND TAMCHEKETT

Wilayas	Year	Area burnt	No. of fires
Hodh Echargui (Néma)	**2016-2017**	**183,25 km2**	**20**
	2018-2019	657,7 km2	33
	2019-2020	413,29 km2	14
	2020-2021	**2528,775 km2**	**43**
Hodh El Gharbi (Tamchekett)	2016-2017	148,2 km2	10
	2017-2018	12,445 km2	3
	2018-2019	6,492 km2	6

Figure 20 provides a summary of the risks chain leading to reduced agricultural yields : it describes exposure issues, climate hazards (direct physical impacts) and vulnerability that were jointly defined by the Focus groups and the team of experts. These elements (measured with a series of indicators listed below) are rated and ranked in the following section. The secondary impacts were used to guide the discussion on exposure and vulnerability.

FIGURE 20 : CHAIN OF RISKS FOR REDUCED AGRICULTURAL YIELDS



3.4 Impacts on livestock productivity

Widespread sedentarization in response to successive droughts has resulted in substantial changes to Mauritania's traditionally extensive production systems, which have diversified from a single nomadic system to numerous agricultural management practices[8]. Livestock management has particularly undergone several changes following severe drought episodes recorded in the country in the 1970s and 1980s (Table 3).

TABLE 3 : FODDER BALANCE FOR MAURITANIAN LIVESTOCK

Wilaya	Consumable plant mass			Requirements (t)	Balance (t/DM)
	Grassland grazing (t/DM)	Aerial grazing (t/DM)	Total Production (t/DM)		
Hodh el Chargui ***(Néma hub)***	2.174.040,0	549.000	2.723.040,0	1,750,517.4	972,522.6
Hodh el Gharbi ***(Tamchekett hub)***	1.268.784,0	320.400	1.589.184,0	1,324,992.5	264,191.5
Assaba	923.967,0	233.325	1.157.292,0	1,011,510.9	145,781.1
Guidimakha	333.102,0	75.705	408.807,0	785,329.0	-376,522.0
Tagant ***(Rachid hub)***	60.588,0	34.425	95.013,0	500,837.9	**-405,824.9**
Gorgol	383.724,0	96.900	480.624,0	663,364.9	-182,740.9
Brakna	343.035,0	111.375	454.410,0	740,700.3	-286,290.3
Trarza	548.163,0	177.975	726.138,0	716,775.0	9,363.0
Inchiri	125.433,0	71.269	196.701,8	288,947.0	-92,245.3
Adrar ***(Ajoueft hub)***	852.588,0	484.425	1.337.013,0	526,594.8	810,418.2
Tiris Zemmour	7.722,4	5.850	13.572,8	165,010.6	-151,437.8
Dakhlet-NDB	528,7	401	929,2	0.0	929.2
Total	**7.021.675**	**2.161.050**	**9.182.725**	**8,474,580.5**	**708,144.2**

(Source: National Expert Report; Legend: t/DM dry mass per ton)

For example, prolonged droughts resulted in the rural exodus of livestock farmers; many of whom had to sell their livestock to urban nationals with the investment capacity to take advantage of the sharp drop in animal prices and the establishment of livestock systems around main roads to enable access to food aid and administrative services. In addition, variations of partial settlement have been observed on former wintering grounds in the two Hodhs — the hubs of Néma and Tamchekett, with the creation of new water points along the Road of Hope[9] in the southeast of the country.

Livestock farmers are particularly affected by the drought because the most widespread survival strategy of rural populations has always been capitalisation by building up herds. As a result, a major rural exodus has been initiated, following the decapitation of herds due to the deterioration of the owners' financial capacity. In the project area, the trend towards the sedentarization of rural populations, which began before the climatic crisis of the 1970s, was amplified during the 1984/1985 droughts. It is in this context that the deterioration of the living conditions of nomadic herders led to a reduction in the number of nomads. This phenomenon of massive sedentarization of nomadic herders was characterised by the appearance of a multitude of new villages along the transhumance routes and asphalted roads. OSS (2015) with regards to livestock, mentioned that "*The constant increase in pastoral*

[8] MDR, 2002 and MDR, 2016
[9] FAO. The Road of Hope: control of moving sand dunes in Mauritania. Available at: https://www.fao.org/3/y2795e/y2795e07.htm

pressure by the birth of a new method of peri-urban livestock farming of cattle and especially camels for the marketing of milk production has caused a strong degradation of the environment."[10].

This livestock sector is an important sector in Mauritania, with large representative of the population in those areas and constitute a real political challenge. Despite their necessity, these shifts in livestock management have adversely impacted surrounding natural and agroecosystems[11]. In addition to the induced climatic hazards, non-climatic drivers are worsening the situation. As earlier mentioned, the major droughts of the 1970s and 1980s created socio-economic-modification of the livestock landscape as follows:

(i) a **significant shift from nomadism to a transhumant system**; the latter evolving over time towards a partial sedentarization of the herds and a drastic reduction in transhumance movements. These phenomena lead to overexploitation of the grazing areas adjacent to the towns, as well as greater recourse to food and veterinary inputs

(ii) a **transfer of ownership of camel herds** (following the impoverishment and sedentarization of nomads) to wealthy owners for whom this type of farming constitutes a means of prestige and a very interesting opportunity for financial investment. This change leads to a less respectful use of natural resources and causes conflicts with agro-pastoralists in the transhumance areas of the camel herds. In addition, there is great instability among good herders and a decrease in the know-how of the majority of salaried herders.

(iii) the **extension of sedentary livestock farming** associated with agriculture, where the animals exploit not only the rangelands close to the farmer's concession, but also the crop residues, either directly through grazing or indirectly after cutting and storing the straw or tops.

(iv) the **development of urban and peri-urban livestock farming** with an emphasis on goats, given their ability to use urban waste and ruderal grazing land.

(v) the **start-up of intensive units** (poultry and, to a lesser extent, cattle) and **semi-intensive dairy units** (cattle and camels).

According to the OSS (2015), "*previously extensive, the livestock has suffered greatly from the latest droughts that have caused a reduction in pastureland. This is the reason for a massive sedentarization resulting from a major rural exodus of men which de-structured most of the old production systems*." Thus, these **profound social changes have resulted in a growing number of villages, where the population is mostly composed of women and children** (MDR, 2012).

Key findings on livestock production issues induced by climate change

- **Disappearance of grazing areas: among the grazing areas disappeared by <u>silting and/or droughts</u> in:**
    - The Tamchekett hub: oued Barka, Ould Ragagi, Hachim, Eguerjt Lehbass, Boutekta, Tetmatt, Moukhaich, Lehbat, Fiiji.
    - The Nema hub: Tichilit Talh, Oum Ettemay and Temachmarit, Oum Larjan, Telmeden (guelta), Guelta Touzelat, Taoujeft Arereji , Taymsett, Iriji).

[10] OSS, 2015. Mauritanie : « Atlas des cartes d'occupation du sol», Projet Amélioration de la résilience des populations sahéliennes aux mutations environnementales – REPSAHEL, 250p.
[11] Strengthening the resilience of ecosystems and populations in four regional hubs in northern Mauritania, Trends analysis, Eco solutions.

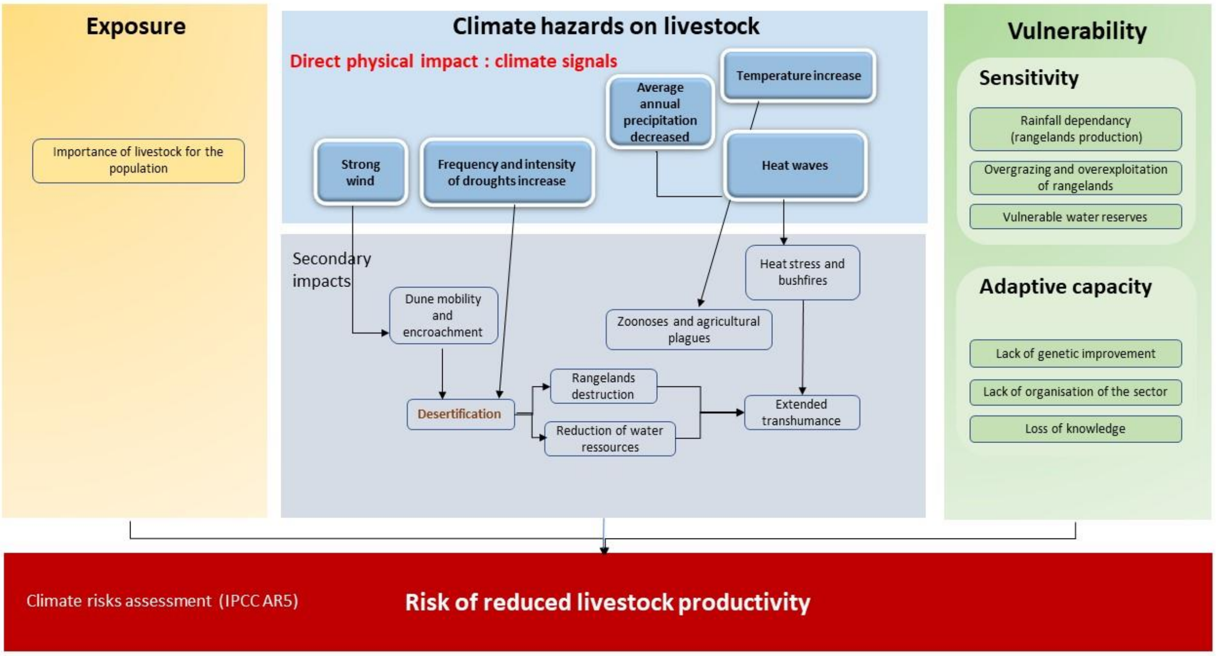
- **Scarcity of fodder** species such as *Acacia senegal* and *Commifora africana*; and reduction of the most palatable plant species because of drought particularly in the wilaya of Tagant (Rachid hub) (Table 3). Access to feed, another alternative to the fodder deficit linked to droughts, remains conditioned by its proximity, its price and the family's available cash. The 2019/2020 season shows, for a majority of non-transhumant herders, an early recourse to feed. Traders are taking the place of financial institutions and providing loans at often usurious rates, which, as it stands, constitutes a **risk of spiralling indebtedness for the middle-class herder.**
- **Disappearance of pastoral wells** because of drought in:
  - The Rachid hub (Aghmachanet, Toum Wersukel, Puits de Khatt, Foum Ajar, Dhaya),
  - The Tamchekett hub (Majhar, Iriji Oum Lemhar, Tegwa; Ain Ajhaniya; Legreywa; El Mbeydih, Le Mbeyha, Aguemoun and Lebyadh);
- **Reduction in the quantity of milking** (before 3litres/hutch; during drought less than 1litre).
- **Reduction of cattle productivity** because of the longer interval between births during the drought which is increasingly prolonged due to the poor quality of feed for the females and the cattle in general.
- **Presence of new livestock diseases** (Rift Valley Fever) and epizootic diseases are a serious threat to all livestock shepherds, even though animal promiscuity undoubtedly increases the risk of contagion.
- **Animal mortality** increase, especially during droughts.
- **Transhumance in drought conditions requires specific resources** (labour force and transport equipment such as carts and draught animals or vehicles). When they are alone (or a family is without livestock) herders may consider hiring out for transhumance with the cattle (one or several owners) which is expensive.

Key findings on non-climatic drivers for change

- **Disappearance of nomadic systems** with spatial and temporal reduction of transhumance of cattle herds combined with a regression of solidarity values among the people.
- **Fixation of animals around the agglomerations for socio-economic reasons** leading to more burdens and domestic work for women and young people.
- **Increase in the monetary needs of livestock breeders** who, as a result, tend to sell their animals earlier, especially in the case of female heads of household.

Figure 21 provides a summary of the risks chain leading to reduced livestock productivity : it describes exposure issues, climate hazards (direct physical impacts) and vulnerability that were jointly defined by the Focus groups and the team of experts. These elements (measured on a series of indicators listed below) are rated and ranked in the following section. The secondary impacts were simply used to guide the discussion on exposure and vulnerability.

FIGURE 21 : CHAIN OF RISKS FOR LIVESTOCK PRODUCTIVITY



3.5 Impacts on infrastructures

The degree or intensity of silting with regards to infrastructures and environment (palm groves, wells, etc.) is a critical issue. Silting is mainly focusing here on sand movements, generated by wind from Sahara. Silting affects all production systems in Tamchekett and reduces the resilience of communities and ecosystems (Table 4).

TABLE 4: SYNTHESIS OF THE INTENSITY OF SILTING IN THE FOUR HUBS

Hub	Infrastructures	Degree/intensity of silting	Observations
NEMA	Palm grove and wells in Oued Nkhal Agouenit	Completely buried	Rural exodus to larger cities
	Tichilit Talh (rainfed cultivation)	Completely buried	Rural exodus to larger cities
	Wells of Zangra and Bamoira	Completely buried	Causing displacement of populations
	Oued Tatrart	Completely buried	Reduction of agricultural land
TAMCHEKETT	Tamchekett City	Highly threatened by gullying	Urgent measures needed
RACHID	Taoujeft and wadi	Highly threatened by gullying	Urgent measures needed
	Wadi Narzik, Talmedi and Tenwarer palm groves	Completely buried	Urgent measures needed
	Axis Rachid-Tidjikja and Ain Savra	Very threatened (up to 60%)	Urgent measures needed
	Wadi Rachid, Dakhlet palm groves and wells	Highly threatened	Urgent measures needed
	North-west part of Rachid	Highly threatened	Urgent measures needed
	Palm grove Iriji, Foum Dar et Saguiya	Highly threatened	Urgent measures needed
AOUJEFT	Oued Tenmour Palm grove	Completely buried	Causing displacement of the village

Hub	Infrastructures	Degree/intensity of silting	Observations
	Palm grove of Aoujeft city	Completely buried	Causing displacement of the village
	The north-eastern part of the Loudeye palm grove	Completely buried	Causing displacement of the village
	Atar Aoujeft Rachid road	Very threatened (up to 70%)	Daily mechanical desilting
	City and palm grove of Aoujeft	Very threatened	Urgent measures needed
	Tenwemed and palm grove	Very threatened	Urgent measures needed
	Mataa Moulana tenwemend	Very threatened	Urgent measures needed
	Ain savra	Very threatened	Urgent measures needed

Source: Based on Focus Group Discussions with Communities and Local administrative authorities met by the team of national experts during field data collection mission.

Key findings on flooding issues

In addition, and in contrast to the persistent drought and the aridification in all the hubs, devastating ***floods*** are observed in the four hubs.

- These flooding events often result in **loss of human and livestock life, destruction of palm groves**, **human habitats, ecosystems and crop fields, damage to hydraulic road and socio-cultural infrastructures and reduced means of subsistence**.
- The flood-related impacts also reduce crop production, decrease incomes, facilitate the extension of shantytowns, and ***contribute towards the urban push that favours the rural exodus of rural community*** members. For example, the dam of Toueymirt, about 10 km south-east of the town of Tamchekett, was destroyed the year it was built due to flooding and the town downstream of Tintane in Hodh el Gharbi disappeared flooded by water from the El Aguer plateau in the Moughataa of Tamchekett. These impacts impact communities' livelihoods and wellbeing, while increasing pressure on their surrounding ecosystems.

Figure 22 provides a summary of the risks chain leading to flooding : it describes exposure issues, climate hazards (direct physical impacts) and vulnerability that were jointly defined by the Focus groups and the team of experts. These elements (measured on a series of indicators listed below) are rated and ranked in the following section. The secondary impacts were simply used to guide the discussion on exposure and vulnerability.

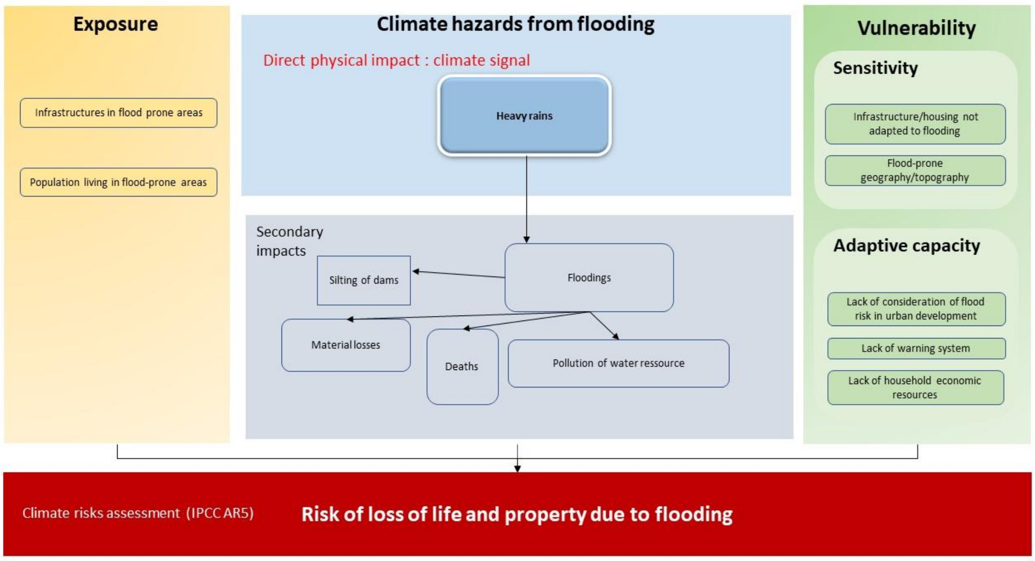


FIGURE 22 : CHAIN OF RISKS FOR FLOOD

3.6 Impacts on human health

With regards to health, the worsening of the worrying nutritional situation (WFP, 2015) and the increase in the prevalence of nutritional pathologies are noted, thus favouring the appearance of infectious and parasitic diseases in children under five. For several years, the country has experienced heat waves along the Tagant and Assaba mountain ranges, causing deaths among the elderly and deaths from thirst. The 4th Mauritania National Communication to UNFCCC (*République Islamique de Mauritanie*, 2019) highlighted health issues in these terms: "*Due to the first climatic casualties recorded in 2012 as a result of heat waves, the health sector was selected as a priority sector but was not included due to the lack of reliable data reported by the expert*.[12]"

Climate change has increased the severity of certain diseases and mortality rates through more frequent heat waves during the summer. The 'urban heat island' phenomenon is also worth watching. Since it is generally warmer, people in the area are more often engaged in activities that expose them to the sun's ultraviolet rays. This may partly explain the current increase in skin cancers. These diseases are difficult to detect in the collection area.

Key findings on health and climate related factors

- The number of **skin diseases** has been increasing in recent years. In the absence of dermatologists, it is difficult for them to determine their prevalence in the health posts and centres. These issues of skin diseases or in general dermatology perspectives in relation with climate change are mentioned in peer review journals, not specifically in Mauritania, but above Sub-Saharan Africa (Coates et al, 2020; Muller, 2011)[13,14] as reported by the DRAS (Regional Direction of Health) of Adrar and Tagant during the field consultations,

- Persistence of a worrying nutritional situation aggravated by the droughts is confirmed in the ***collection area by the Focus Group***: people have lost lives due to heat waves over the last two years, (2 in the Aoujeft hub and 2 in the Tamchekett hub). Mauritania is characterised by a worrying **nutritional situation**[15] (WFP, 201b5[16]), aggravated by difficult environmental conditions, which leads to an increase in the prevalence of nutritional pathologies, thus favouring infectious and parasitic diseases, in particular diarrhoea and ARI (Acute Respiratory Infection); Ozer, 2006[17]). Among children under five, infant mortality is dominated by ARI (21%), malaria (15%) and diarrhoeal diseases (13.5%) according to the Demographic and Health Survey (EDSM). These three conditions alone account for 5% of the causes of death among children under 5 years of age and 35% of children over 5 years of age. In addition, 32% of children under 5 years of age suffer from chronic malnutrition and underweight, of which 17% and 10% respectively in their severe forms.

- It is confirmed that health consequences related to the degradation and deterioration of the natural environment include, inter alia: i) **increased incidence of malaria** as a result of the proliferation of

[12] National Communication to the UNFCCC (NC) *République Islamique de Mauritanie*, 2019, p.19

[13] Coates S.J, Enbiale W., Davis M.D.P., Andersen L. K., 2020. The effects of climate change on human health in Africa, a dermatologic perspective: a report from the International Society of Dermatology Climate Change Committee. Int J Dermatol. 2020 Mar;59(3):265-278. doi: 10.1111/ijd.14759. Epub 2020 Jan 22. PMID: 31970754.

[14] Muller S.A., 2011. Climate change, dermatology and ecosystem services; trends and trade-offs. Int J Dermatol. 2011 May;50(5):504-7. doi: 10.1111/j.1365-4632.2011.04929.x. PMID: 21506962.

[15] https://www.thenewhumanitarian.org/analysis/2015/05/26/food-worries-widen-mauritania

[16] WFP, 2015b. Mauritania Situation Report #26 March 2015, 2p.

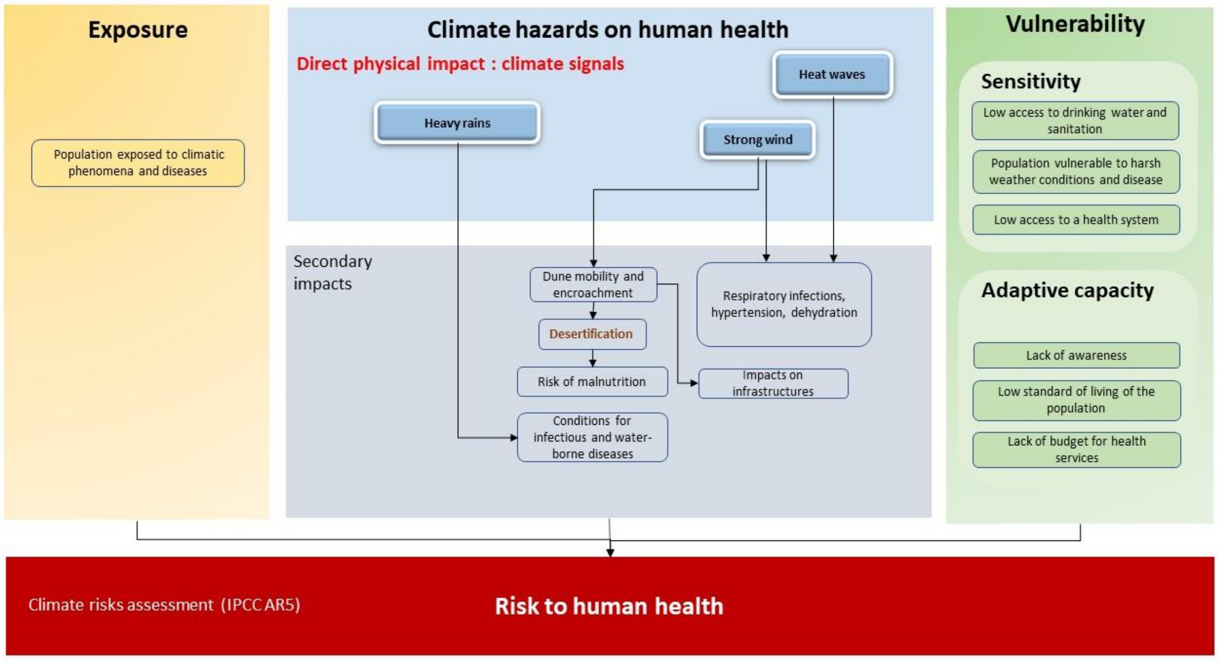
[17] Ozer P. 2006. Dust in the Wind and Public Health: Example from Mauritania, pp. 55-74. In: Desertification: Migration, Health, Remediation and Local Governance., Royal Academy for Overseas Sciences, Bruxelles, Belgique

mosquitos; ii) **high blood pressure** in response to increasing temperatures; iii) diseases related to **reproductive health**; iv) **malnutrition and nutritional anaemia** as a result of food deficiencies.

In conclusion, the impacts on health in the four hubs, apart from the pathologies listed above, vector-borne diseases, schistosomiasis, venereal diseases, pregnancy at risk, Rift Valley fever outbreaks, dysenteries, trachoma, conjunctivitis (Interview with the Direction Régionale pour l'Action Sanitaire -Dras- of Tagant) were noted. AfdB (2018)[18] confirms health matters in Mauritania related to climate change: "[…] *negative health impacts resulting from deteriorating water quality; increased incidence of heat stress and stroke*."

Figure 23 provides a summary of the risk chain to human health describing exposure issues, climate hazards (direct physical impacts and secondary impacts) as well the vulnerability that was jointly defined by the Focus groups and the team of experts. These elements (measured with a series of indicators) are rated and ranked in the following section.

FIGURE 23 : CHAIN OF RISKS FOR HUMAN HEALTH



[18]AfDB, 2018.National Climate Change Profile, 27p.

4. Critical risks under projected climate change

4.1 Reminder about the method

The indicators corresponding to the risk identified in the risks chains and their rating are described in section 4.1.2. The climate hazards defined in the Report 3.1 are summarized in section 4.1.1 below. Since little socioeconomic data were available in a usable format, the assessment of exposure and vulnerability was conducted using qualitative and quantitative data collected and rated based on expert judgement and local knowledge collected during visits to the hubs. They are presented in section 5.

4.1.1 Climate hazards

The '***Climate Trends and Projections report'*** outlined observed trends and projected changes for the four hubs, based on observational data time-series as well as outputs from new high-resolution future climate projections run with a regional climate model (RCM) and two GHG emissions scenarios (IPCC - Representative Concentration Pathway): the mid-range scenario (RCP4.5) and the high scenario (RCP8.5). This work provides results on five climate hazards described in ***Report 3.1*** .

Heatwaves associated with WSDI (Warm Spell Duration Index), the annual count of days with ***at least 3 consecutive days when daily maximum temperature is higher than 90th percentile of daily maximum temperature*** during the period of 1981-2010.

Evapotranspiration affected by weather parameters, crop characteristics, management and environmental aspects generating Water Balance Deficit.

Heavy rains associated with R10mm index, the annual count of days when ***daily precipitation is higher than 10mm.***

Droughts associated with CDD index (Maximum length of dry spell), the annual maximum number of consecutive days with daily precipitation ***less than 1 mm***.

Strong winds coming from Northeast associated with the annual number of days with wind>6m/s, with Northeast as prevailing direction. Wind speed is an essential factor of sand encroachment, it determines the force of sand removal. The greater is the speed, the greater is the carrying capacity. The 6m/s value represents the threshold at which a wind can lift sand particles off the ground (FAO, 2010)[19].

Climate hazard rated 5 (extremely high) : Significant event of high occurrence or severe event of moderate occurrence whose frequency and/or intensity will strongly increase due climate change.

Climate hazard rated 4 (high) : Significant event of high occurrence or severe event of moderate occurrence whose frequency and/or intensity will moderately increase due to climate change; significant event of moderate occurrence or severe event of rare occurrence whose frequency and/or intensity will strongly increase due climate change.

Climate hazard rated 3 (moderate) : Significant event of high occurrence or severe event of moderate occurrence whose frequency and/or intensity will not be impacted by climate change: or significant event of moderate occurrence or severe event of rare occurrence whose frequency and/or intensity will moderately increase due to climate change. Significant event (but not severe) of rare occurrence whose frequency and/or intensity will strongly increase due climate change.

Climate hazard rated 2 (slight) : Significant event of moderate occurrence or severe event of rare occurrence whose frequency and/or intensity will not be impacted by climate change; Significant event of high occurrence or severe event of moderate occurrence whose frequency and/or intensity will decrease due to climate change. Significant event (but not severe) of rare occurrence whose frequency and/or intensity will increase due to climate change.

Climate hazard rated 1 **(marginal)** : Event, but not severe, of rare occurrence whose frequency and/or intensity will not be impacted by climate change; or Significant event of moderate occurrence or severe event of rare occurrence whose frequency and/or intensity will decrease due to climate change.

[19] FAO, 2010: Fighting sand encroachment, lessons from Mauritania

It is worth noting that the choice was made in the scoring to limit the scores from 1 to 3 for observed climate data, to leave space for an increase with climate indicators for 2050 scenarios. *In theory, 1 to 5 scores could have been given for the observed climate but it would not have been possible to go beyond 5 to reflect the climate indicators increase.*

The four tables below provide a summary of the rating results are displayed in details in Deliverable 3.1. They are included into the equation of the risk calculation as the 'climate hazard' factor in the following sections.

Those climate change **simulations** clearly show a very strong increase for 2 hazards over time, namely drought / dry spells and water deficit in the four hubs (to a lesser extend in Aoujeft for drought). Heat waves are also a strong projected hazard, mostly under scenario 8.5 in the four hubs and even under scenario 4.5 in Rachid. Flood are projected to decrease because of lower values for heavy rain in the four hubs.

Drought and dry spells

Hubs	Observed	RCP 4.5	RCP 8.5
Néma	3	4	4
Tamchekett	3	4	4
Rachid	3	5	5
Aoujeft	3	2	3

Water balance deficit

Hubs	Observed	RCP 4.5	RCP 8.5
Néma	3	5	5
Tamchekett	3	5	5
Rachid	3	5	5
Aoujeft	3	5	5

Heat waves

Hubs	Observed	RCP 4.5	RCP 8.5
Néma	1	2	3
Tamchekett	1	2	3
Rachid	1	3	3
Aoujeft	1	2	3

Heavy rain / Flood

Hubs	Observed	RCP 4.5	RCP 8.5
Néma	2	1	1
Tamchekett	2	1	1
Rachid	1	1	1
Aoujeft	1	1	1

Strong winds and storm: The climate report 3.1 emphasized that other climate-related hazards are associated with risk levels that are, at the very least, comparable in extent to those highlighted above. Hence, despite the limited scope of the climatological research affordable to the project, a literature review was conducted to highlight observed and expected future trends of critical importance for the four hubs, such as sandstorm and associated silting[20]. Strong winds and storms, currently the direct cause of desertification with silting, could not be projected because of lack of data. **This does not mean therefore that the situation will remain constant and might well further deteriorate in the future**.

4.1.2 Exposure and vulnerability

The scores range for exposure and vulnerability is from 0 to 4 for the observed situation and from 0 to 5 for the situation projected by 2050. The scoring of non-climatic factors in 2050 is based on hypotheses of evolution proposed by the national experts based on their observations of current dynamics and their knowledge of past or

[20] UNEP, WMO, UNCCD (2016). Global Assessment of Sand and Dust Storms. United Nations Environment Programme, Nairobi.

ongoing plans or strategies (independently of the adaptation options proposed under this project) and that are underway or will soon be implemented.

- The **indicators** applied to each sector to calculate their exposure and vulnerability are listed in Table 5; they were formulated by the project team based on the results of the risk chains exercise.
- Table 6 provide the **ratings applied** with the definition of the degree of exposure and sensitivity/adaptive capacity based on risks chains displayed in the previous sectoral chapters.

TABLE 5 : INDICATORS FOR VULNERABILITY AND EXPOSURE ASSESSMENT BY SECTORS

ECOSYSTEMS INDICATORS	
Issues on the biotope (living environment defined by specific physicochemical characteristics): quantity/proportion of biotopes or habitats of ecological interest subject to climate change impacts	Exposure
Issues on the biocenosis (set of life forms including fauna and flora living in the biotope): quantity/proportion of animal or plant species of ecological interest subject to climate change impacts	Exposure
Degree of sensitivity of ecosystems to hazards: intrinsic characteristics of ecosystems that make them more or less vulnerable to the impacts of climate change (e.g., water requirements, resistance to high temperatures, etc.)	Vulnerability
Degree of overexploitation of ecosystems: Proportion of overexploitation and therefore fragility of ecosystems by human practices (overpopulation, deforestation, etc.).	Vulnerability
Degree of lack of implementation of conservation measures: creation of protected areas, sustainable ecosystem management measures, etc.	Vulnerability
FLOODING INDICATORS	
Presence of infrastructure in flood-prone areas: number of infrastructures directly exposed to flooding	Exposure
Presence of inhabitants in flood-prone areas: number of inhabitants directly exposed to flooding	Exposure
Degree of susceptibility of infrastructure and housing to flooding: propensity of infrastructure/housing to cope with flooding by design/architecture/materials...	Vulnerability
Degree of susceptibility of the topography to flooding: propensity of the topography to favor flooding phenomena (steep slopes, deep valleys, etc.)	Vulnerability
Degree of lack of inclusion of flood risk in planning documents and in local development plan: integration or not of flood risk in urban planning documents or in local territorial development strategies	Vulnerability
Degree of inefficiency of the warning system: existence or not of an early warning system for floods and effectiveness if it exists	Vulnerability
Lack of economic means for households to cope with floods: economic capacity of local people to protect themselves from flooding or to recover from flooding	Vulnerability
WATER RESOURCES INDICATORS	
Share of population dependent on threatened water resources: proportion of the population directly exposed to water problems because of dependence on threatened resources	Exposure
Sensitivity of catchment areas to erosion: propensity of the catchment to erosion (steep slopes, bare soil, etc.)	Vulnerability
Extent of population growth: population growth leading to increased water needs	Vulnerability
Degree of overexploitation of water resources: population growth leading to increased water needs	Vulnerability
Difficulty in mobilising water resources: high cost, reduced storage capacity of dams due to silting, low groundwater resources, etc.	Vulnerability
Degree of lack of capacity to control water abstraction: capacity of local authorities to monitor and control water withdrawals to ensure sustainable resource management	Vulnerability
Degree of lack of quantitative and qualitative monitoring of water resources: capacity of local authorities to monitor and control the quality and quantity of available resources	Vulnerability
AGRICULTURE INDICATORS	
Degree of importance of vegetable production for the population: importance of this production for food security and income generation for the local population	Exposure
Degree of importance of cereal production (Dieri crops, behind dams and decru) for the population: importance of this production for food security and income generation for the local population	Exposure
Degree of importance of date production (phoeniculture) for the population: importance of this production for food security and income generation for the local population	Exposure
Degree of crop susceptibility to pests, diseases and water stress: propensity of crop varieties to be affected by pests, diseases, water stress and other climatic parameters	Vulnerability
Degree of soil sensitivity to erosion, silting and salinization: propensity of soils to be impacted by erosion, silting and salinization	Vulnerability

Degree of crop dependency on rainfall: proportion of crops with high water requirements that are fed solely by rainwater	Vulnerability
Degree of lack of variety improvement program: existence or not of a varietal improvement program to adapt crops to climate change	Vulnerability
Lack of agricultural guidance and advice: existence or not of structures providing technical support to farmers	Vulnerability
Degree of use of rudimentary agricultural techniques: no soil protection measures, no water saving actions, etc.	Vulnerability
LIVESTOCK INDICATORS	
Degree of importance of livestock for the population: importance of this activity for food security and income generation for the local population	Exposure
Degree of overgrazing of rangelands: proportion of overgrazed pastures	Exposure
Degree of vulnerability of watering points: proportion of watering points vulnerable to drought	Vulnerability
Dependence of rangeland productivity on rainfall: importance of the fluctuation of production according to rainfall	Vulnerability
Degree of lack of genetic improvement: existence or not of a varietal improvement program to adapt breeds to climate	Vulnerability
Degree of lack of organization of the sector: organization of farmers for water resource management, pasture management, knowledge transfer, etc.	Vulnerability
Degree of loss of know-how among farmers: replacement of professional livestock farmers by poorly trained salaried shepherds.	Vulnerability
HEALTH INDICATORS	
Share of the population exposed to climatic phenomena: the proportion of the population that cannot afford to protect themselves against climatic hazards and their health consequences or that is particularly or directly exposed to climatic hazards and their health consequences	Exposure
Proportion of the population vulnerable to harsh weather conditions and diseases: the proportion of the population represented by children, the elderly, pregnant women or any other person likely to be particularly vulnerable to climatic hazards and their consequences	Vulnerability
Degree of access to drinking water and sanitation services: proportion of population with direct access to drinking water and sanitation services	Vulnerability
Degree of access and efficiency of the health system: geographical proximity to a functioning health system (sufficient staff and supplies)	Vulnerability
Degree of lack of awareness of the population: implementation of good population health practices	Vulnerability
Standard of living of the populations: population's standard of living sufficient to access the health system	Vulnerability
Public investment in the health sector: importance of public investment in the health field	Vulnerability

TABLE 6: SCORING GRID FOR EXPOSURE AND VULNERABILITY

SCORING GRID FOR EXPOSURE AND VULNERABILITY			
RATING	DEGREE OF EXPOSURE	DEGREE OF SENSITIVITY & ADAPTIVE CAPACITY	
0	Element not present/no importance/no population presence/no climate issue	No sensitivity/ not appropriate	No lack of adaptability/no appropriate means exist
1	Element weakly present/low degree of importance/low population presence/low climate issue	The element is not very sensitive/ weak	Reduced lack of adaptability/ low
2	Element present/ medium importance/ medium population presence/ medium climate issue	The element is moderately sensitive/moderate	Some lack of adaptability/ moderate
3	Element particularly present/ significant degree of importance/ significant population presence/ significant climate issue	The element is particularly sensitive/ medium	Lacks adaptability/means
4	Strongly present/ high degree of importance/ high population presence/ high climate challenge	The element is highly sensitive/ strong	Strong lack of adaptability
5	Element extremely present/ extremely high degree of importance/ extremely high population presence/ very high climate challenge.	The element is extremely sensitive/very strong	The element has an extreme lack of adaptability

The results obtained for each sectoral assessments, with the required combination of exposure and vulnerability indicators (Table 5 and 6) according to the risks chains prepared for each sector, were aggregated to the climate hazard values deriving from to IPCC RCP 4.5 and RCP 8.5 modelling results (section 4.1.1).

Box 3 : Reading the results with caution

The hazard scores on the one hand, and the exposure and vulnerability scores on the other hand, are calculated according to different scoring grids and methods, on the basis of observed and projected climate data for the former and on expert opinion for the latter, therefore comparing between scores can be misleading. They should rather be used to compare the situation between hubs (e.g. the climate component is more impactful in hub A than in hub B etc..) or between scenarios (e.g. the climate component is much more impactful in 2050 under RCP 8.5 than under the current climate). They should not be considered as mathematical 'hard values' per se but used as a tool to help visualizing the trend of risk levels.

- ⇨ The results obtained by sectors for each hub and each factor are commented in sections 4.2 to 4.8 and illustrated with corresponding graphs.
- ⇨ The detailed calculation of the socres are displayed in a series of tables (Tables A, B, C, D and E) for each sector in Annex 4)

4.2Risk of ecosystem degradation

The radar graphs (Figure 24, 25, 26 and 27) visualise the scores obtained for each factor identified in the ecosystem risk chains for ecosystem degradation (15) that are presenting an average of every factor of each component.

The **Error! Reference source not found.** A, B, C, and D (Annex 4) presents the average scores per risk component (hazard, exposure and vulnerability) that are summarized in box 1.

The risk of ecosystem degradation varies from a hub to hub with a higher risk in Aoujeft and the climate component of the risk is quite high. Recurrent droughts have a significant impact on ecosystems in the 4 hubs. So does the silting up caused by sandy winds. The risk is less significant in Tamchekett and Néma where the exposure of ecosystems and their vulnerability are considered to be lower. This risk is mainly present in Aoujeft due to a high degree of exposure and vulnerability. Indeed, there is a very strong disturbance of the biotopes (in particular by silting up) and of the biodiversity (almost total disappearance of the fauna and strong degradation of the flora). Moreover, ecosystems are very fragile and already disturbed (high sensitivity). As in the other hubs, the wildlife has almost totally disappeared. A replacement of the Sahelian flora by the Saharan flora is observed. In each location, although there is a high awareness ecosystems risks, but a general lack of economic means is preventing the implementation of any adaptation measures. By 2050, a progressive transformation of the ***Sahelian climate into a Saharan climate*** with a regular disturbance of the biotopes is clearly projected.

Box 1 : Summary of key scores for the risks of ecosystem degradation

Aoujeft : High exposure and vulnerability scores for current situation and at maximum score in 2050. Climate change scenarios adds a little more stress only along the 8.5 RCP trajectory.

Rachid : Medium exposure and vulnerability scores for current situation and at maximum score in 2050. Climate change scenarios add stress on ecosystems especially under RCP 8.5.

Tamchekett and Nema : exposure and vulnerability scores are relatively low in the current situation and remain lower than those of Aoujeft and Rachid in 2050. Climate change scenarios increase stress on ecosystems, particularly in Nema and under RCP 8.5. The risks will be lower than in Rachid and Aoujeft.

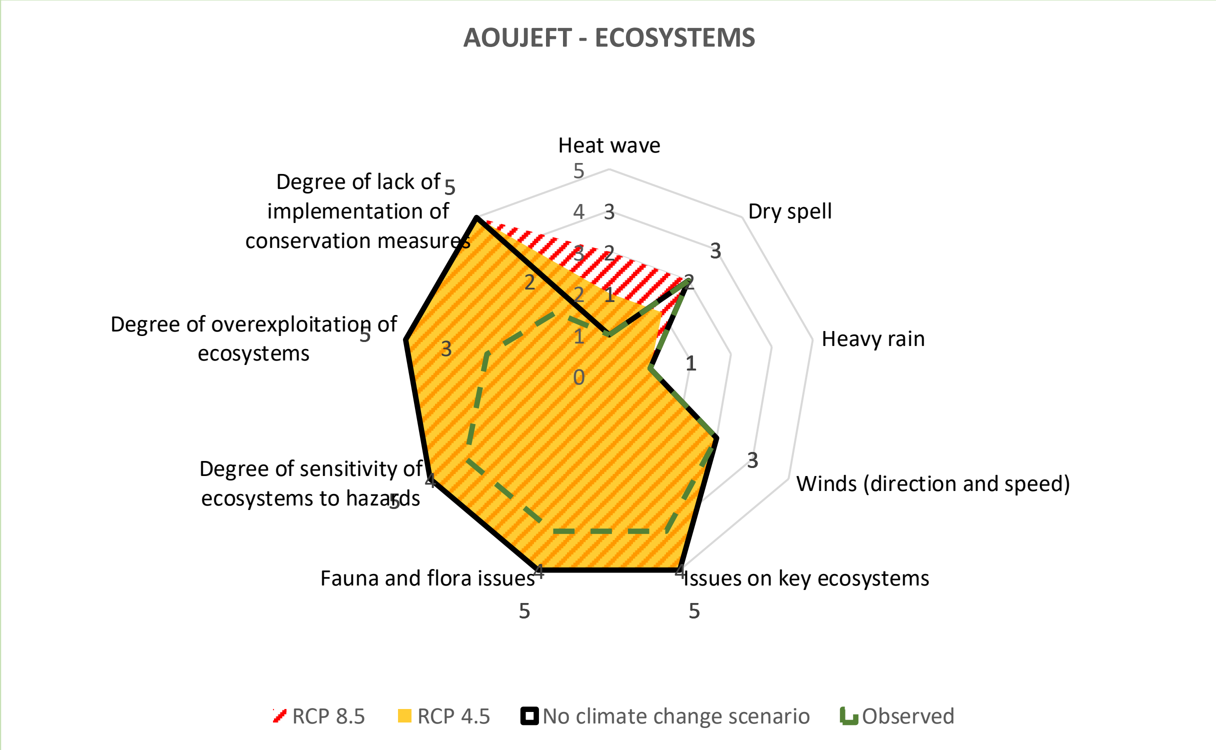


FIGURE 24 : SCORES FOR THE ECOSYSTEM IN NÉMA

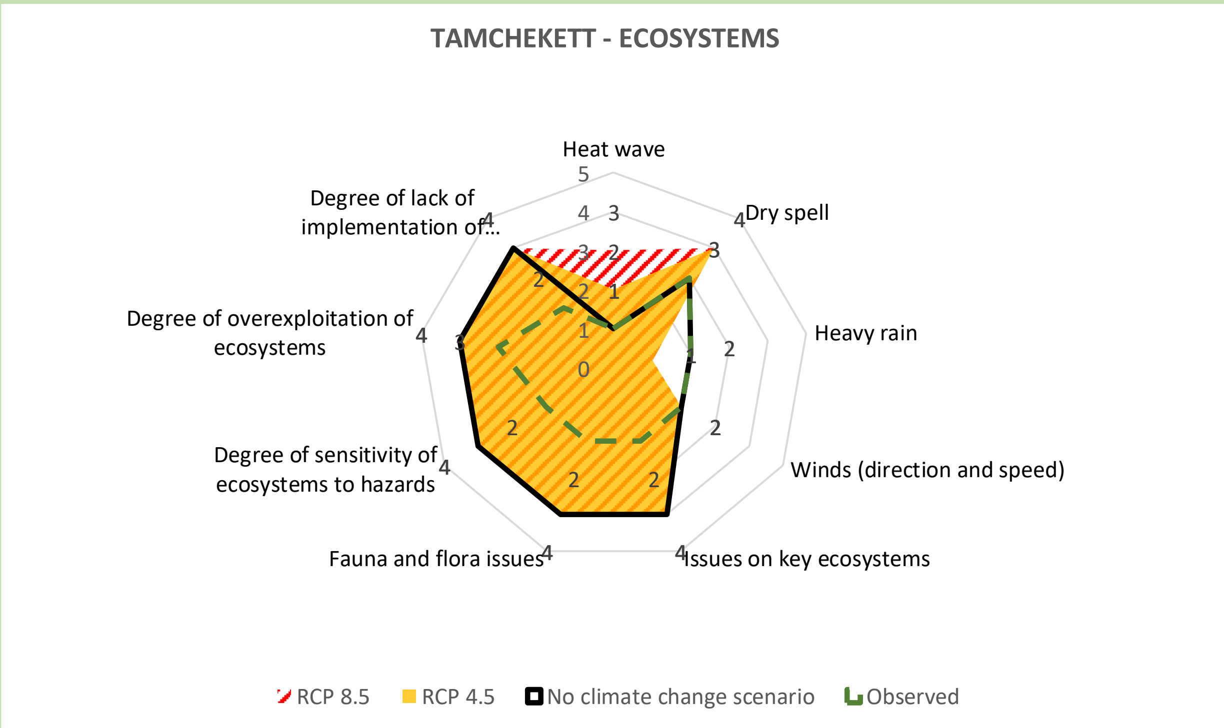


FIGURE 25 : SCORES FOR THE ECOSYSTEM IN TAMCHEKETT

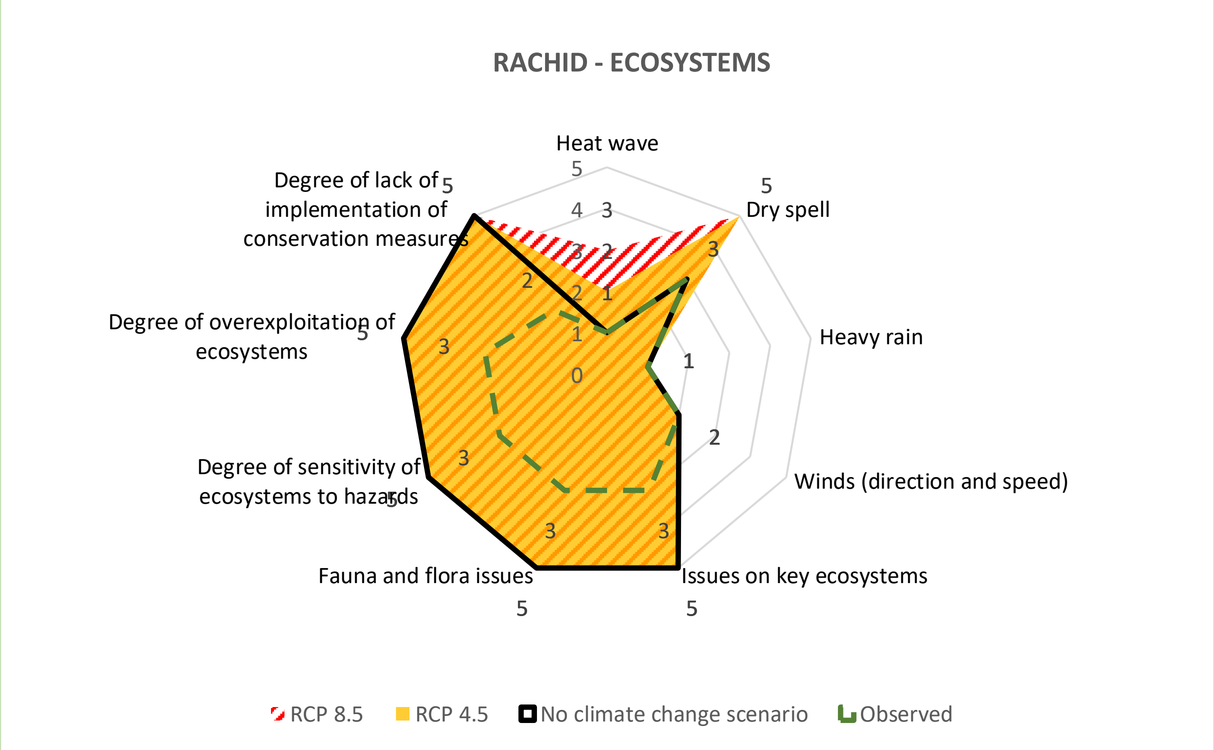


FIGURE 26 : SCORES FOR THE ECOSYSTEMS IN RACHID

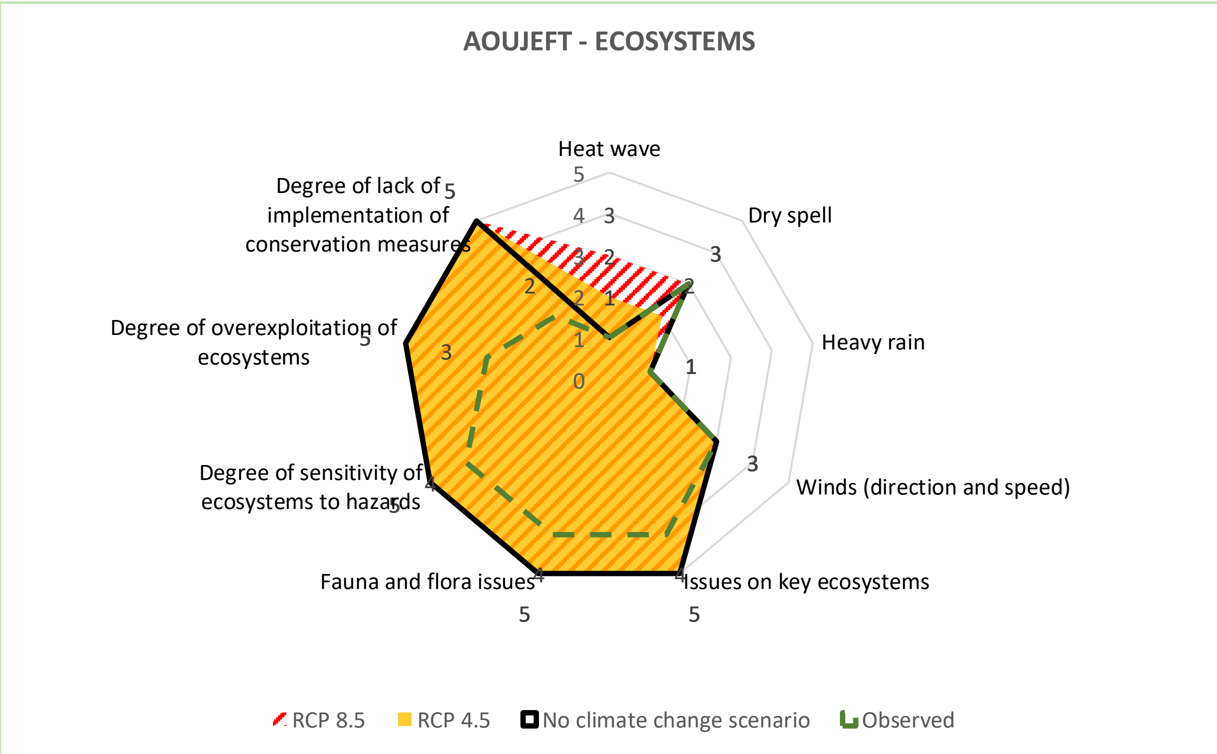


FIGURE 27 : SCORES FOR THE ECOSYSTEM IN AOUJEFT

4.3 Risk of degradation of water resources

The radar graphs (Figure 28, 29, 30 and 31) displays the scores attributed to each factor (i.e. exposure, hazard and vulnerability) identified for the water resources risks chains for each hub. (**Error! Reference source not found.**). The detailed **Error! Reference source not found.** (A, B, C and D) in Annex 4 presents the average scores per risk component hazard, exposure and vulnerability (i:e: an average of the factors of each component presented in the following graphs) and the resulting final risk score.

The climate factor is uniform and high across the hubs. It is explained by the high intensity and recurrence of droughts as well as by the increase in temperature and ETP. The winds, responsible for the silting up of water points, are also particularly impactful in Aoujeft and Néma with a significant decrease in rainfall in Néma is noted. The risk of degradation of water resources is quite high in all hubs with a higher risk in Aoujeft and lower in Néma. The Aoujeft hub is particularly at risk from water resources due to the population's heavy dependence on these threatened resources.

By 2050, the demographic growth is expected to be significantly higher, which could lead to a strong increase in water needs. There is also a strong lack of adaptive capacity in Aoujeft, Rachid and Tamchekett: water services have only recently been taken over by a dedicated entity. Thus, the control of withdrawals and the quantitative and qualitative monitoring of water resources are not yet sufficiently developed. In Néma, the management of water resources by a dedicated entity was established earlier.

BOX 2 : SUMMARY OF KEY SCORES FOR THE RISKS OF ECOSYSTEM DEGRADATION

Aoujeft: High exposure and vulnerability scores for current situation but the exposure would decrease by 2050 thanks to improved service with the Northern AEP Project. Climate change adds moderate stress on water resources.

Rachid : Medium exposure and vulnerability scores for current situation but high increase in 2050 due to difficult to access and unsustainable underground resources. Climate change will particularly add stress on water resources especially under RCP 8.5 due to drought and PET increase.

Tamchekett : Medium exposure and vulnerability scores for current situation but slight by 2050 decrease through groundwater recharge projects. Climate change will particularly add stress on water resources due to drought, decrease rainfall and PET increase.

Nema : exposure and vulnerability scores are relatively low in the current situation and for 2050 thanks to water supply projects and well-established network management. Climate change adds moderate stress on water resources.

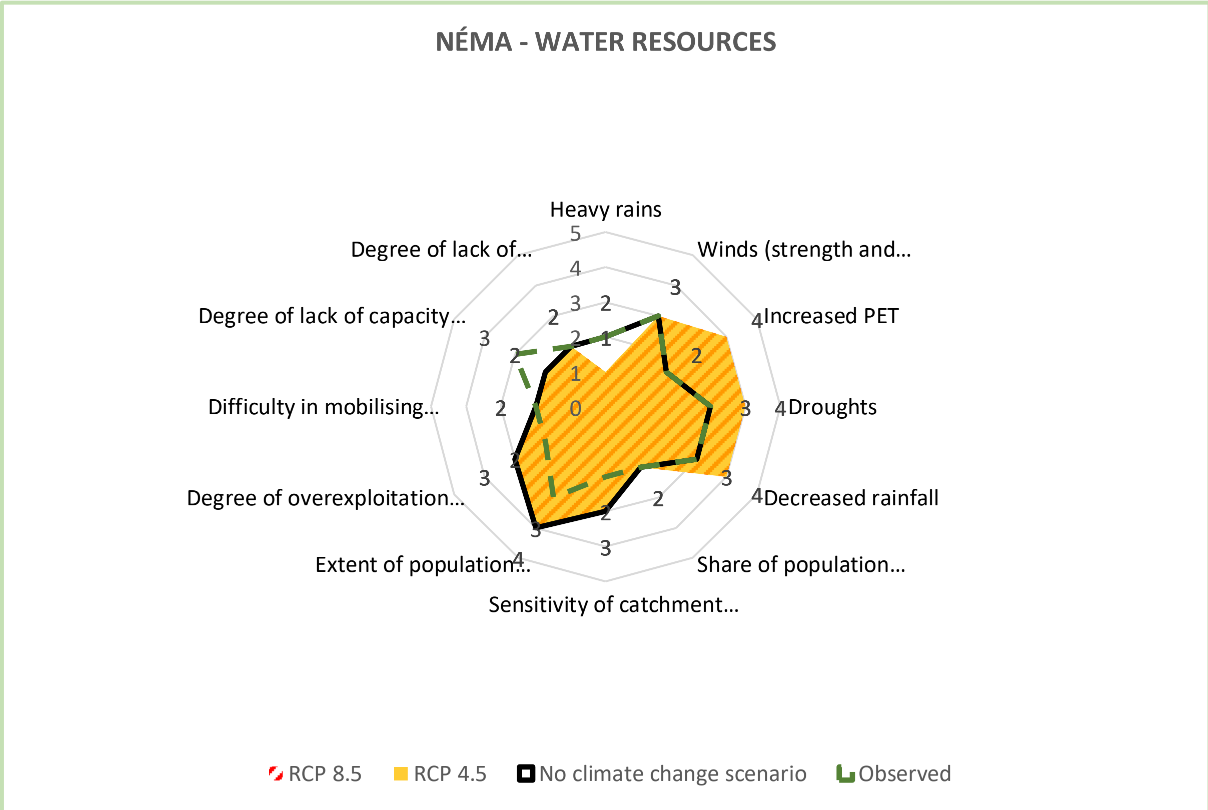


FIGURE 28 : SCORES FOR THE WATER RESOURCES RISKS CHAIN IN NEMA

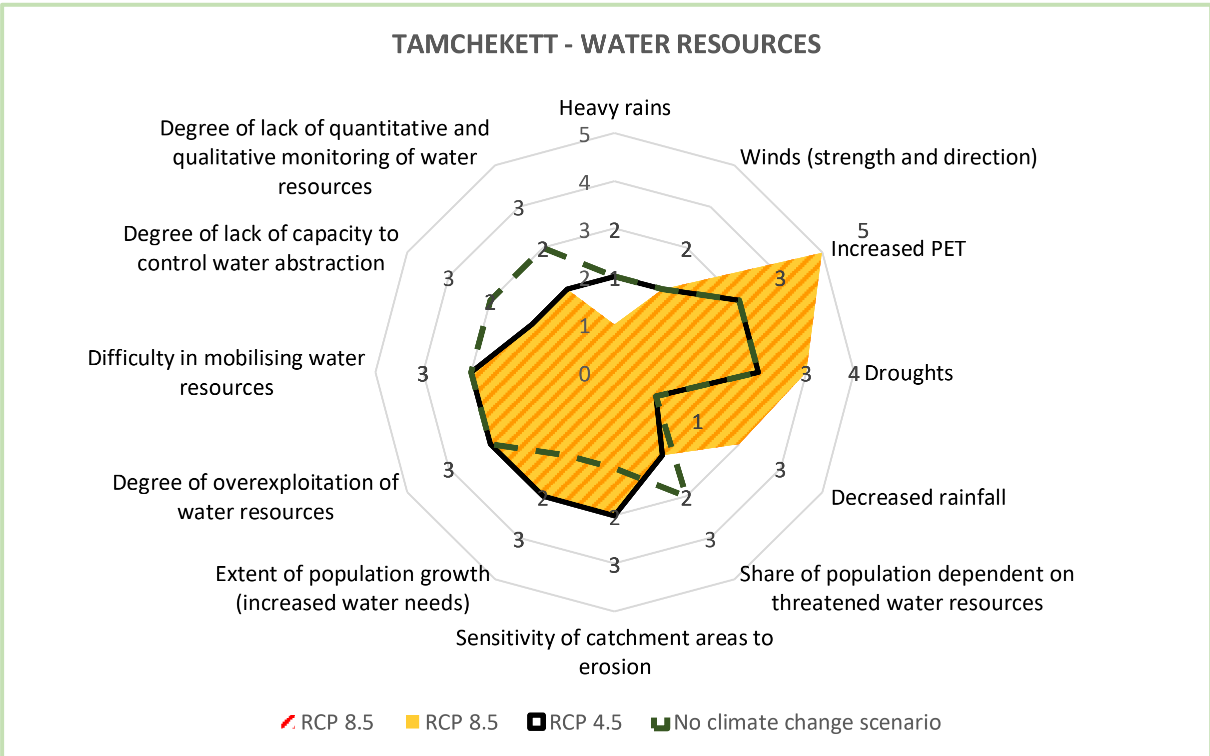


FIGURE 29 : SCORES FOR THE WATER RESOURCE RISKS CHAIN IN TAMCHEKETT

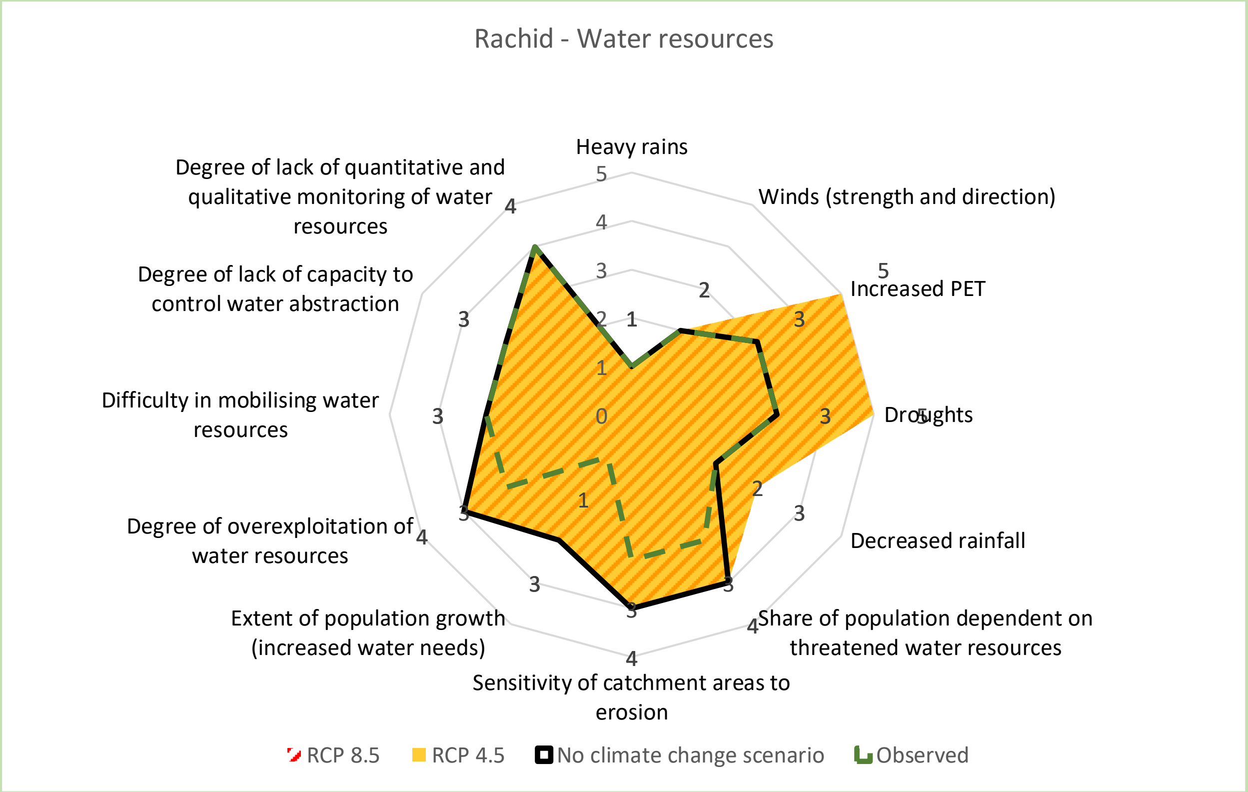


FIGURE 30 : SCORES OF THE WATER RESOURCES RISK CHAIN IN RACHID

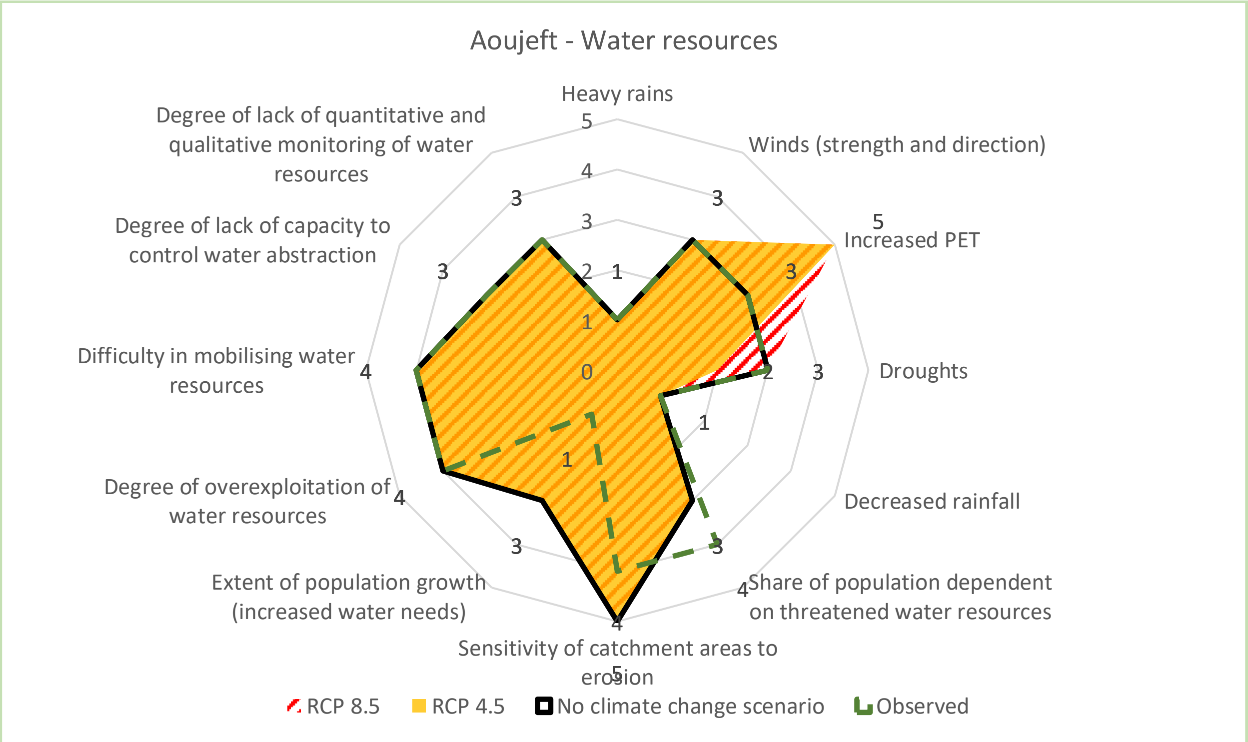


FIGURE 31 : SCORES OF THE WATER RESOURCES RISK CHAIN IN AOUJEFT

4.4 Risk of infrastructures flooding

The radar graphs (Figure 32, 33, 34 and 35) display the scores attributed to each factor (i.e. exposure, hazard and vulnerability) identified for the flooding risks chains for each hub (**Error! Reference source not found.**). The Tables 10 in Annex 4 presents the average scores per risk component hazard, exposure and vulnerability (average of the factors of each component presented in the following graphs) and the resulting final risk score.

Box 3 : SUMMARY OF KEY SCORES ON THE RISKS OF FLOODING

> **Nema :** exposure and vulnerability scores are relatively high in the current situation and for 2050 due to the high presence of informal settlements in flood-prone areas and the lack of defence infrastructure. Climate change scenarios add moderate stress in the current situation but will decrease by 2050 (fewer heavy rains).
>
> **Tamchekett** : similar situation to Nema with a lower level of exposure (fewer dwellings in the flood zone).
>
> **Aoujeft and Rachid** : risks level of flooding are lower because of a lower level of exposition and lower level of climate change impacts.

The current risk of flooding is quite **high in the Néma hub** and lower in the three other hubs. The risk is mostly due to its exposure and vulnerability combined to climate change elements.

The sensibility of Néma is particularly high due to the lack of drainage works combined with a topography favourable to flooding (convergence of catchment areas, low-lying location). The climatic component of flood risk is low in Aoujeft and Rachid on the long term : heavy rainfall has a relatively low occurrence and as in **Rachid's hub** is partly built on raised ground, few people live in flood-prone areas (low exposure) so people remains relatively unaffected due to the location of the infrastructures on elevated land : this is the reason why the score is not visible on the graph. The hubs of **Aoujeft and Tamchekett** are also affected by the convergence of several watersheds. A very strong lack of adaptability potential is noted in each hub, including due to financial means. The project areas are not identified in the Stormwater Master Plan study (SWMP, PDA in French), the risk of flooding seems **insufficiently taken into account in urban development with no efficient warning system** according to this SWMP study.

By 2050 though, the projection for the climate change factor (heavy rain) contributes to the sharp decrease of the risks with a reduction by 50% in Tamchekett and in Néma and 0% both in Aoujeft and Rachid. The risk is higher in **Tamchekett and Néma** where there are twice more days of heavy rain per year. The Néma hub, on the other hand, is particularly exposed in the short and medium due to a large proportion of the population living in flood-prone areas.

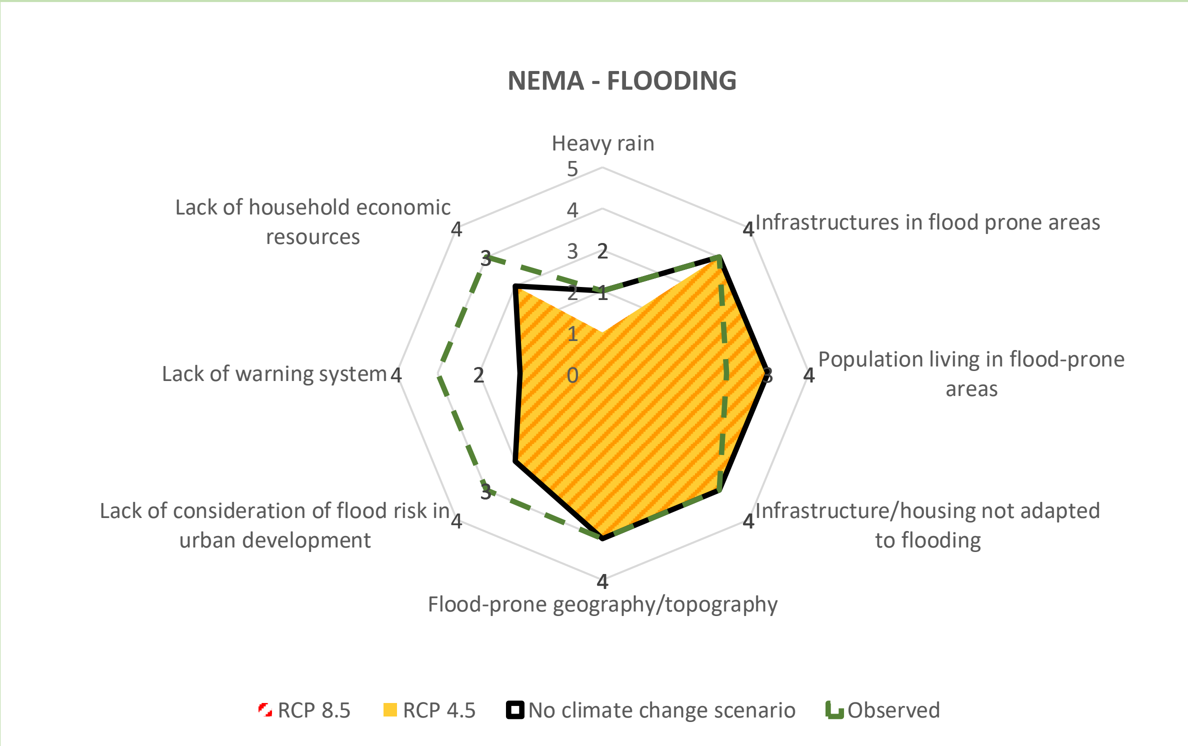


FIGURE 32 : SCORES FOR FLOODING IN THE RISK CHAIN FOR NÉMA

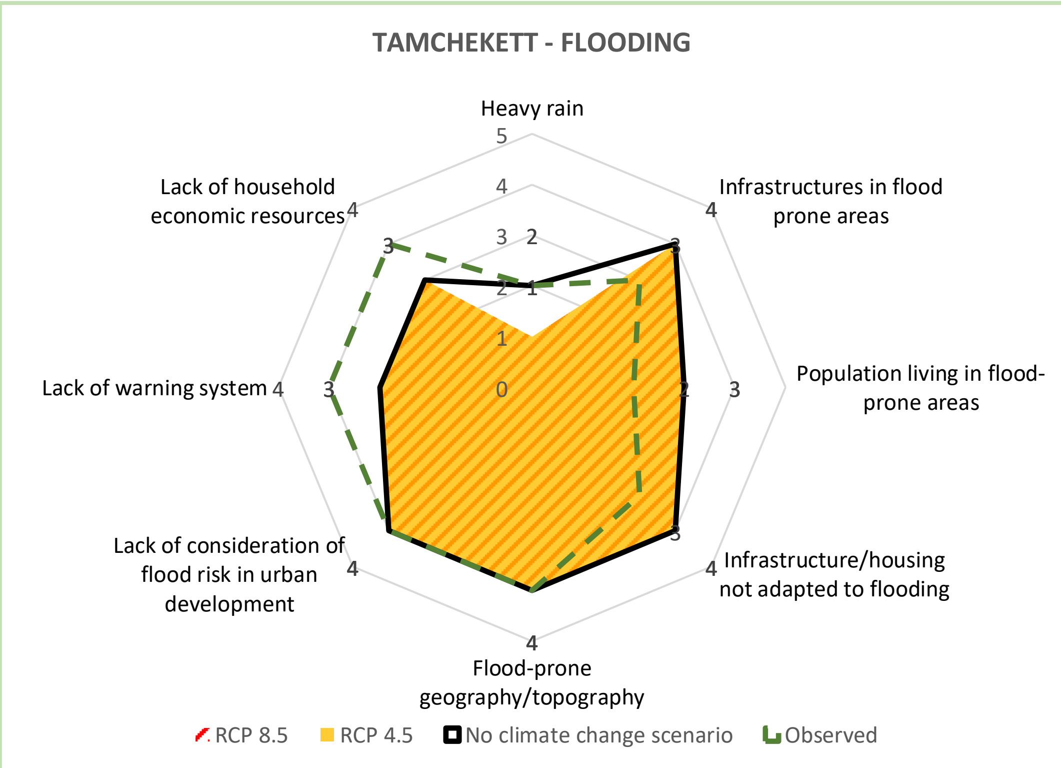


FIGURE 33 : SCORES FOR FLOODING IN THE RISK CHAIN FOR TAMCHEKETT

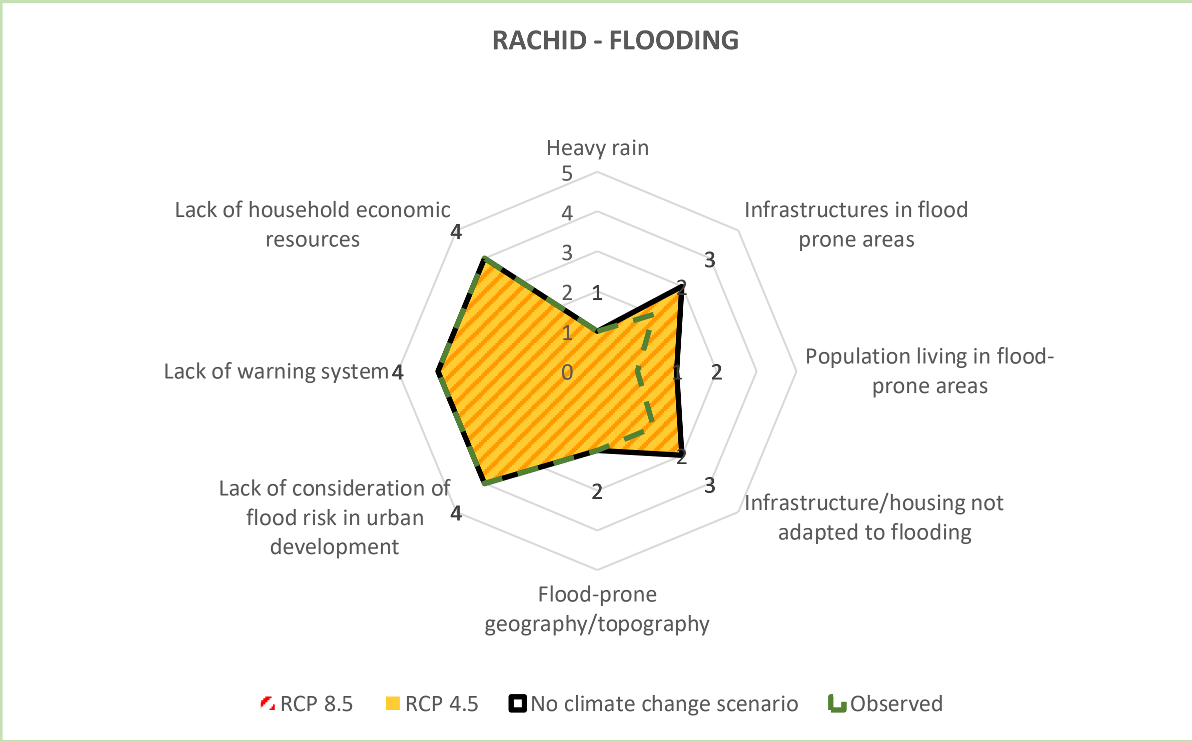


FIGURE 34 : SCORES FOR FLOODING IN THE RISK CHAIN FOR RACHID

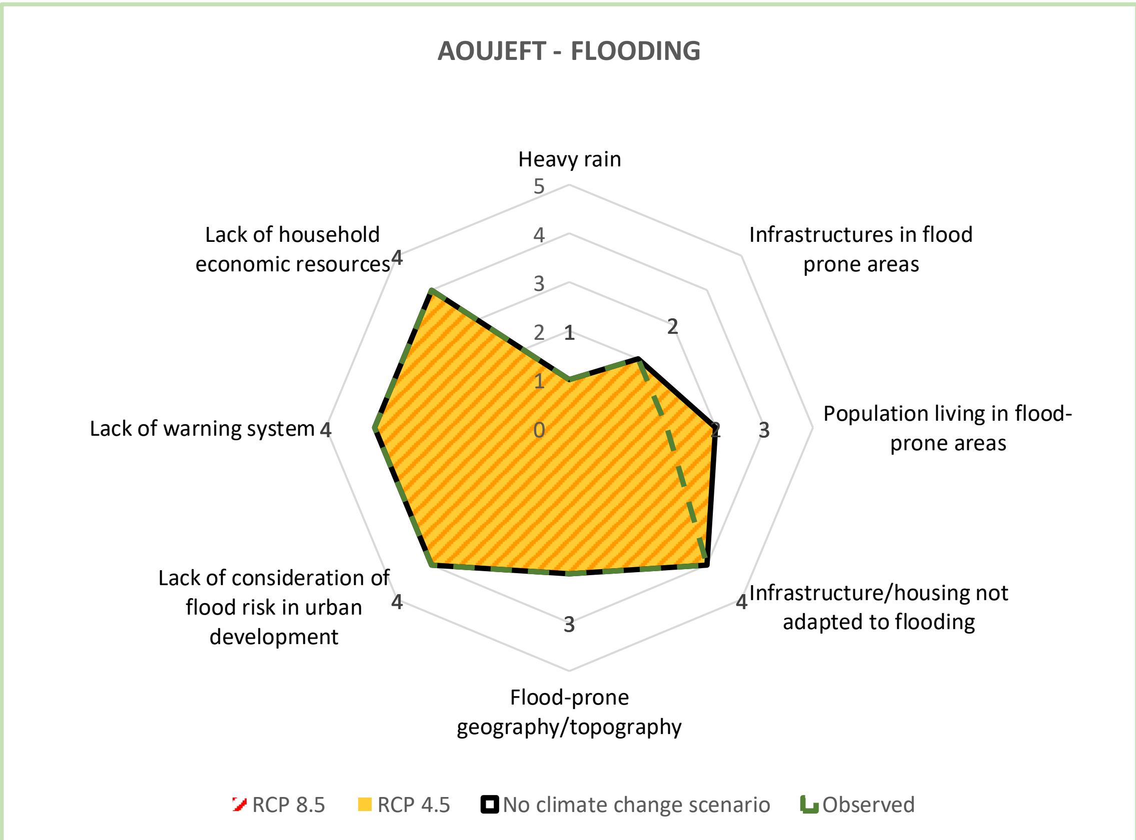


FIGURE 35 : SCORES FOR FLOODING IN THE RISK CHAIN FOR AOUJEFT

4.5 Risk of reduced agricultural yields

The radar graphs (Figure 36, 37, 38, and 39) illustrate those results for each factor (i.e. exposure, hazard and vulnerability) identified for the flooding risks chains for each hub (**Error! Reference source not found.**). The Tables 10 in Annex 4 presents the average scores per risk component hazard, exposure and vulnerability (average of the factors of each component presented in the following graphs) and the resulting final risk score.

BOX 4 : SUMMARY OF KEY SCORES FOR THE RISKS REDUCTION OF AGRICULTURE YIELDS

Risks score on agriculture are high for **each hub** with similar situations.

- **Exposure scores** are high because local populations depend on agricultural production for their livelihood.
- **Vulnerability scores** are high because crops are very sensible to climate conditions and Aoujeft and Rachid are specially affected by erosion and silting. Programmes to improve practices and varietal selection are planned.
- **Climate change scenarios** shows that it is particularly impacting because crops are very sensible to climate conditions. The impacts of climate change are expected to be particularly important in Rachid, Tamchekett and Nema due to increased ETP, droughts and temperatures.

The risk of reduced agricultural yields is high in all hubs, with a higher risk in Rachid and Tamchekett. The climate component of risk is very high in all the hubs. This is mainly due to a strong increase in evapotranspiration (water balance deficit) in connection with an increase in temperature as well as an increase in the intensity of droughts. In addition, there was a significant decrease in rainfall in Rachid and especially in Néma. As these 4 hubs are agricultural zones, they are particularly exposed to risks on agricultural yields. Rachid is the most exposed, with a very high dependence on date production (the country's 2nd most productive zone) and market gardening, and a high dependence on cereal growing. The hub of Aoujeft is mainly dependent on market gardening and date production (1st productive zone of the country) while Tamchekett is more dependent on cereal growing and to a lesser extent on phoeniculture. The vulnerability of the four hubs is rated high in the four scenarios : Aoujeft and Rachid are slightly more sensitive to agricultural risk due to the high sensitivity of their crops to limited, combined to highly endangered water resources and the sensitivity of the soils, often bare and dry, to sand winds. Tamchekett and Néma are more dependent on rainfall due to the predominance of rainfed crops. The lack of adaptability is very high in the 4 hubs due to the absence of varietal improvement programme and the use of rudimentary agricultural practices and a low level of supervision and agricultural advice. By 2050, the risk is sharply increasing under both IPCC scenarios, from 23% in Aoujeft to 58% in Tamchekett.

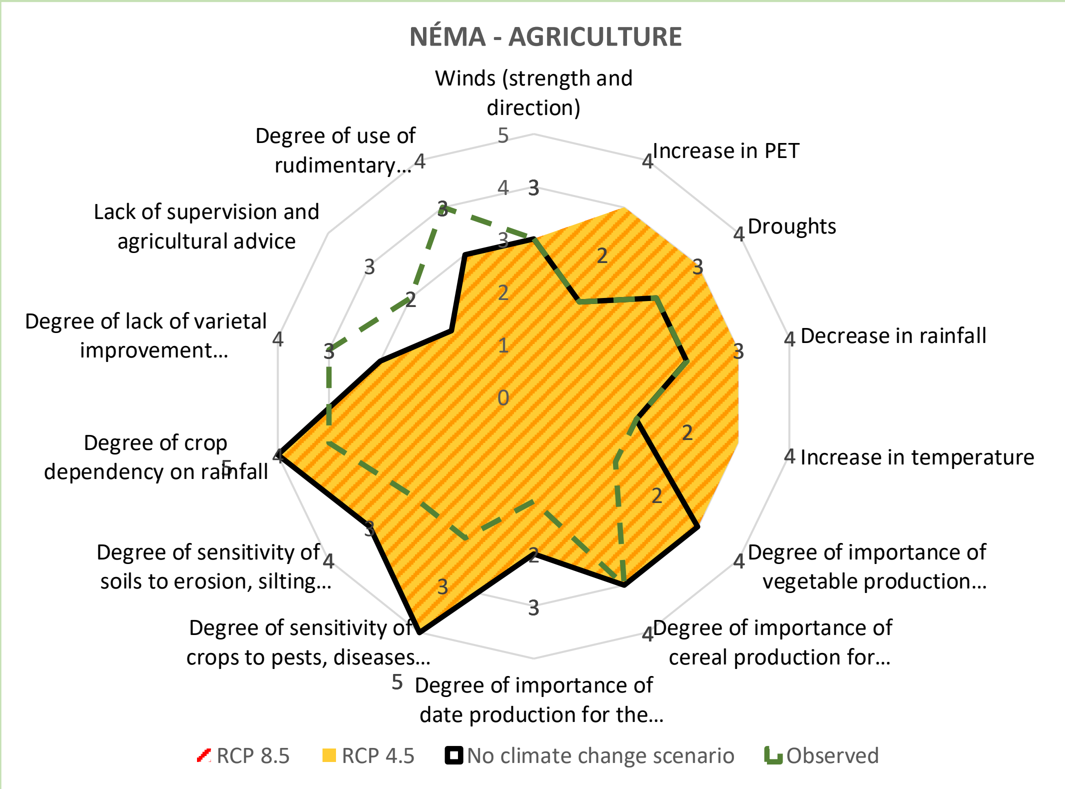


FIGURE 36 : SCORES FOR AGRICULTURE FOR NÉMA

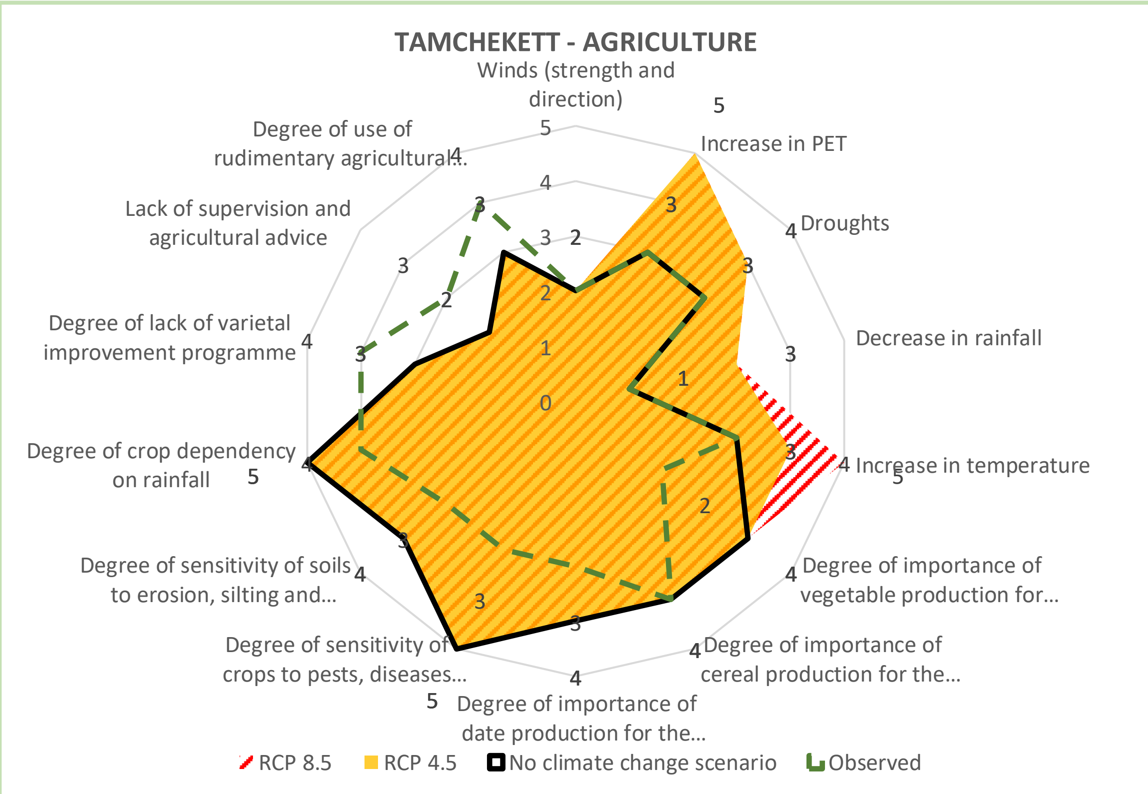


FIGURE 37 : SCORES FOR AGRICULTURE IN THE RISKS CHAIN FOR TAMCHEKETT

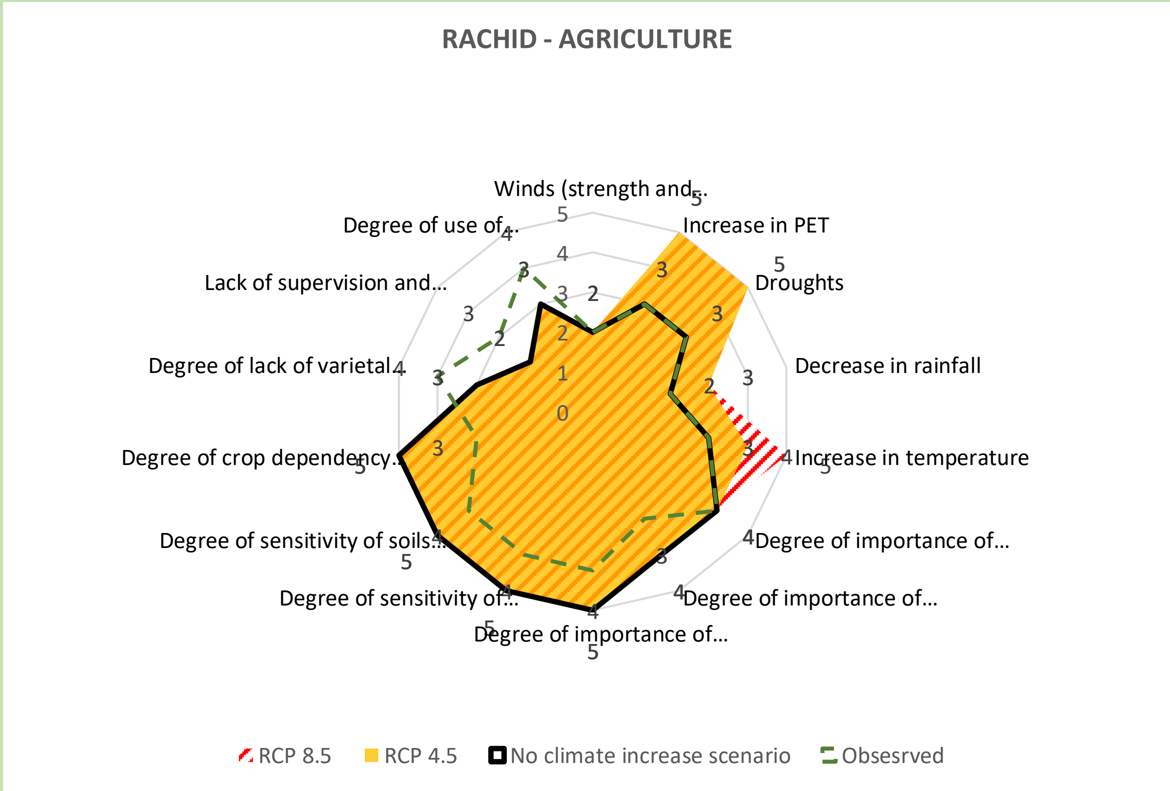


FIGURE 38 : SCORES FOR AGRICULTURE FOR RACHID

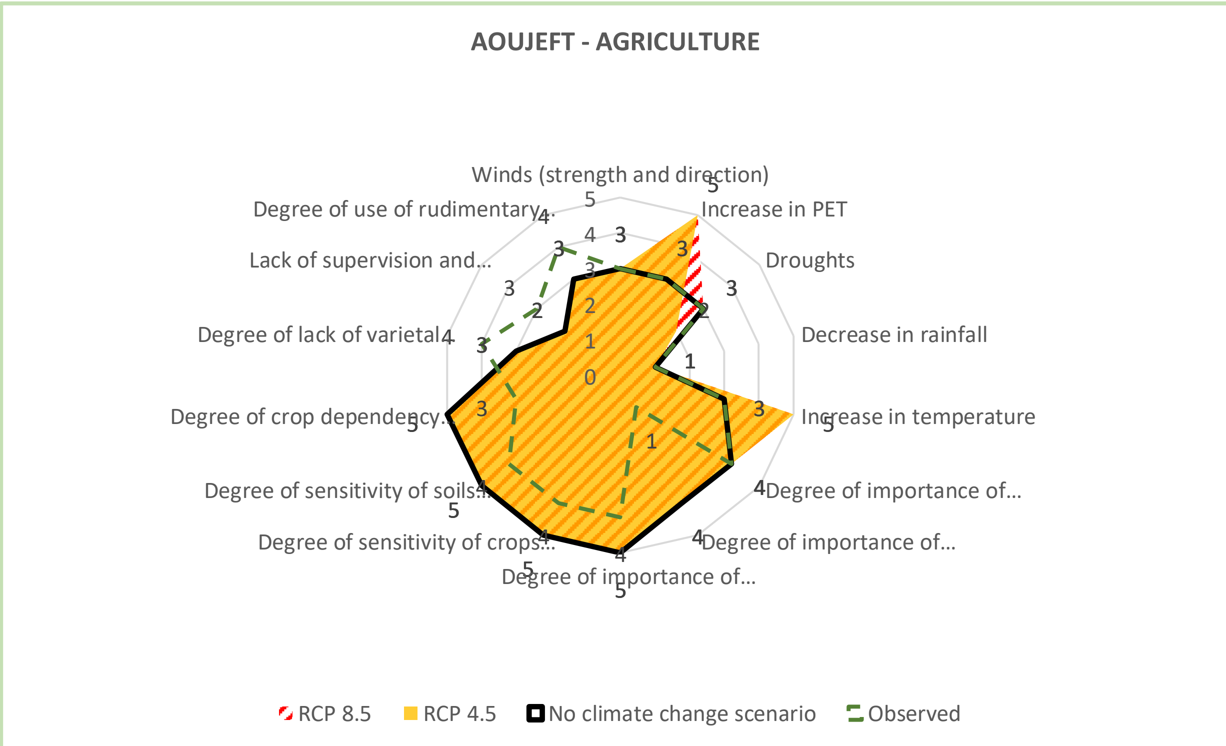


FIGURE 39 : SCORES FOR AGRICULTURE FOR AOUJEFT

4.6 Risk of reduced livestock productivity

The radar graphs (Figures 40, 41, 42 and 43) illustrate the scores attributed to each factor (i.e. exposure, climate hazard and vulnerability) that were identified for the flooding risks chains for each hub (figure 22). The **Error! Reference source not found.** in Annex 4 presents the average scores per risk component hazard, exposure and vulnerability (average of the factors of each component presented in the following graphs) and the resulting final risk score.

Box 5 : Summary of key scores for livestock productivity

> Risks score for reduced livestock productivity are high for the four hubs having very similar situations.
>
> - **Exposure scores are high** because a large proportion of the population earns their incomes from livestock.
> - **Vulnerability scores are high** because of overgrazing (especially in Aoujeft and Rachid for current situation) dependency of rangeland to rainfall or loss of know-how among farmers. Programmes for genetic improvement and better organisation of the sector are planned.
> - **Climate change scenarios show a high impact** in Rachid, Nema and Tamchekett because of increase of temperature, drought and heat waves.

Livestock is a key activity in the four hubs, their exposure is therefore significant for this factor. The populations of the Tamchekett and Néma hubs are particularly dependent on income from livestock. The four poles are highly vulnerable to the risk of livestock farming, particularly the hubs of Aoujeft and Rachid that are particularly sensitive due to the high rate of overgrazing and the drying up of pastoral water points. In Néma and Tamchekett, livestock farming is particularly dependent on rainfall, which has a direct impact on the productivity of the grazing lands. An important lack of adaptability is noted in each cluster which can be explained by a significant delay in the genetic improvement of breeds on a national scale, a low level of organisation in the sector and a severe loss of knowledge among breeders because of the rural exodus, especially in Aoujeft and Rachid.

By 2050, exposure and vulnerability remain equally high to which is added a sharp increase of the climate score (up to 64% in Rachid and 70% in Tamchekett under CRP 8.5).

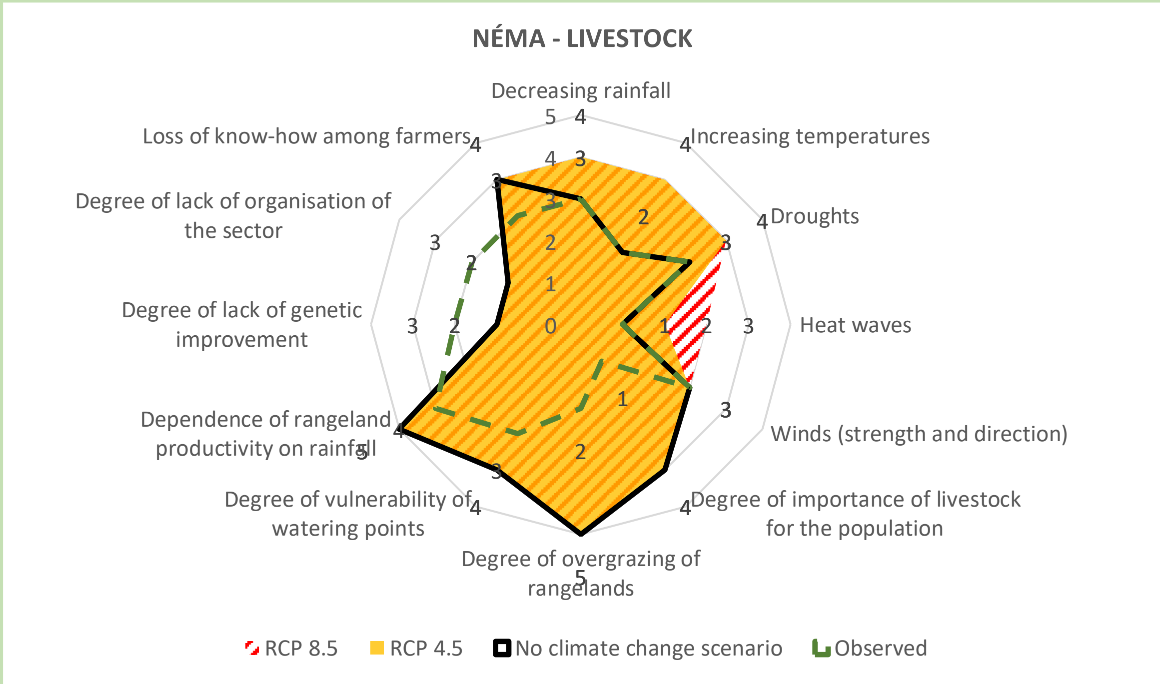


FIGURE 40 : SCORES FOR LIVESTOCK PRODUCTIVITY IN THE RISK CHAIN FOR NÉMA

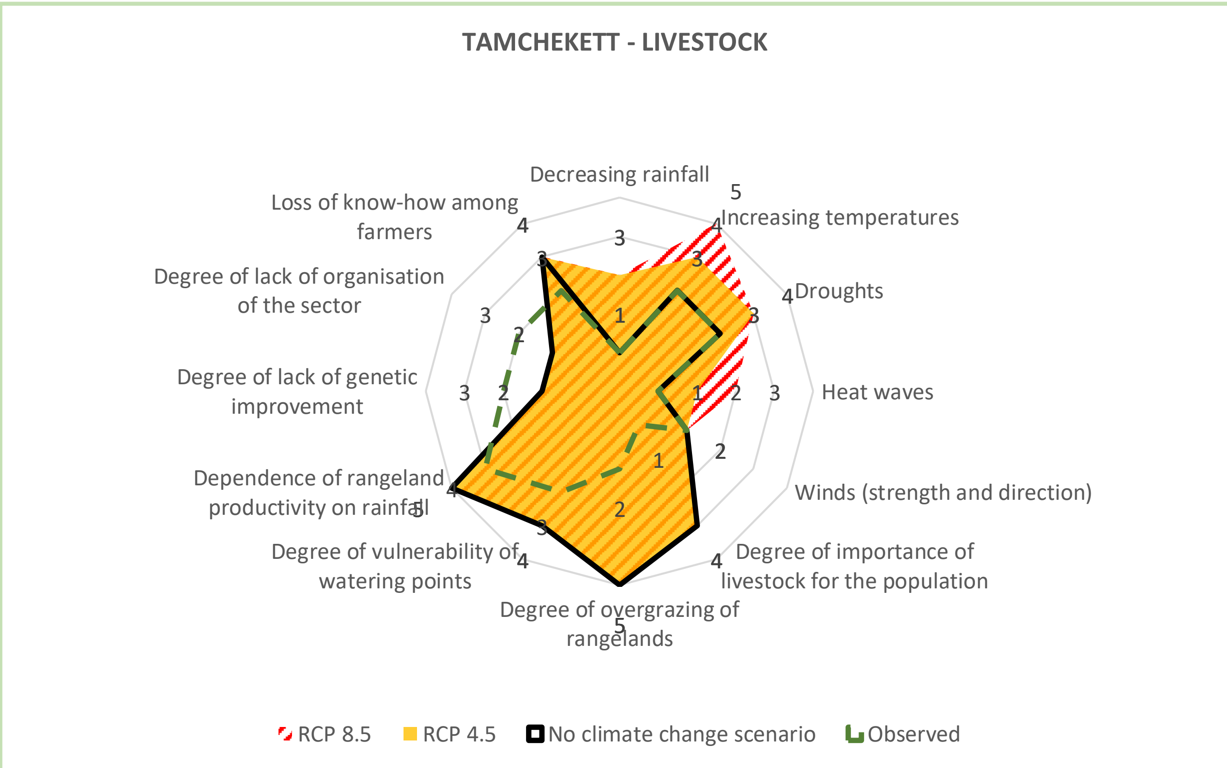


FIGURE 41 : SCORES FOR LIVESTOCK PRODUCTIVITY IN THE RISK CHAIN FOR TAMCHEKETT

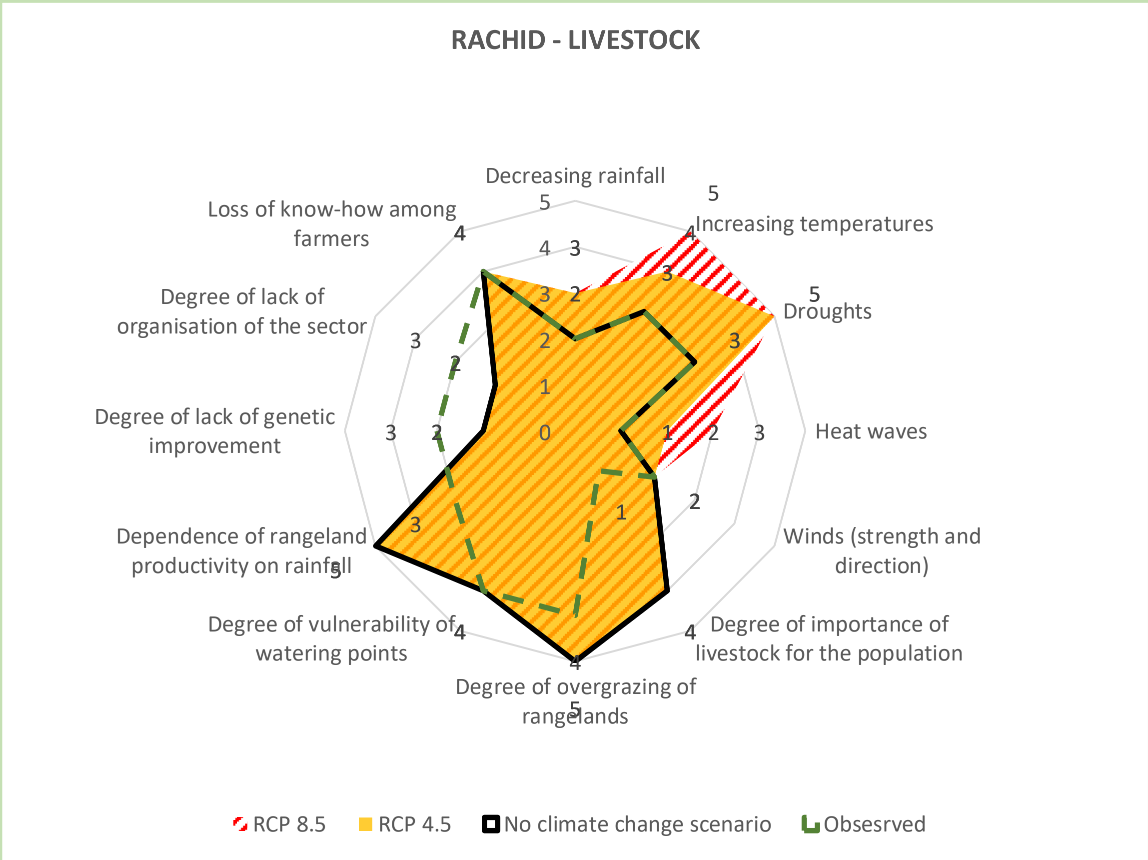


FIGURE 42 : SCORES FOR LIVESTOCK PRODUCTIVITY IN THE RISK CHAIN FOR RACHID

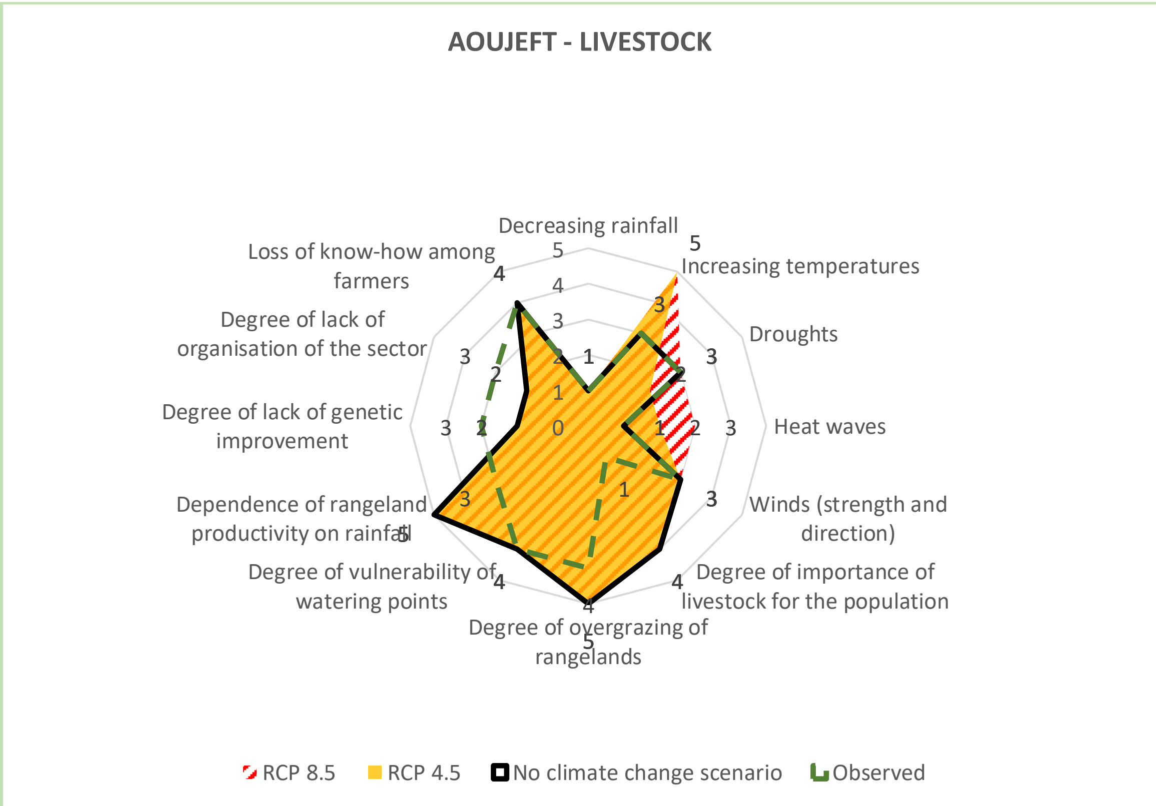


FIGURE 43 : SCORES FOR LIVESTOCK PRODUCTIVITY IN THE RISK CHAIN FOR AOUJEFT

4.7 Risk to human health

The radar graphs (Figures 44, 45, 46, and 47) display the scores attributed to each factor (i.e. exposure, hazard and vulnerability) identified for the flooding risks chains for each hub (figure 24). The **Error! Reference source not found.** in Annex 4 presents the average scores per risk component hazard, exposure and vulnerability (average of the factors of each component presented in the following graphs) and the resulting final risk score.

Box 6 : Summary of key scores for human health

Aoujeft: High exposure and vulnerability scores for current situation and the exposure would increase by 2050 due to accelerated desertification. Climate change scenarios add moderate stress on health.

Rachid : High exposure and vulnerability scores for current situation and the vulnerability would increase by 2050 because of the low standard of living of the population and the lack of health infrastructure. Climate change scenarios add moderate stress on health especially due to heat waves.

Tamchekett : Moderate exposure and vulnerability scores for current situation and the vulnerability would decrease by 2050 thanks to a new health centre. Climate change scenarios add low stress on health.

Néma : exposure and vulnerability scores are relatively low in the current situation but exposure will increase by 2050 due to the increased distances to be covered in the heat and wind for transhumance. Climate change scenarios add low stress on health.

The risk on human health is still moderate but quite high in Aoujeft and lower in Rachid. Exposure and vulnerability are extremely high which is exacerbated by climate factors. The climatic component is not rated as a high cause of this risk. It is mostly due to the sandy winds which can cause respiratory problems but also and above all which can isolate the population from health centres via the silting up of roads. Heat waves are still reasonably low although local people complain of it. However, the populations of the 4 poles are exposed to health risks. The populations of Aoujeft and Rachid are particularly exposed to difficult climatic conditions (winds favouring the appearance of respiratory infections, exposure to heat waves...). However, the vulnerability of the four hubs to health risks is significant. The level of access to drinking water and sanitation services is considered average in each hub. The population is particularly vulnerable in Aoujeft (high infant mortality linked to climate-related diseases) and Néma (high poverty rate of 52% compared to 48% nationally). Access to health services is poor in each governorate, but access is particularly difficult for some isolated populations in the Tamchekett pole. Similarly, the lack of adaptability potential is glaring in the four hubs. The low standard of living of the population and their lack of awareness of health issues explain this lack. Although Néma has a fairly good health structure, easy access is still lacking. In the other hubs, in particular in Tamchekett, the health centres are insufficiently equipped and not easily accessible.

By 2050, the projection for health risks reach the level 5 for Aoujeft and Néma in terms of exposure and vulnerability due to the current weakness of the health services. Climate change impacts are adding 20 to 25% risk in Aoujeft and Rachid (stay stable in Tamchekett and Néma) for the RCP 4.5 and between 17 to 50% for the RCP 8.5.

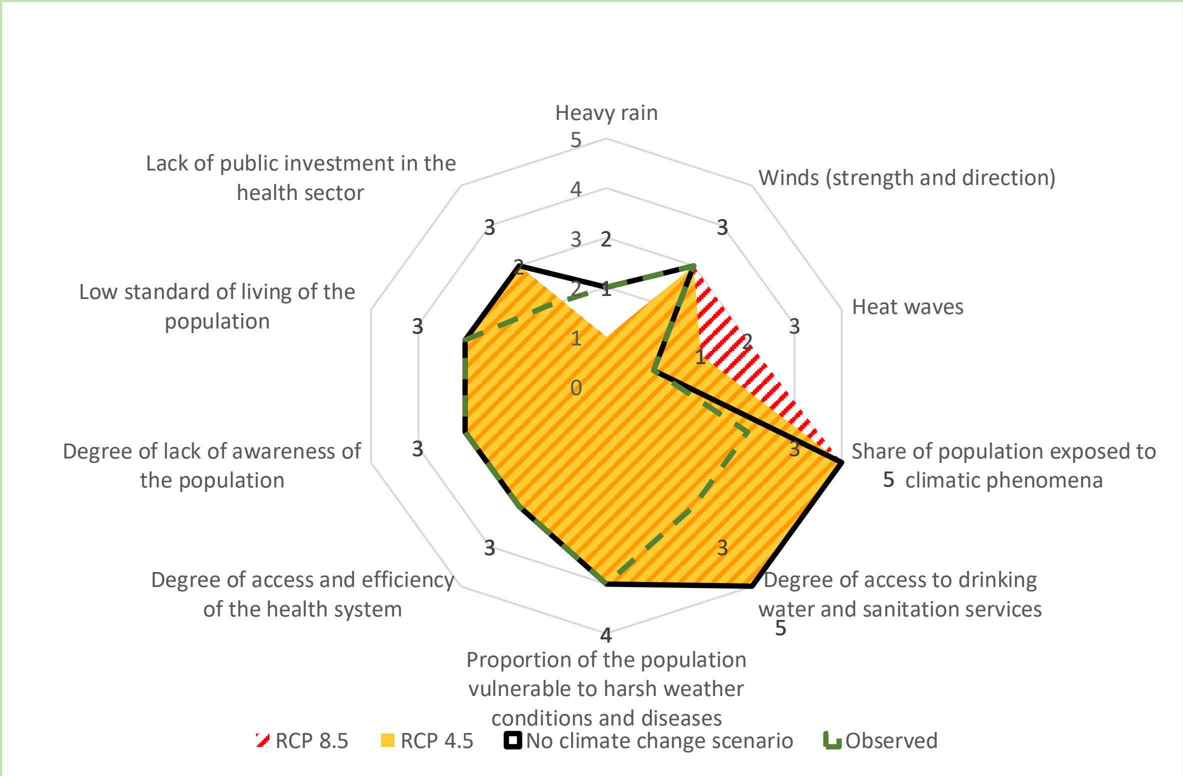


FIGURE 44 : SCORES FOR HEALTH IN THE RISK CHAIN FOR NEMA

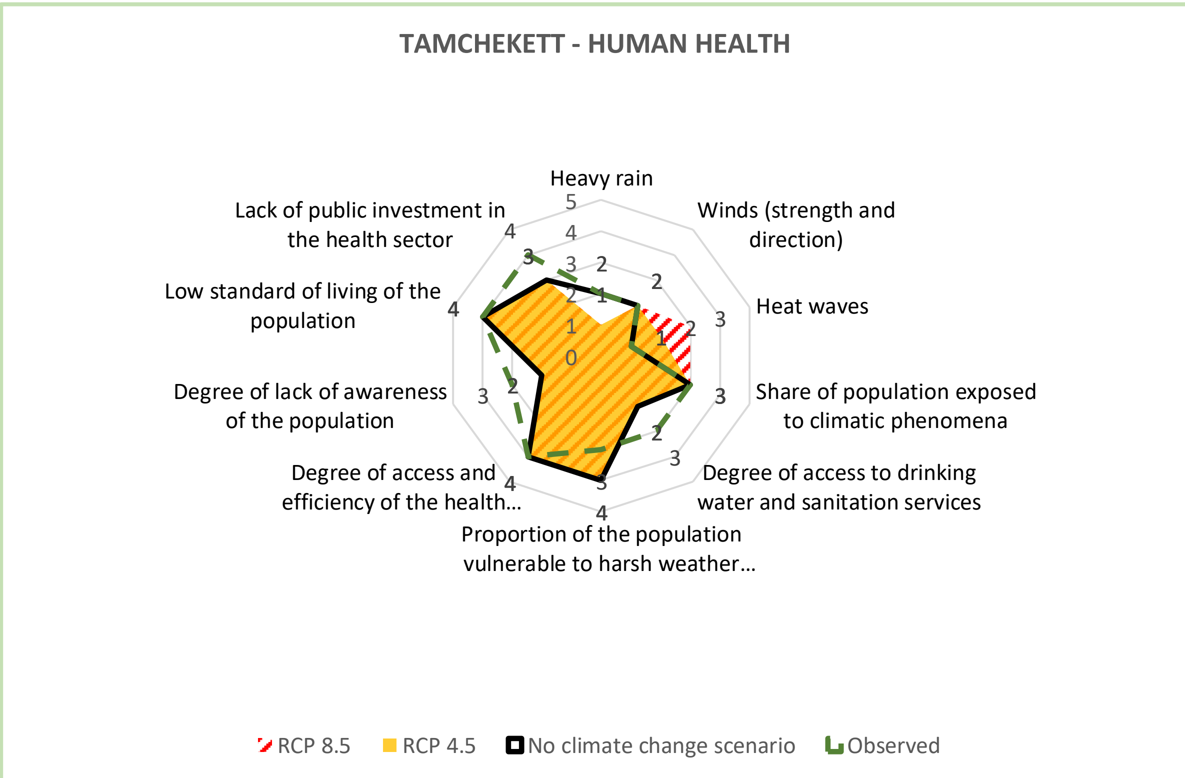


FIGURE 45 : SCORES FOR HEALTH IN THE RISK CHAIN FOR TAMCHEKETT

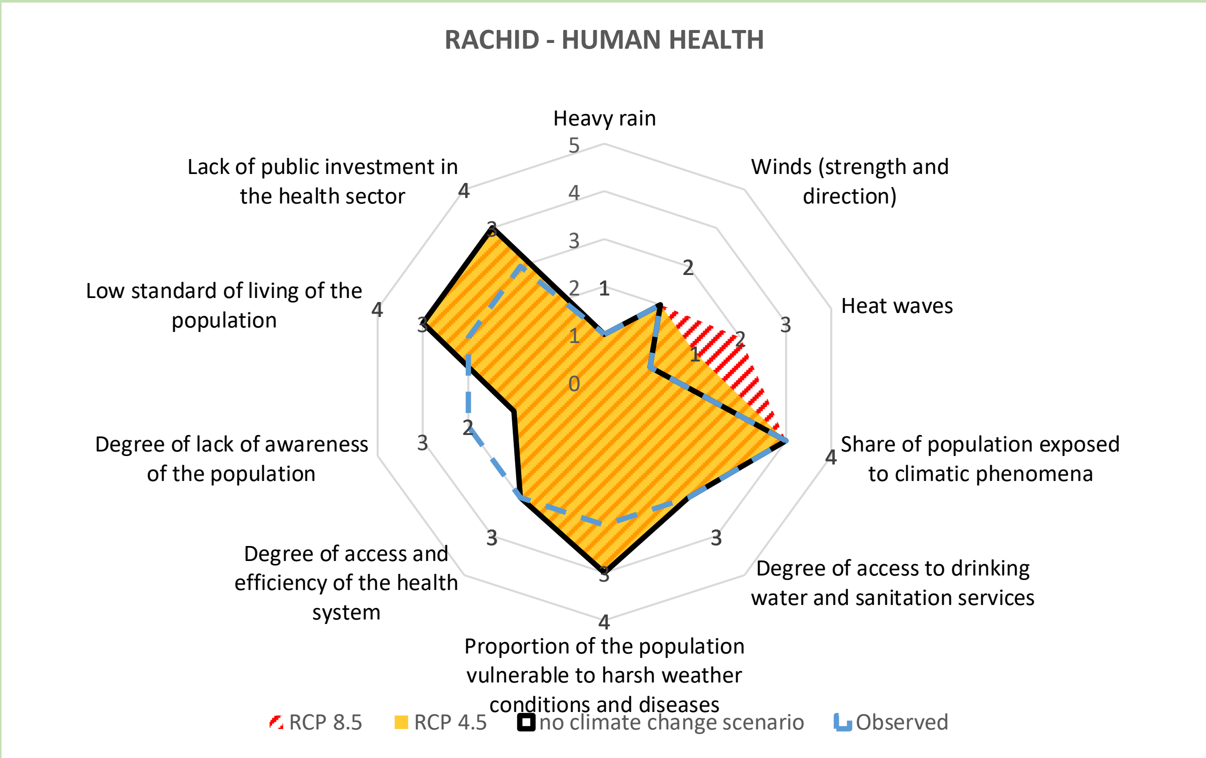


FIGURE 46 : SCORES FOR HEALTH IN THE RISK CHAIN FOR RACHID

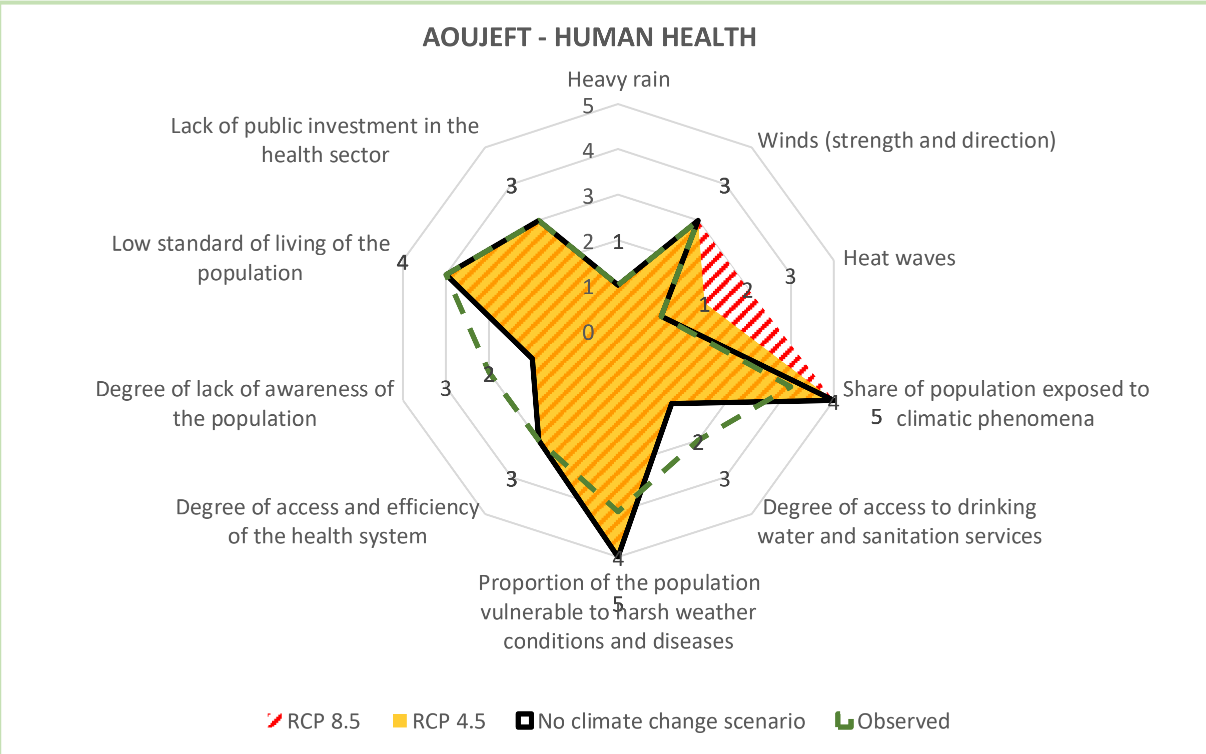


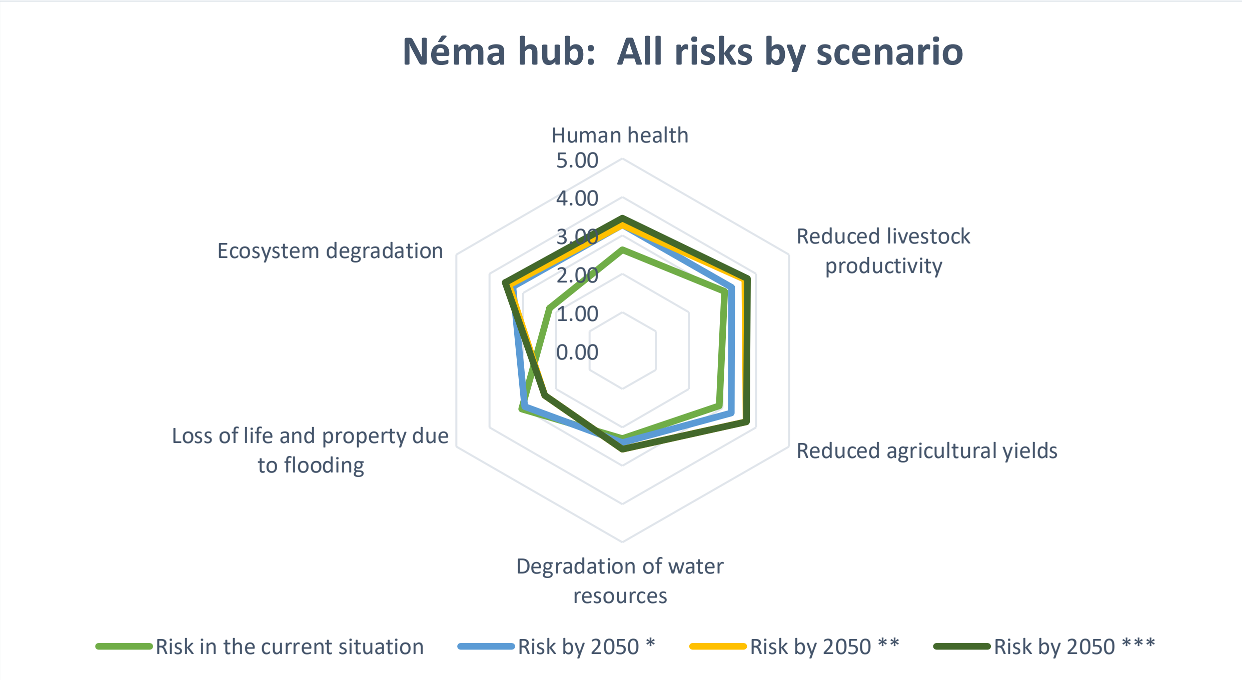
FIGURE 47 : SCORES FOR HEALTH IN THE RISK CHAIN FOR-AOUJEFT

5. The risks ranked by hub

A synthesis of the risks assessments was produced with the ranking of the scores obtained for the 6 studied sectors for each hub for the 4 scenarios : risks in the current situation, by 2050 with no climate change, by 2050 under RCP 4.5 and under RCP 8.5. The full summary table of the risks scores are displayed in Annex 4 (Risks scoring by sector for each hub).

5.1 The Néma hub

For the Néma hub, the top-ranking risks for the longer term are related to reduced agricultural yields and livestock productivity; with ecosystem degradation arriving third. The projected water balance deficit goes from class 3 to class 5, both with the RCP 4.5 and RCP8.5 scenarios because of a strong increase of the evapotranspiration. The risks are summarized in the graphic below for each scenario for each thematic area and a synthesis of the thematic priorities is provided by level of importance in the following table.



Risk level synthesis	Observed	Projections RCP 4.5	Projections RCP 8.5
Very High	Flooding	Reduced livestock productivity	Reduced livestock productivity
	Reduced Livestock productivity	Reduced agricultural yields	Reduced agricultural yields
	Agriculture	Ecosystem degradation	Ecosystem degradation
High	Human health	Human health	Human health
	Water resource	Water resource	Water resource
Intermediate	Ecosystem degradation	Flooding	Flooding

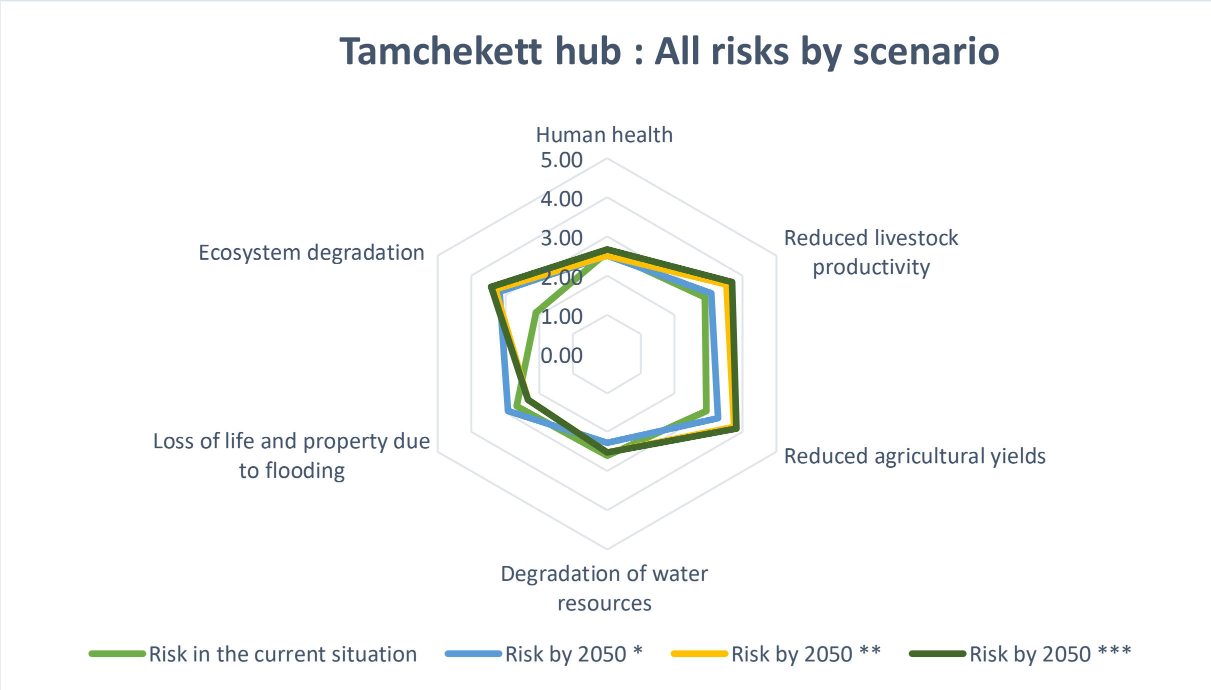
Very High : Observed and projected priority risk to be addressed urgently

High : Observed and projected medium-term risk

Moderate: Observed high priority risk but should not increase by 2050 in connexion with the decrease in precipitation (however bearing in mind the current lack of wind data that do not allow to project more precisely)

5.2 The Tamchekett hub

For the Tamchekett hub, the higher risks are related to reduced agricultural yields and livestock productivity; even ecosystem degradation arrives third. The projected water balance deficit from class 3 to class 5, both with the RCP 4.5 and RCP8.5 scenarios because of a strong increase of the evapotranspiration (from class 3 to 5 both under both IPCC scenarios). The risks are summarized in the graphic below for each scenario for each thematic area and a synthesis of the thematic priorities is provided by level of importance in the following table.



Risk level synthesis	Observed	Projected RCP 4.5	Projected RCP 8.5
Very high	Reduced agricultural yields	Reduced livestock productivity	Reduced livestock productivity
	Reduced livestock productivity	Reduced agricultural yields	Reduced agricultural yields
	Flooding	Ecosystem degradation	Ecosystem degradation
High	Human health	Human health	Human health
	Degradation of water resources	Degradation of water resources	Degradation of water resources
Intermediate	Ecosystem degradation	Flooding	Flooding

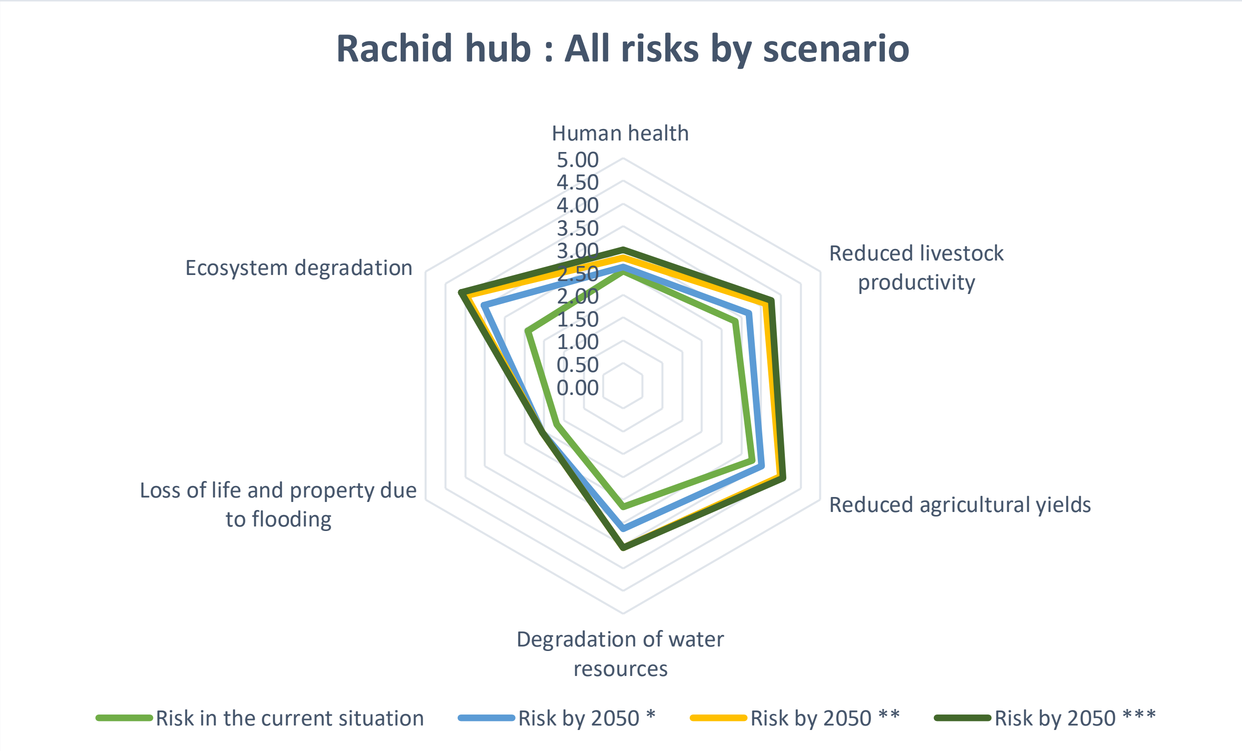
Very High — Observed and projected priority risk to be addressed urgently

High — **Observed and projected medium-term risk**

Intermediate — **Observed high priority risk but should not increase by 2050 in connexion with the decrease in precipitation (bearing in mind the current lack of wind data that do not allow to project more precisely)**

5.3 The Rachid hub

For Rachid, the higher risks are also related to ecosystem degradation with a projected water balance deficit from class 3 to class 5, both with the RCP 4.5 and RCP8.5 scenarios. This is the consequence of a similar temperature increase from class 3 to 5 and evapotranspiration from class 3 to 4 with the RCP 4.5 and RCP 8.5 scenarios. The risks are displayed in the graphic below for each scenario for each thematic area and a synthesis of the thematic priorities in ranking order by level of importance is provided in the following table.



Risk level synthesis	Observed	Projected RCP 4.5	Projected RCP 8.5
Very high	Reduced agricultural yields	Ecosystem degradation	Ecosystem degradation
	Reduced livestock productivity	Reduced agricultural yields	Reduced agricultural yields
	Degradation of water resources	Degradation of water resources	Degradation of water resource
High	Human health	Reduced livestock productivity	Reduced livestock productivity
	Ecosystem degradation	Human health	Human health
Intermediate	Flooding	Flooding	Flooding

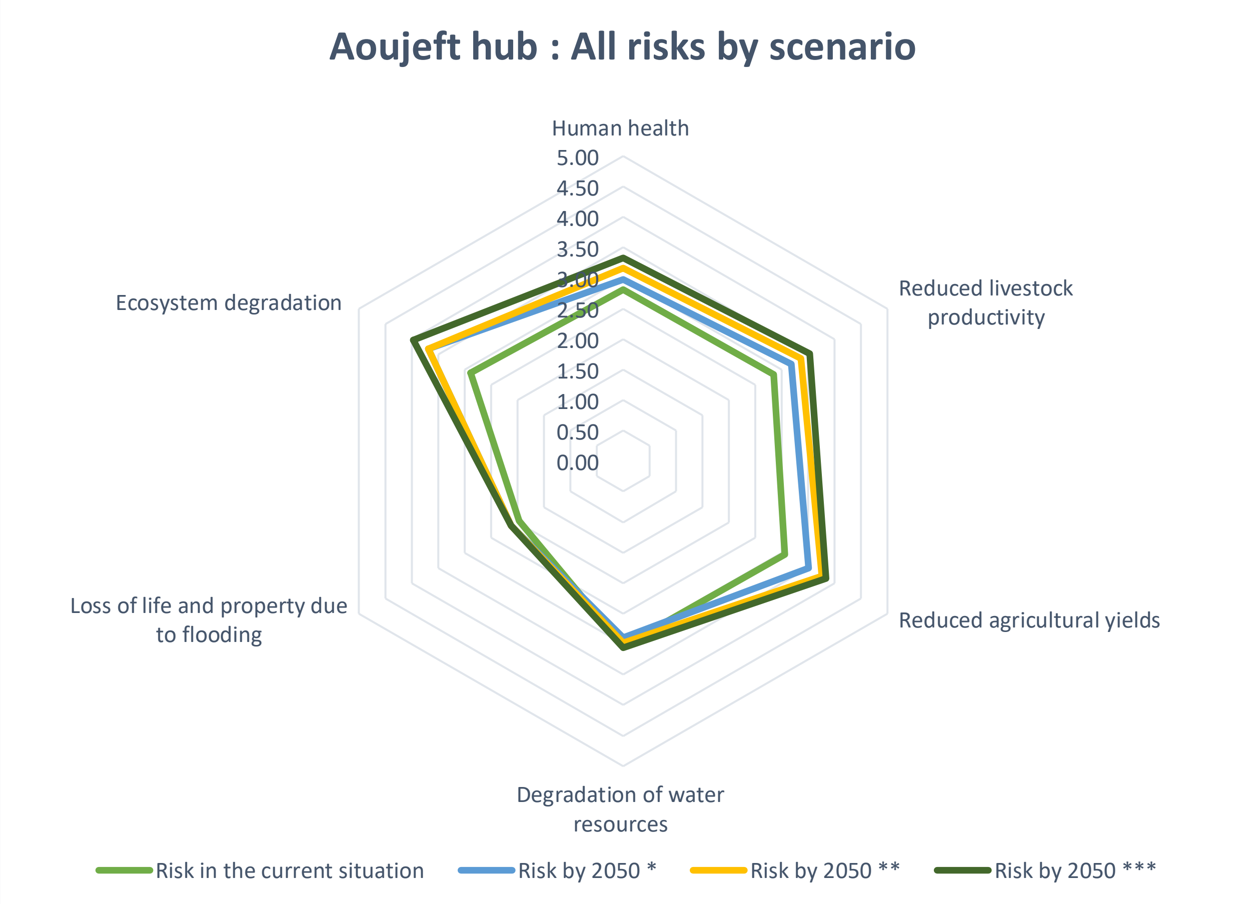
Very High **Observed and projected priority risk to be addressed urgently**

High **Observed and projected medium-term risk**

Intermediate **Observed high priority risk but should not increase by 2050 in connexion with the decrease in precipitation bearing in mind the current lack of wind data that do not allow to project more precisely)**

5.4 The Aoujeft hub

In Aoujeft the higher risks are related to ecosystem degradation with a projected water balance deficit from class 3 to class 5, both with the RCP4.5 and RCP8.5 scenarios. This is the consequence of the similar temperature increase and evapotranspiration from class 3 to 5, also both with the RCP 4.5 and RCP 8.5 scenarios. The risks are displayed in the graphic below for each scenario for each thematic area and a synthesis of the thematic priorities in ranking order by level of importance is provided in the following table.



Risk level synthesis	Observed	Projected RCP 4.5	Projected RCP 8.5
Very high risk	Agriculture	Agriculture	Ecosystem
	Water resources	Ecosystem	Agriculture
	Ecosystem	Livestock	Livestock
High risk	Livestock	Human health	Human health
	Human health	Water resources	Water resources
Intermediate	Flooding	Flooding	Flooding

Very High **Observed and projected priority risk to be addressed urgently**

High **Observed and projected medium-term risk**

Intermediate **Observed high priority risk but should not increase by 2050 in connexion with the decrease in precipitation (bearing in mind the current lack of wind data that do not allow to project more precisely)**

6 Conclusion

The four hubs located in this highly exposed area of Mauritania face challenges similar to those faced by other Sahelian countries, including economic vulnerability due to their undiversified economies, limited capacity within governments due to small populations, and a lack of economies of scale driving high costs, even for government services. This review highlights that, as climate change increases temperatures and alters the hydrological cycle, the burden of climate risks to Mauritania is expected to severely increase without additional interventions to safeguard resources and people from them. Table 7 provides an overall summary synthesis ranked by sectors of priority risks in all hubs.

TABLE 7: OVERALL RISKS SCREENING IN A 2050 PERSPECTIVE

Sector	Detailed sector	Specific Impacts	Ranking by sector in the four hubs
Infrastructures	Housing	**Flooding of settlements**	
	Roads, Housing	**Silting**	
Natural resources	Water resources	**Degradation of water availability** • Unavailability of conventional water resources • Water quality degradation	
	Biodiversity & Forests	**Ecosystems degradation**	
	Agriculture	**Reduced crop production** • Reduced productivity of degraded land • Yield loss due to water stress • Reduced quantity & quality of crop production due to sanitary problems	
	Livestock	**Reduced livestock productivity** • Pastoral water unavailability • Food availability decrease • Loss of cattle due to sanitary problems	
Social Services	Public health	**Climate sensitive human health impacts** • Mortality due to flooding • Nutrition deficit due to unavailability of local food • Increased occurrence of water borne diseases & acute respiratory infections	

Priority ranking

Very High : Observed and projected priority risk to be addressed urgently

High : Observed and projected medium-term risk

Intermediate: Observed high priority risk but should not increase by 2050 in connexion with the decrease in precipitation (however bearing in mind the current lack of wind data that do not allow to project more precisely)

Some projected losses are potentially preventable by improving the knowledge base on existing hazards and building resilience and response capacity. Reducing others will require modifying current policies and programmes and implementing new ones to explicitly consider climate variability and change both at local and national levels.

Climate change impacts do not affect all sectors equally but they all are highly vulnerable to rising temperatures combined to a decrease in precipitation. Climate impacts are also combined to a range of social and economic factors, many of which are described in Section 3. However, adaptation actions should focus on building more resilient systems overall, to reduce vulnerability and develop specific system capacities that address key risks (Table 13) on the basis of the projections described under Section 4.1.1 and 4.2.2. Adaptations options are analysed in the final Deliverable 4.

7 Bibliography

African Development Bank. (2018). *National climate change profile.*

ALIVE, UNEP. (2018). *Outil de planification pour l'adaptation, les moyens de subsistance et les écosystèmes.*

Bassirou Diagana. (2007). *Les ressources en eau en Mauritanie.*

CARE. (2019). *Analyse des Vulnérabilités et des Capacités d'adaptation aux changements climatiques.*

Euronet Consortium. (2013). *Profil environnemental de la Mauritanie.*

FAO. (2014). *Evaluation des ressources forestières mondiales 2015 - rapport national Mauritanie.*

FAO. (2014). *Evaluation des ressources forestières mondiales 2015 : Mauritanie.*

FAO. (2015). *Analyse de la résilience dans le triangle de l'espoir.*

FAO. (2017). *L'agriculture familiale à petite échelle au Proche-Orient et Afrique du Nord - pays focus : Mauritanie.*

FAO. (2018). *Impacts of climate change on farming systems and livelihoods in the near east and north Africa.*

GCF. (2020). *Project Preparation Funding Application.*

GIZ. (2018). *Climate Risk Assessment for Ecosystem-based Adaptation - A guidebook for planners and practitioners.*

GIZ and EURAC. (2017). *Risk Supplement to the Vulnerability Sourcebook.*

GIZ. (s.d). *Climate risk profile: Mauritania.*

IPCC. (2014). *Climate change 2014 - Impacts, Adaptation, and Vulnerability.*

J.Coates and al. (2020). *The effects of climate change on health in Africa, a dermatologic perspective: a report from the international society of dermatology climate change commitee.*

Jouan et al. (1990). *Epidémie de la fièvre de la vallée du Rift en république islamique de Mauritanie - données géographiques et écologiques.*

MEDD. (2006). *Statégie nationale de développement durable.*

MEDD. (2011). *Forêt, pâturages et changement climatique en Mauritanie.*

MEDD. (2014). *Troisième communication nationale sur le chanagement climatique.*

MEDD. (2015). *Contribution prévue déterminée au niveau national (CPDN).*

MEDD. (2016). *La Tamourt de Tamchekett, ses assins versants et ses écosystèmes.*

MEDD. (2019). *Rapport de la quatrième communication nationale sur le changement climatique.*

MEDD. (2021). *Second rapport biennal actualisé sur le changement climatique.*

MEDD. (s.d). *Stratégie Nationale de Croissance Accélérée et de Prospérité Partagée 2016-2020.*

MEDD. (s.d. a). *Programme d'action naional de lutte contre la désertification en Mauritanie.*

MEDD, OSS. (s.d). *Réalisation d'un inventaire pour identifier et collecter les données et les informations existantes au niveau national.*

Ministère des affaires économiques et du développement. (2011). *Bilan de la mise en oeuvre du CSLP 2006-2010.*

Ministère du Développement Rural et de l'Environnement. (2004). *Programme d'Action National d'adaptation aux Changements Climatiques.*

OSS. (2015). *Analyse des processus décisionnels et définition du rôle de la population.*

OSS. (2015). *Mauritanie : atlas des cartes d'occupation du sol.*

Oud El Mamy and al. (2014). *L'épidémie de fièvre de la vallée du Rift en Mauritanie en 2012.*

PNUD. (2015). *Rapport national sur le développement humain.*

RICCAR. (2017). *Arab climate change assessment report - main report.*

Rojas-Downing et al. (2017). *Climate change and livestock Impacts, adaptation, and mitigation.*

Thornton et al. (2009). *The impacts of climate change on livestock systems in developing countries : A review of what we know and what we need to know.*

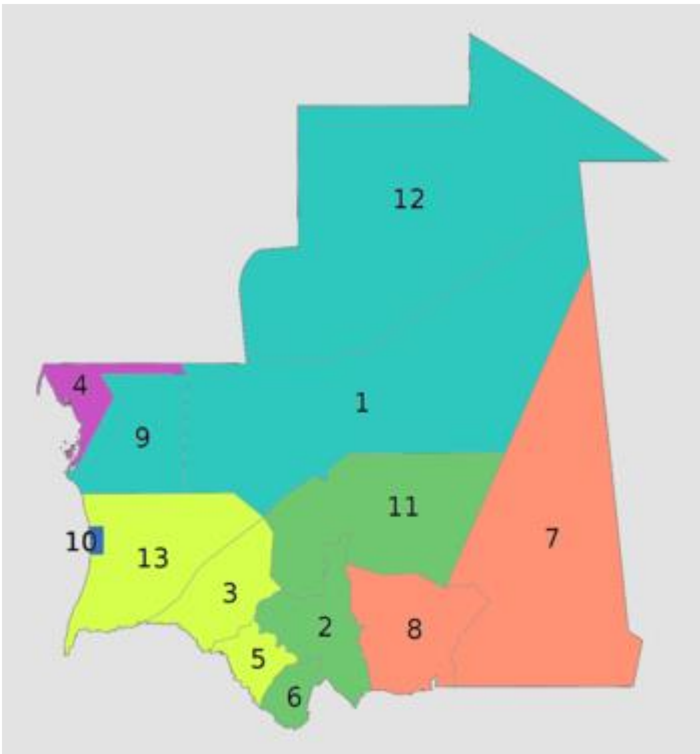
8 Annex

Annex 1: The six regions of Mauritania and the 13 Wilayaas

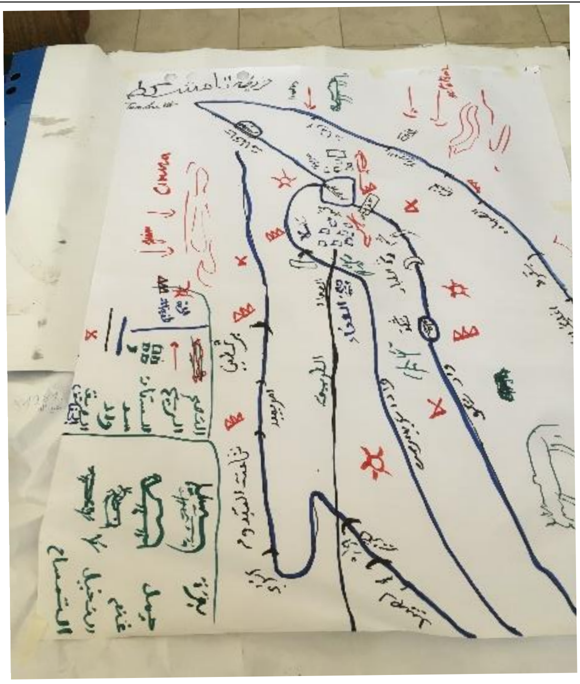
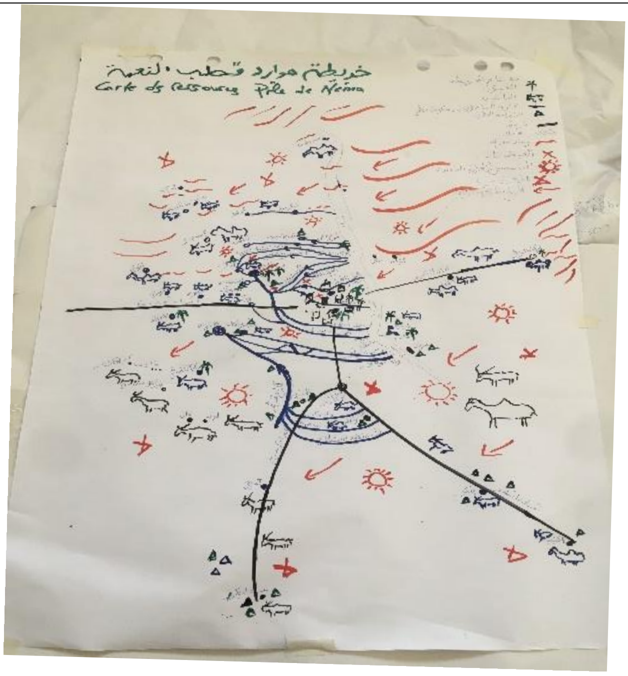
The **six *regions*** of Mauritania, (composed of wilayas that compose them) are listed below. Following the constitutional referendum of 2017, a decentralization measure was implemented with the creation of six regions. On January 8, 2018, the Mauritanian National Assembly ratified this choice by passing an organic law establishing six administrative regions grouping the existing 13 wilayas:

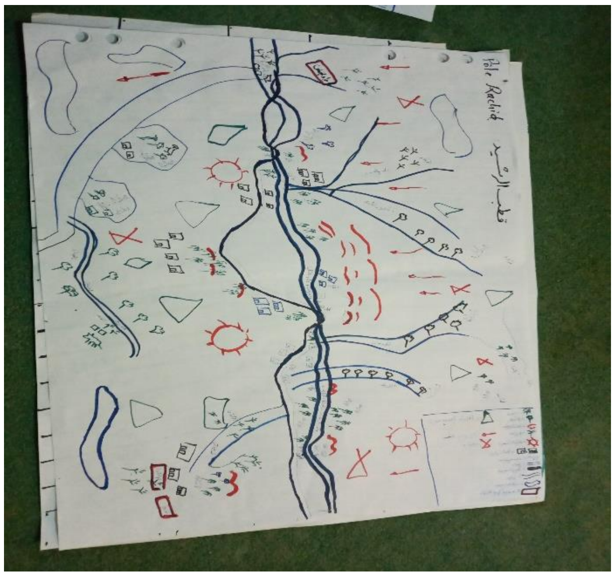
- The first region includes the Wilayas of Hodh el Gharbi and Hodh el Charqui; numbered respectively 8 and 7 in the map below;
- The second region those of Assaba, Tagant and Guidimaka; numbered respectively 2, 11 and 6 in the map below;
- The third region those of Gorgol, Brakna and Trarza; numbered respectively 5, 3 and 13 in the map below;
- The fourth region those of Tiris Zemmour, Adrar and Inchiri; numbered respectively 12, 1 and 9 in the map below;
- The fifth region replaces the Urban Community of the capital Nouakchott numbered 10 in the map below; and
- The sixth region replaces the country's second city wilaya of Dakhlet Nouadhibou, numbered 4 in the map below;

The organic law defines the ***regions*** powers in terms of economic, social, cultural and scientific development in their territory. They are administered by a regional council elected by direct universal suffrage for a term of five years, an executive entity composed of a regional president also elected by direct suffrage and regional councils that elect their own vice-presidents.



Annex 2 : Participatory mapping of resources and climate hazards in the four hubs

Mapping of the resources and hazards in the Tamchekett hub	Mapping of the resources and hazards in the Néma hub
	

Mapping of the resources and hazards in the Aoujeft hub	Mapping of the resources and hazards in the Rachid hub
	

Annex 3 : Endangered and extinct species in the four hubs

The Tamchekett and Nema hubs

Biotope	Floristic elements in literature	Endangered species	Extinct species
Massifs of the Affolé	*Adansonia digitata; Adenium obesum; Commiphora africana; Cadaba farinosa Forsk; Capparis decidua Forsk; Maerua crassifolia Forsk; Sclerocarya birrea; Maytenus senegalensis; Euphorbia balsamifera ; Acacia leata; Acacia raddiana; Acacia Senegal; Acacia nilotica; Dalbergia melanoxylon; Ziziphus mauritiana; Grewia tenax; Grewia bicolor; Hyphaene thebaica and Acacia seyal.*	*Adansonia digitata; Adenium obesum; Ziziphus mauritiana; Grewia tenax.*	*Cadaba farinosa Forsk; Sclerocarya birrea; Maytenus senegalensis; Acacia nilotica; Dalbergia melanoxylon.*
Surrounding plains	*Acacia raddiana; Acacia Senegal; Acacia laeta; Acacia nilotica; Acacia seyal; Acacia albida; Capparis decidua; Tapinanthus sp; Cocculus pendulus; Leptadenia pyrotechnica; Chrosophora brocchiana; Maerua crassifolia Forsk ; Indigofera senegalensis; Alysicarpus avalifolius; Cynodon dactylon; Cenchrus biflorus; Aristida funiculata; Heliotropium bacciferum; Gisekia pharmacoides; Boerhavia repens; Aerva javanica; Aristida mutabilis*	*Acacia Senegal; Acacia laeta; Acacia nilotica; Acacia seyal; Acacia albida*	*Chrosophora brocchiana; Maerua crassifolia Forsk; Gisekia pharmacoides; Boerhavia repens ;*

Rachid hub

Biotope	Floristic elements in the literature	Endangered species	Extinct species
18° North latitude	*Acacia sp and Aristida sp; Commiphora africana*	*Aristida pengens*	*Commiphora africana; Acacia senegal*
Northern part	*perennial grasses such as Aristida pallida, Panicum turgidum, forming open mats. Balanites aegyptiaca, Maerua crassifolia, Euphorbia balsamifera, Leptadenia pyrotechnica. The most widespread element is Acacia raddiana.*	*Leptadenia pyrotechnica*	*Balanites aegyptiaca, Maerua crassifolia,*
	Aristida pallida, Cenchrus biflorus, Sesamum alatum, Aristida mutabilis... Aristida acutiflora, Euphorbia scordifolia, Indigofera argentea, Neurada procumbens, Heliotropium sp... ; Guiera senegalensis, Sterculia setigera, Combretum glutinosum, Piliostigma reticulata, Mimosa pigra, Commiphora africana, ...etc	*Euphorbia scordifolia, Indigofera*	*Aristida pallida, Cenchrus biflorus, Sesamum alatum, Aristida mutabilis ; Combretum glutinosum, Piliostigma reticulata, Mimosa pigra, Commiphora africana, .*

Aoujeft Hub

Biotope	Floristic elements in the literature	Endangered species	Extinct species
Rocky stations	*Fagonia isotricha, Heliotropium trigosum, Trichodesma africanum, Helianthemum lippii, Rumex Vesicarius, Cleome brachycarpa, Morretia canescens, Plantago akhensis, Seddera latifolia, Farsetia aegyptiaca, Sclerocephalus arabicus, Forskalea tenacissima, Atractylis aristata, Reseda villosa, Traganum nudatum* *In the wadis, residual species of Sudanese origin are sometimes found: Cordia gharaf, Combretum aculeatum, Grewia villosa, Rhus tripartita*	*Grewia villosa*	*Fagonia isotricha, Heliotropium trigosum, Trichodesma africanum, Helianthemum lippii, Rumex Vesicarius, Cleome brachycarpa, Morretia canescens, Plantago akhensis, Seddera latifolia, Farsetia aegyptiaca, Sclerocephalus arabicus, Forskalea tenacissima, Atractylis aristata, Reseda villosa, Traganum nudatum*
Sandy or dune stations	*Consists of some psammophyte species: Aristida pungens, Calligonum comosum, Moltka ciliata, Indigofera semitrijuga, Aristida ciliata, Polygala obtusata, Euphorbia scordifolia Polycarpea repens etc. On the sandy wadi beds we find : Acacia tortillis, Leptadenia pyrotechnica, Panicum turgidum, Boscia senegalensis, Balanites aegyptiaca, Capparis decidua, Pennisetum dichotomum, Maerua crassifolia, chrosophora brocchiana, Cocculus pendulus, etc. The vegetation of the grara, "a spreading area generally located at the foot of a mountain or at the outlet of a wadi, thus constituting a floodable and temporarily cultivable surface", is made up of : Psoralea plicata, Indigofera oblongifolia, Abutilon muticum, Ipomea repens*	*Pennisetum dichotomum, Maerua crassifolia, chrosophora brocchiana, Cocculus pendulus*	*Moltka ciliata, Indigofera semitrijuga, Aristida ciliata, Polygala obtusata, Euphorbia scordifolia Polycarpea repen; Psoralea plicata, Indigofera oblongifolia, Abutilon muticum*
Salt-land stations	*Tamarix sp, Cressa cretica, Sporobolus spicatus*	*Tamarix sp*	*Cressa cretica, Sporobolus spicatus*
Reg.	*Acacia erhembergiana, Maerua crassifolia.*	*Maerua crassifolia*	*Acacia erhembergiana, Ziziphus lotus.*

Annex 4 : Risks scoring by sector for each hub

Scenarios	Risks sectors	Néma	Tamchekett	Rachid	Aoujeft
Risk in the current situation	Ecosystem degradation	2,19	2,11	2,41	2,88
	Human health	2,62	2,60	2,52	2,81
	Degradation of water resources	2,30	2,60	2,65	3,03
	Loss of life and property due to flooding	3,04	2,67	1,69	1,97
	Reduced agricultural yields	2,90	2,93	3,27	3,06
	Reduced livestock productivity	3,07	2,88	2,85	2,85
Risk by 2050 *	Ecosystem degradation	3,30	3,17	3,52	3,68
	Human health	3,27	2,51	2,61	2,98
	Degradation of water resources	2,40	2,27	3,13	2,89
	Loss of life and property due to flooding	2,95	2,93	2,04	2,12
	Reduced agricultural yields	3,27	3,28	3,51	3,51
	Reduced livestock productivity	3,28	3,08	3,18	3,18
Risk by 2050 **	Ecosystem degradation	3,42	3,30	3,97	3,68
	Human health	2,34	2,33	2,04	2,12
	Degradation of water resources	3,44	2,67	2,99	3,33
	Loss of life and property due to flooding	3,68	3,53	3,61	3,37
	Reduced agricultural yields	3,27	2,51	2,81	3,16
	Reduced livestock productivity	2,57	2,52	3,55	2,98
Risk by 2050 ***	Ecosystem degradation	3,53	3,42	4,10	3,97
	Human health	3,71	3,75	3,98	3,76
	Degradation of water resources	2,57	2,52	3,55	3,06
	Loss of life and property due to flooding	2,34	2,33	2,04	2,12
	Reduced agricultural yields	3,71	3,82	4,05	3,84
	Reduced livestock productivity	3,75	3,68	3,75	3,53

* Scenario 1: Hazard is kept constant (current situation); the exposure and vulnerability are projected from hypotheses of evolution assessed by national consultants on the basis of field data collected and major strategies implemented or planned in Mauritania.

** Scenario 2 :Hazard is scored using climate modelling results based on IPCC RCP 4.5 scenario. the exposure and vulnerability are projected from hypotheses of evolution assessed by national consultants on the basis of field data collected and major strategies implemented or planned in Mauritania

*** Scenario 3 : Hazard is scored using climate modelling results based on IPCC RCP 8.5 scenario. the exposure and vulnerability are projected from hypotheses of evolution assessed by national consultants on the basis of field data collected and major strategies implemented or planned in Mauritania

The results presented in Tables A, B, C and D are the geometric mean of the 3 scores: climate hazard, vulnerability and exposure. They are used to produce the analysis illustrated by the graphs in section

4.2, 4.3, 4.4, 4.5, 4.6 and 4.7. Tables E provides the ratio of the projected hazard scores compared to the observed hazard score, with no inclusion of vulnerability and exposure scores.

Risk on ecosystem degradation

TABLES 8 (A, B, C, D, E) : OBSERVED AND PROJECTED CLIMATE CHANGE RISKS ON ECOSYSTEM DEGRADATION

7A - Observed risk for ecosystem degradation				
Hub	Observed climate hazard	Exposure	Vulnerability	Observed Risk
Aoujeft	*2*	*4*	*3,00*	**2,88**
Rachid	*1,75*	*3*	*2,67*	**2,41**
Tamchekett	*2*	*2*	*2,33*	**2,11**
Néma	*2*	*2*	*2,33*	**2,11**

7B – Scenario 1: risk by 2050 with no further climate change				
Hub	Observed climate hazard	Exposure by 2050	Vulnerability by 2050	= Risk by 2050
Aoujeft	*2*	*5,00*	*5,00*	**3,68**
Rachid	*1,75*	*5,00*	*5,00*	**3,52**
Tamchekett	*2*	*4,00*	*4,00*	**3,17**
Néma	*2*	*4,00*	*4,00*	**3,17**

7C- Scenario 2: risk by 2050 with RCP 4.5 projections				
Hub	Projected climate hazard - **RCP 4.5**	Exposure by 2050	Vulnerability by 2050	= Risk by 2050
Aoujeft	*2*	*5,00*	*5,00*	**3,68**
Rachid	*2,5*	*5,00*	*5,00*	**3,97**
Tamchekett	*2,25*	*4,00*	*4,00*	**3,30**
Néma	*2,5*	*4,00*	*4,00*	**3,42**

7D – Scenario 3: risk by 2050 with RCP 8.6 projections				
Hub	Projected climate hazard - **RCP 8.5**	Exposure by 2050	Vulnerability by 2050	= Risk by 2050
Aoujeft	*2,5*	*5,00*	*5,00*	**3,97**
Rachid	*2,75*	*5,00*	*5,00*	**4,10**
Tamchekett	*2,5*	*4,00*	*4,00*	**3,42**
Nema	*2,75*	*4,00*	*4,00*	**3,53**

7E – Ratio between RCP climate hazard scores / observed climate hazard score					
Hub	Observed hazard	Projected hazard **RCP 4.5**	%	Projected hazard **RCP 8.5**	%
Aoujeft	*2*	*2*	0%	*2,5*	25%
Rachid	*1,75*	*2,5*	43%	*2,75*	57%
Tamchekett	*2*	*2,25*	13%	*2,5*	25%
Nema	*2*	*2,5*	11%	*2,75*	22%

This table provides the relationship between projected RCP4.5 and RCP 8.5 hazard scores and observed hazard score for ecosystem degradation (with no inclusion of vulnerability and exposure scores).

Risks on water resources

TABLES 9 (A, B, C, D, E) : OBSERVED AND PROJECTED RISKS ON WATER RESOURCES

9A: Observed risks on water resources				
Hub	Observed climate hazard	Exposure	Vulnerability	Observed risk
Aoujeft	2,20	4	3,17	3,03
Rachid	2,20	3	2,83	2,65
Tamchekett	2,20	3	2,67	2,60
Nema	2,60	2	2,33	2,30

9B Scenario 1: Risk on water resources by 2050 with no further CC hazard				
Hub	Observed climate hazard	Exposure by 2050	Vulnerability by 2050	= Risk By 2050
Aoujeft	*2,20*	*3*	*3,67*	**2,89**
Rachid	*2,20*	*4*	*3,50*	**3,13**
Tamchekett	*2,20*	*2*	*2,67*	**2,27**
Nema	*2,60*	*2*	*2,67*	**2,40**

9C – Scenario 2: risk by 2050 with RCP 4.5 projections				
Hub	Projected climate hazard **RCP 4.5**	Exposure by 2050	Vulnerability by 2050	= Risk by 2050
Aoujeft	*2,40*	*3,00*	*3,67*	**2,98**
Rachid	*3,20*	*4,00*	*3,50*	**3,55**
Tamchekett	*3,00*	*2,00*	*2,67*	**2,52**
Nema	*3,20*	*2,00*	*2,67*	**2,57**

8 D - Scenario 3: risk by 2050 with RCP 8.5 projections				
Hub	Projected climate hazard **RCP 8.5**	Exposure by 2050	Vulnerability by 2050	= Risk by 2050
Aoujeft	*2,60*	*3,00*	*3,67*	**3,06**
Rachid	*3,20*	*4,00*	*3,50*	**3,55**
Tamchekett	*3,00*	*2,00*	*2,67*	**2,52**
Néma	*3,20*	*2,00*	*2,67*	**2,57**

9E – Ratio between RCP climate hazard / observed climate hazard score for water resources					
Hub	Observed hazard	Projected hazard **RCP 4.5**	%	Projected hazard **RCP 8.5**	%
Aoujeft	*2,20*	*2,40*	**9%**	*2,60*	**18%**
Rachid	*2,20*	*3,20*	**45%**	*3,20*	**45%**
Tamchekett	*2,20*	*3,00*	**36%**	*3,00*	**36%**
Néma	*2,40*	*3,20*	**23%**	*3,20*	**23%**

This table provides the relationship between RCP 4.5 and RCP 8.5 hazard scores and observed hazard score for water resources (with no inclusion of vulnerability and exposure scores).

TABLES 10 (A, B , C, D, E) : OBSERVED AND PROJECTED RISKS OF FLOODING

10A - Current risk of flooding				
Hub	Observed climate hazard	Exposure	Vulnerability	= Observed Risk
Aoujeft	1,00	2,00	3,80	**1,97**
Rachid	1,00	1,50	3,20	**1,69**
Tamchekett	2,00	2,50	3,80	**2,67**
Néma	2,00	3,50	4,00	**3,04**

10B Scenario 1: Risk on water resources by 2050 with no further CC hazard				
Hub	Observed climate hazard	Exposure by 2050	Vulnerability by 2050	= Risk By 2050
Aoujeft	1,00	2,50	3,80	**2,12**
Rachid	1,00	2,50	3,40	**2,04**
Tamchekett	2,00	3,50	3,60	**2,93**
Néma	2,00	4,00	3,20	**2,95**

10C - Scenario 2: risk by 2050 with RCP 4.5 projections				
Hub	Projected risk **RCP 4.5**	Exposure by 2050	Vulnerability by 2050	= Risk By 2050
Aoujeft	1,00	2,50	3,80	**2,12**
Rachid	1,00	2,50	3,40	**2,04**
Tamchekett	1,00	3,50	3,60	**2,33**
Néma	1,00	4,00	3,20	**2,34**

10D - Scenario 3: risk by 2050 with RCP 8.5 projections				
Hub	Projected risk **RCP 8.5**	Exposure by 2050	Vulnerability by 2050	= Risk by 2050
Aoujeft	1,00	2,50	3,80	**2,12**
Rachid	1,00	2,50	3,40	**2,04**
Tamchekett	1,00	3,50	3,60	**2,33**
Néma	1,00	4,00	3,20	**2,34**

10E : Ratio between RCP hazard scores / observed hazard score for flooding					
Hub	Observed climate hazard	Projected climate hazard **RCP 4.5**	%	Projected climate hazard **RCP 8.5**	%
Aoujeft	1,00	1,00	**0%**	1,00	**0%**
Rachid	1,00	1,00	**0%**	1,00	**0%**
Tamchekett	2,00	1,00	**-50%**	1,00	**-50%**
Néma	2,00	1,00	**-50%**	1,00	**-50%**

This table provides the relationship between RCP4.5 and RCP 8.5 hazard scores and observed hazard score for flooding (with no inclusion of vulnerability and exposure scores).

Risks on livestock productivity

TABLES 11 (A, B , C, D, E) : OBSERVED AND PROJECTED RISKS ON LIVESTOCK PRODUCTIVITY

11A - Observed risk on livestock production				
Hub	Observed climate hazard	Exposure	Vulnerability	= Observed Risk
Aoujeft	*2,20*	*3,00*	*3,50*	**2,85**
Rachid	*2,20*	*3,00*	*3,50*	**2,85**
Tamchekett	*2,00*	*4,00*	*3,00*	**2,88**
Nema	*2,20*	*4,00*	*3,00*	**2,98**

11B - Scenario 1: Risk on livestock production with no further climate change				
Hub	Observed climate hazard	Exposure by 2050	Vulnerability by 2050	= Risk By 2050
Aoujeft	*2,20*	*4,00*	*3,67*	**3,18**
Rachid	*2,20*	*4,00*	*3,67*	**3,18**
Tamchekett	*2,00*	*4,00*	*3,67*	**3,08**
Nema	*2,40*	*4,00*	*3,67*	**3,28**

11C – Scenario 2: Risk by 2050 with RCP 4.5 projections				
Hub	Projected Climate hazard **RCP 4.**	Exposure by 2050	Vulnerability by 2050	= Risk by 2050
Aoujeft	*2,60*	*4,00*	*3,67*	**3,37**
Rachid	*3,20*	*4,00*	*3,67*	**3,61**
Tamchekett	*3,00*	*4,00*	*3,67*	**3,53**
Nema	*3,40*	*4,00*	*3,67*	**3,68**

11D - Scenario 3: Risk by 2050 with RCP 8.5 projections				
Hub	Projected climate hazards **RCP 8.5**	Exposure by 2050	Vulnerability by 2050	= Risk by 2050
Aoujeft	*3,00*	*4,00*	*3,67*	**3,53**
Rachid	*3,60*	*4,00*	*3,67*	**3,75**
Tamchekett	*3,40*	*4,00*	*3,67*	**3,68**
Nema	*3,60*	*4,00*	*3,67*	**3,75**

11 E - Ratio RCP climate hazard scores / Observed climate hazard score for livestock production					
Hub	Observed climate hazard	Projected climate hazard **RCP 4.5**	%	Projected climate hazard **RCP 8.5**	%
Aoujeft	*2,20*	***2,60***	**18%**	***3,00***	**36%**
Rachid	*2,20*	***3,20***	**45%**	***3,60***	**64%**
Tamchekett	*2,00*	***3,00***	**50%**	***3,40***	**70%**
Néma	*2,40*	***3,40***	**42%**	***3,60***	**50%**

This table provides the relationship between projected RCP4.5 and RCP 8.5 hazard scores and observed hazard score for livestock production (with no inclusion of vulnerability and exposure scores).

Risks on human health

TABLES 12 (A, B , C, D, E): OBSERVED AND PROJECTED RISKS ON HUMAN HEALTH

12 A - Observed risk on health				
Hub	Observed climate hazard	Current Exposure	Current Vulnerability	Observed Risk
Aoujeft	*1,67*	*4,00*	*3,33*	**2,81**
Rachid	*1,33*	*4,00*	*3,00*	**2,52**
Tamchekett	*1,67*	*3,00*	*3,50*	**2,60**
Nema	*2,00*	*3,00*	*3,00*	**2,62**

12B – Scenario 1: Risk by 2050 with no further climate change				
Hub	Observed climate hazard	Exposure by 2050	Vulnerability by 2050	= RISK by 2050
Aoujeft	*1,67*	*5,00*	*3,17*	**2,98**
Rachid	*1,33*	*4,00*	*3,33*	**2,61**
Tamchekett	*1,67*	*3,00*	*3,17*	**2,51**
Nema	*2,00*	*5,00*	*3,50*	**3,27**

12C – Scenario 2 : Risk by 2050 with RCP 4.5 projections				
Hub	Projected climate hazard **RCP 4.5**	Exposure by 2050	Vulnerability by 2050	= RISK by 2050
Aoujeft	*2,00*	*5,00*	*3,50*	**3,27**
Rachid	*1,67*	*4,00*	*3,33*	**2,81**
Tamchekett	*1,67*	*3,00*	*2,83*	**2,42**
Néma	*2,00*	*5,00*	*3,50*	**3,27**

12D – Scenario 3: Risk by 2050 with RCP 8.5 projections				
Hub	Projected climate hazards **RCP 8.5**	Exposure by 2050	Vulnerability by 2050	= RISK by 2050
Aoujeft	*2,33*	*5,00*	*3,17*	**3,33**
Rachid	*2,00*	*4,00*	*3,33*	**2,99**
Tamchekett	*2,00*	*3,00*	*3,17*	**2,67**
Néma	*2,33*	*5,00*	*3,50*	**3,44**

12E - Ratios RCP hazard scores / observed hazard score for health					
Hub	Observed climate hazard	Projected climate hazard **RCP 4.5**	%	Projected climate hazard **RCP 8.5**	%
Aoujeft	*1,67*	*2,00*	**20%**	*2,33*	**40%**
Rachid	*1,33*	*1,67*	**25%**	*2,00*	**50%**
Tamchekett	*1,67*	*1,67*	**0%**	*2,00*	**20%**
Néma	*2,00*	*2,00*	**0%**	*2,33*	**17%**

This table provides the relationship between projected RCP4.5 and RCP 8.5 hazard scores and observed hazard scores for the health sector (with no inclusion of vulnerability and exposure scores) (with no inclusion of vulnerability and exposure scores).