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AGRICULTURAL ADAPTATION TO CLIMATE CHANGE IN THE SAHEL:

EXPECTED IMPACTS ON PESTS AND DISEASES AFFLICTING LIVESTOCK

AUGUST 2014

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ARCC

African and Latin American
Resilience to Climate Change Project

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Tetra Tech ARD Contacts:

Patricia Caffrey
Chief of Party
African and Latin American Resilience to Climate Change (ARCC)
Burlington, Vermont
Tel.: 802.658.3890
Patricia.Caffrey@tetratech.com

Anna Farmer
Project Manager
Burlington, Vermont
Tel.: 802.658.3890
Anna.Farmer@tetratech.com

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AFRICAN AND LATIN AMERICAN RESILIENCE TO CLIMATE CHANGE (ARCC)

AUGUST 2014

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ABOUT THIS SERIES

ABOUT THE STUDIES ON CLIMATE CHANGE VULNERABILITY AND ADAPTATION IN WEST AFRICA

This document is part of a series of studies that the African and Latin American Resilience to Climate Change (ARCC) project produced to address adaptation to climate change in West Africa. Within the ARCC West Africa studies, this document falls in the subseries on Agricultural Adaptation to Climate Change in the Sahel. ARCC also has produced a subseries on Climate Change and Water Resources in West Africa, Climate Change and Conflict in West Africa, and Climate Change in Mali.

THE SUBSERIES ON AGRICULTURAL ADAPTATION TO CLIMATE CHANGE IN THE SAHEL

At the request of the United States Agency for International Development (USAID), ARCC undertook the Sahel series of studies to increase understanding of the potential impacts of climatic change on agricultural productivity in the Sahel, and identify means to support adaptation to these impacts. Other documents in the Agricultural Adaptation to Climate Change in the Sahel series include: An Approach to Conducting Phenological Screening, An Approach to Evaluating the Performance of Agricultural Practices, Profiles of Agricultural Management Practices, A Review of 15 crops Cultivated in the Sahel, and Expected Impacts on Pests and Diseases Afflicting Selected Crops.

INTRODUCTION TO THE TABLES

The tables present an analysis of the potential impact of a changed climate on the most common diseases afflicting cattle, sheep, goats, camels, donkeys, pigs, and chickens in the Sahel. Information used to develop these tables was drawn from over 60 peer-reviewed scholarly journals and books related to animal health. The website of the World Organisation for Animal Health (OIE) was also consulted. This analysis does not include information from theses, technical reports, newspapers, mainstream magazines or proceedings of conferences.

For each livestock disease identified, the disease status under current climate was assessed, including the geographical range of the endemic zone, the rate of disease outbreaks within endemic zones, the mode of pathogen transmission, and the relative economic importance to livestock owners. These served as the baseline for an assessment of the likely change in risk of infection under climate scenarios for the 2025 to 2050 period.

The fact that projections of changes to the climate of the Sahel for this period are currently uncertain informed the scenarios used. There is agreement among climate models that temperatures will increase, although the models differ on the extent and rate of that change. Precipitation for this region of the world is particularly difficult to model and existing projections based on these models all differ on the long-term evolution of annual rainfall amounts. Different models produce divergent outcomes for the region; a limited number project increased annual rainfall. The models also provide little insight regarding potential in geographic distribution of precipitation. Most models project a slight increase in annual rainfall in the central Sahel and a decrease in the western Sahel.

Some models project that the onset of the rainy season may be delayed and that extreme events may increase. Such intra-annual patterns play a critical role in the severity of disease impact. Changes in the frequency of floods and drought, for example, may significantly impact prevalence. Unfortunately, on the whole, model projections do not address intra-annual weather patterns and such intra-annual changes in patterns were not considered in this analysis.

This uncertainty regarding projections argues for an analysis based upon simplified climate scenarios. Because projections are considered reliable with regard to temperature yet inconclusive with regard to annual rainfall amounts, the analysis considered two scenarios. One assumes warmer climate with increased rainfall. A second also assumes a warmer climate, but with lower rainfall.

Because the climate scenarios used were basic, the potential impacts identified are straightforward; they consist of risk values of change in infestation or outbreak levels. A number of unknowns prevent greater precision. These include uncertainty regarding the impact of new climatic conditions on pathogen transmission and the immune status of livestock populations. Other factors less dependent on climate will also change. Farmers and pastoralists will adopt new techniques for managing diseases and likely adopt livestock breeds with a different resistance to various pests and diseases. Owners may also move their livestock to new agro-ecological zones that pose a lesser (or greater) risk of infection.

Further, available research to explore these issues is limited, especially regarding environmentally and animal-to-animal transmitted diseases. Little information exists on the sensitivity of specific livestock pathogens to moisture and humidity in a hot tropical environment with high ultraviolet radiation, making it difficult to gauge the severity of response to changes in climate.

The predictions that follow are based on expert opinion. They are not the result of modeling or experimentation. They are intended to highlight potential areas of concern. For greater precision, dedicated research targeting the specific geographic zones, livestock species, disease vectors, and pathogens under consideration will be necessary.

PRESENTATION OF THE TABLES

The report contains two tables: a summary table, followed by a more detailed table. The summary table is organized by animal and the current prevalence and impact of each pest or disease afflicting it; the effects are characterized as "very high," "high," and "moderate." It presents, for each pest or disease, a brief description of the likely impact on livestock populations under the two climate scenarios. Impacts are tailored to the species and pest or disease, but generally reported in terms of likely changes in numbers of animals lost (higher, stable, or lower).

The second table is organized by species in this order: cattle; camel; sheep and goats; chickens; donkeys, mules, and horses; and pigs. For each species, the table presents the following information concerning vector-borne diseases, environmentally transmitted diseases, and animal-to-animal transmitted diseases: a general description, including modes and conditions of transmission, and geographic regions of prevalence. This is followed by notes regarding the relationships between climate, livestock management, land use, and pathogen transmission. A table concludes the profile, describing the current status of the disease and the potential impact of each of the two climate change scenarios. The table also presents possible mitigation strategies.

VERY HIGH *Pests and diseases currently of serious prevalence and impact*		
AFFECTED SPECIES	***PEST OR DISEASE***	***CLIMATE IMPACT***
CAMEL	Rift Valley Fever (RVF)	Hot/Wet – Expanded area at risk & increased risk of outbreaks → Could become **major livestock & human disease problem**; higher impact than in cattle Hot/Dry – Reduced area at risk & decreased risk of RVF outbreaks
	Surra	Hot/Wet – No change –if camel population relocates; in the absence of relocation Surra would occur more frequently and cause higher losses Hot/Dry – No change; camel population relocates
SHEEP AND GOATS	Rift Valley Fever (RVF)	Hot/Wet – Expanded area at risk & increased risk of outbreaks → Could become major livestock & human disease problem; in sheep highest RVF impact of all livestock!; lower impact in goats Hot/Dry – Reduced area at risk & decreased risk of RVF outbreaks; possibility of new RVF foci in irrigation areas
	Peste Des Petits Ruminants (PPR)	Hot/Wet – No change Hot/Dry – No change; more frequent outbreaks possible in highly mobile pastoralist livestock
	Contagious Caprine Pleuro-Pneumonia (CCPP)	Hot/Wet – No change Hot/Dry – No change; more frequent outbreaks possible in highly mobile pastoralist livestock
CHICKENS	Newcastle Disease (ND)	Hot/Wet – Stable losses Hot/Dry – More frequent Newcastle Disease outbreaks →increased risk and losses
	Highly Pathogenic avian influenza (HPAI)	Hot/Wet – Stable risk Hot/Dry – Increased risk because of higher concentration of migratory birds in fewer over-wintering habitats
DONKEYS, MULES, AND HORSES	African Horse Sickness	Hot/Wet – Increased risk of disease and loss of traction power Hot/Dry – Reduced risk of disease and loss of traction power
PIGS	African Swine Fever (ASF)	Hot/Wet – Increased risk of transmission to free ranging domestic pigs Hot/Dry – Reduced risk of transmission to free ranging domestic pigs

HIGH/SIGNFICANT *Pests and diseases currently of significant prevalence and impact*		
AFFECTED SPECIES	***PEST OR DISEASE***	***CLIMATE IMPACT***
CATTLE	Rift Valley Fever (RVF)	Hot/Wet – Expanded area at risk & increased risk of outbreaks → Could become **major livestock & human disease problem**; lower impact than in other livestock Hot/Dry – Reduced area at risk & decreased risk of RVF outbreaks; possibility of **new RVF foci** in irrigation areas
	Tropical Theileriosis	Hot/Wet – No major change Hot/Dry – In currently free areas initial high losses followed by "endemic stability" with stable losses (overall higher losses caused by this disease because of expanded range)
	Trypanosomosis	Hot/Wet – Stable disease risk; overall higher losses because of expanded range of tse-tse Hot/Dry – Lower losses; only localized *G. palpalis* tse-tse risk; *G.morsitans* tse-tse may disappear from the Sahel
	Gastro-Intestinal Helminths	Hot/Wet – Heavier endoparasite burden → Increased losses; lower impact than in sheep, goats, and camels Hot/Dry – Lighter endoparasite burden → Reduced losses
	Lumpy Skin Disease	Hot/Wet – Enhanced opportunities for spread of infected insects → higher production losses Hot/Dry – Reduced opportunities for spread of infected insects → lower production losses
	Foot-and-Mouth Disease (FMD)	Hot/Wet – Stable risk and losses Hot/Dry – More frequent FMD outbreaks → higher production losses; this applies esp. to highly mobile pastoralist livestock; CC effect on low mobility / stationary cattle management systems is less predictable
	Contagious Bovine Pleuro-Pneumonia (CBPP)	Hot/Wet – No change Hot/Dry – No change
CAMEL	Gastro-Intestinal Helminths	Hot/Wet – Heavier endoparasite burden →Increased production losses; gains much more importance; higher impact than in cattle Hot/Dry – Lighter endoparasite burden →Reduced production losses
	Orf (Pustular dermatitis)	Hot/Wet – More severe clinical disease →higher losses Hot/Dry – Less severe clinical disease →lower losses (modulating effect of nutritional status)

	Camel Pox	Hot/Wet – More severe clinical disease →higher losses Hot/Dry – Less severe clinical disease →lower losses (modulating effect of nutritional status)
SHEEP AND GOATS	Sheep & Goat Pox	Hot/Wet – More severe clinical disease →higher losses Hot/Dry – Less severe clinical disease →lower losses (modulating effect of nutritional status)
	Orf (Pustular dermatitis)	Hot/Wet – More severe clinical disease →higher losses Hot/Dry – Less severe clinical disease →lower losses (modulating effect of nutritional status)
	Gastro-Intestinal Helminths	Hot/Wet – Heavier endoparasite burden →Increased production losses; much higher impact than in cattle – likely to gain major importance in sheep and goats Hot/Dry – Lighter endoparasite burden →Reduced production losses
	Footrot	Hot/Wet – Disease more common → increased production losses Hot/Dry – Disease absent for long periods→ reduced production losses
CHICKENS	Avian coccidiosis	Hot/Wet – More frequent disease →higher losses Hot/Dry – Less frequent disease →lower losses (modulating effect of poor body condition in relation to feed situation)
	Pullorum Disease	Hot/Wet – Stable losses Hot/Dry – Stable losses
	Marek Disease	Hot/Wet – Slightly increased risk of outbreaks (due to heat stress) Hot/Dry – Slightly increased risk of outbreaks (due to heat stress)
DONKEYS, MULES, AND HORSES	Trypanosomosis	Hot/Wet – Increased transmission risk over wider area and loss of traction power Hot/Dry – Reduced loss of traction power, esp. in relation to infections by *Trypanosoma brucei* – less pronounced for *Trypanosoma evansi*

MODERATE *Pests and diseases currently of moderate prevalence and minor impact*		
AFFECTED	***PEST OR DISEASE***	***CLIMATE IMPACT***

SPECIES		
CATTLE	Anthrax	Hot/Wet – Less time spent grazing on infected pastures →Lower losses Hot/Dry – Longer time spent grazing on infected pastures →Higher losses
	Bovine Anaplasmosis & Bovine Babesiosis	Hot/Wet – Endemic stability established over expanded range → reduced disease risk; but overall increased losses because of expanded area at risk Hot/Dry – Aridity increases instability (loss of endemic stability) with increased risk of sporadic severe disease → high losses in wet years; but overall reduced losses because of reduced area at risk
	Bovine Brucellosis	Hot/Wet – No change Hot/Dry – No change
	Fluke (Fasciola)	Hot/Wet – Less time spent in risk zones → lower disease risk and losses Hot/Dry – Longer time spend in fluke areas → higher risk of disease and losses
	Dermatophilosis	Hot/Wet – More common occurrence → Significant increase in production losses Hot/Dry – Less common occurrence → Decrease in production losses
	Salmonellosis	Hot/Wet – Higher losses Hot/Dry – Reduced losses esp. under mobile management system
	Hemorrhagic Septicemia (HS)	Hot/Wet – Endemic HS enhanced with seasonal but less severe outbreaks → lower losses Hot/Dry – Unstable HS situation with sporadic but more severe outbreaks → higher losses
CAMEL	Anthrax	Hot/Wet – Less time spent grazing on infected pastures → Lower losses Hot/Dry – Longer time spent grazing on infected pastures → Higher losses
	Salmonellosis	Hot/Wet – Higher losses Hot/Dry – Reduced losses esp. under mobile management system
	Dermatophilosis	Hot/Wet – More common occurrence → Increase in production losses; camels shift north Hot/Dry – Less common occurrence → Decrease or even absence of production losses; camels kept in arid areas
	Hemorrhagic Septicemia (HS)	Hot/Wet – More frequent outbreaks in camel regions *(pure guesswork as long as there is no information on the pathogen and the immunity of camels)* Hot/Dry – Sporadic but more severe outbreaks *(pure guesswork as long as there is no information on the pathogen and the immunity of camels)*
	Brucellosis	Hot/Wet – No change Hot/Dry – No change

	Trypanosomosis	Camel-keeping is only possible in free area, Hot/Wet – camel population shifts North Hot/Dry – camel population shifts South
SHEEP AND GOATS	Heartwater	Hot/Wet – Endemic stability established over expanded range; stable disease risk → overall higher losses because of expanded range of area at risk Hot/Dry – Aridity leads to loss of endemic stability; risk of sporadic severe disease in wet years; → overall lower losses because of reduced range of area at risk
	Bluetongue	Hot/Wet – Endemic over expanded range → overall higher losses Hot/Dry – Smaller endemic area → overall lower losses
	Trypanosomosis	Hot/Wet – Stable disease risk; overall higher losses because of expanded range of tse-tse Hot/Dry – Range of trypanosome susceptible sheep breeds may expand; lower losses
	Anthrax	Hot/Wet – Less time spent in risk zones → lower risk of disease and losses Hot/Dry – Longer time spend in risk areas → higher risk of disease and losses
	Clostridiosis	Hot/Wet – Disease occurs more frequently and more widespread → higher losses Hot/Dry – Disease occurs less frequently; losses in wet years but overall lower losses
	Ovine Brucellosis	Hot/Wet – No change Hot/Dry – No change
	Salmonellosis	Hot/Wet – Higher losses Hot/Dry – Reduced losses esp. under mobile management system
	Fluke (Fasciola)	Hot/Wet – Less time spent grazing risky pasture → Lower losses Hot/Dry – More time spent grazing risky pasture → Higher losses
CHICKENS	Fowl Pox	Hot/Wet – Increased risk of outbreaks and higher production losses Hot/Dry – Reduced risk of outbreaks → lower production losses
	Gastro-Intestinal Helminths	Hot/Wet – Heavier endoparasite burden → increased losses Hot/Dry – Lighter endoparasite burden → reduced losses
	Gumboro Disease	Hot/Wet – Stable losses Hot/Dry – Stable losses
	Salmonellosis	Hot/Wet – Higher losses Hot/Dry – Reduced losses (modulating effect of poor body condition in relation to feed situation)

	Avian infectious bronchitis	Hot/Wet – More severe outbreaks → higher production losses Hot/Dry – More severe outbreaks → higher production losses
	Avian mycoplasmosis	Hot/Wet – More severe clinical disease → higher production losses Hot/Dry – More severe clinical disease → higher production losses
	Fowl Cholera	Hot/Wet – Stable losses Hot/Dry – Stable losses
DONKEYS, MULES, AND HORSES	Gastro-Intestinal Helminths and Liver Fluke	Hot/Wet – Increased losses of traction power Hot/Dry – Reduced losses of traction power
	Glanders	Hot/Wet – Stable losses Hot/Dry – Stable losses

CATTLE

VECTOR-BORNE DISEASES

BOVINE ANAPLASMOSIS[i]

- Intra-erythrocytic bacteria (*Anaplasma marginale*) causing fever, progressive anemia, jaundice, weight-loss and death; calves possess innate protection up to 9 months of age; if exposed early, cattle acquire lasting immunity; susceptibility increases with age, infection of non-immune adults leads to severe acute disease and death.
- Tick-transmitted, while mechanical transmission by biting flies and by unclean injection needles (vaccinations) also plays a role.
- Absent from semi-arid and arid regions ("Sahel Savanna"), it poses a risk to migratory herds entering infested grazing areas; reported exposure rates in the sub-humid "Sudan Savanna" vary between 4 percent and 51 percent.
- In sub-humid areas with consistent exposure of cattle to Anaplasma and endemic stability mostly absence of clinical disease and production losses.

BOVINE BABESIOSIS[ii]

- Intra-erythrocytic protozoan parasite (*Babesia spp.*) causing fever, intra-vascular hemolysis, hematuria ("Redwater"), progressive anemia, jaundice, weight-loss and death; innate protection lasts up to 6 months of age; early exposed cattle acquire good lasting immunity.
- Transmitted exclusively by *Boophilus spp.* ticks.
- Absent from semi-arid and arid regions ("Sahel Savanna"), it poses a risk to migratory herds entering infested grazing areas; reported exposure rates in the sub-humid "Sudan Savanna" vary between 0 percent and 80 percent.
- In sub-humid areas with endemic stability immune-suppression (drought, calving stress) can lead to recurrence of clinical disease.

Climate change influence on vector, pathogen-transmission, livestock management, land use (for Babesiosis and Anaplasmosis)

- Increased humidity enhances reproduction and feeding activity of ticks resulting in more frequent and more regular exposure of cattle to TBD; increased aridity has the opposite effect
- Hot temperatures shorten survival of ticks under both CC scenarios; under hot & humid conditions shorter survival rate is offset by a higher reproductive rate of ticks
- Migration from non-infected areas into endemic areas occurs more frequently under arid CC scenario

Current Disease	Climate	**Expected Climate Change Impacts by 2025**	Possible

Status in the Sahel	Change Scenario	**Disease unlikely to gain in importance**	**Disease likely to gain in importance**	mitigation strategy
Endemic in all sub-humid and riverine zones of the Sahel; sporadic cases in non-immune cattle; both diseases reported in 2012 by Niger	Hot/Wet		Expanded area at risk → overall **increased losses**	
	Hot/Dry	Reduced area at risk → overall **reduced losses**		Tick control in wet years

LUMPY SKIN DISEASE[iii]

- Viral pathogen causing fever, multiple skin nodules, and lesions on the inner surfaces of the mouth and respiratory tract; self-limiting with low mortality, but has a prolonged debilitating effect on cattle.
- Transmitted by biting insects, which can be carried by wind over long distances.
- Occurs in periodic epidemics that affect large cattle numbers in vast regions, including in the semi-arid Sahel-Savanna.
- Economic importance because of prolonged course leading to temporary emaciation, cessation of lactation, temporary loss of fertility, permanent damage to hides.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Increased humidity results in higher reproduction rates and longer activity periods of biting insects resulting in a growing population of infected biting insects; increased aridity has the opposite effect
- Wind speed may be important for regional spread of infected insects

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Outbreaks occur at intervals of several years; reported by Burkina Faso, Niger, and Senegal in 2012	Hot/Wet		Enhanced opportunities for spread of infected insects → **higher** production **losses**	Improved vaccination cover
	Hot/Dry	Reduced opportunities for spread of infected insects → **lower** production **losses**		

RIFT VALLEY FEVER (RVF)[iv]

- Viral pathogen causing mass abortions, hepatitis, and deaths in newborn calves (10 percent-70 percent mortality), sporadic disease and death in adult cattle; very dangerous zoonosis.
- Transmitted by mosquitoes (*Aedes* & *Culex*), which can be wind-carried over long distances; RVF outbreaks in East Africa triggered by abnormally high rainfall with flooding and mass-reproduction of the mosquito vectors – no clear correlation between RVF epidemics and rainfall in West Africa.
- Occurs in periodic epidemics that affect several countries, including in the semi-arid Sahel-Savanna.
- Sudden mass abortions lead to disruption of reproductive and production cycles; complete disruption of trade (slaughter ban); RVF can cause potentially lethal disease in humans exposed to infected livestock (during abortions, at slaughter).

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Abnormally high rainfall with flooding leads to mass-reproduction of mosquitoes and a surge in virus transmission; wind speed can affect long distance spread of infected mosquitoes
- In West Africa, expansion of irrigation agriculture has improved conditions for virus transmission significantly

Current Disease Status in the Sahel	Climate Change Scenario	Expected Climate Change Impacts by 2025		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
In 2012 outbreaks in Mauritania, Niger, Senegal; regional outbreaks at intervals of several years	Hot/Wet		Expanded area at risk & increased risk of outbreaks → Could become **major livestock & human disease problem; in cattle lower impact than in other livestock**	Improved vaccination cover
	Hot/Dry	Reduced area at risk & decreased risk of RVF outbreaks; possibility of **new RVF foci** in irrigation areas		

TROPICAL THEILERIOSIS[v],[vi]

- Protozoan parasite (*Theileria annulata*) infecting white and red blood cells and causing fever, respiratory symptoms, immune-suppression, diarrhea, anemia, rapid weight loss, and death; young calves are also susceptible, but cattle in endemic regions acquire immunity; mortality of up to 90 percent in naïve cattle.
- Transmitted by *Hyalomma spp.* ticks, which are adapted to arid conditions.
- Present in parts of semi-arid regions ("Sahel Savanna") of West Africa and in North Africa, it poses a risk of spread into currently non-infected areas and a high risk of severe clinical disease in cattle herds entering infested areas.
- Local endemic stability in permanently infected areas.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Main vector ticks are well adapted to hot and arid conditions; no clear CC effect; potential tick-vectors are already present in non-infected areas
- More frequent long distance transport and migration of livestock due to increased aridity could potentially spread this infection throughout the Sahel region

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in Africa, especially north of the Sahara; reported by Senegal and Niger in 2012	Hot/Wet	Less likely to be introduced into new regions		
	Hot/Dry		Unusual livestock movement → Increased **risk of spread into new regions**	Strict control of cross-border cattle movement

TRYPANOSOMOSIS[vii]

- Protozoan blood parasites (in West Africa especially *Trypanosoma congolense and Trypanosoma vivax,* also *Trypanosoma brucei*) cause intermittent fever, lasting immune-suppression, chronic progressive anemia, progressive weight loss (over several months to more than a year), and eventually death. Cattle breeds vary in susceptibility; trypano-tolerant cattle breeds kept in endemic sub-humid to humid regions are in general not suitable for semi-arid Sahel-Savanna conditions because they lack drought resistance and good trekking ability.
- Transmitted by tse-tse flies (*Glossina morsitans* group in open Savanna habitats and *Glossina palpalis* group in riverine habitats); in adjacent areas without tse-tse flies transmission of Trypanosomes by biting flies can play a role (especially for *Trypanosoma vivax*).
- Present in all sub-humid regions ("Sudan Savanna") of West Africa where tse-tse flies occur.
- Leads to complete loss of productivity in infected cattle; unless tse-tse fly vector is efficiently controlled, cattle-keeping becomes un-economical due to frequent Trypanosomosis.
- Cattle are more affected than sheep and goats because they are much more likely to be bitten by tse-tse flies and to become infected with Trypanosomes.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Increased humidity improves tree cover (long-term) and enhances range, reproduction and feeding activity of tse-tse leading to more frequent infection of cattle with trypanosomes; increased aridity reduces range, reproduction and feeding activity of tse-tse (*G.morsitans)*
- Local emergence of trypanosome transmission by biting flies possible in areas that become unsuitable for tse-tse
- New, very localized tse-tse habitats inside irrigation areas could emerge (*G. palpalis*)

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Over the past three decades range of disease and its main vector (*G.morsitans)* has been shrinking, only of importance in southern (sub-humid) parts of the Sahel; reported in 2012 by Burkina Faso and Niger	Hot/Wet		**Higher losses** because of expanded range of ts-tse flies	Change to more trypano-tolerant cattle breeds
	Hot/Dry	**Greatly reduced or no losses**; tse-tse and disease may disappear from the Sahel		

ENVIRONMENTALLY TRANSMITTED DISEASES

ANTHRAX[viii]

- Spore-forming bacteria (*Bacillus anthracis*) found in soil and particularly in sediment of ponds and lakes; spores survive in the environment for decades if not for centuries; when ingested during grazing or drinking the spores germinate into bacteria and cause a peracute septicemia that leads to death within hours; important zoonosis.
- When carcasses are opened (e.g., by scavengers) bacteria form spores, which again contaminate the environment; spores can be carried by floods onto clean pastures.
- Sporadic outbreaks occur particularly in dry season when animals graze in dry flood zones and gather at overcrowded contaminated watering ponds.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid CC scenario increased availability of grazing throughout the year allows livestock to spend shorter time grazing infected flood zones
- Increased aridity would see herds spend longer time grazing in high risk areas

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic on localized infected pastures, esp. in flood zones; reported 2012 by Burkina Faso, Chad, Niger, and Senegal	Hot/Wet	Less time spent grazing on infected pastures → **Lower losses**		
	Hot/Dry		Longer time spent grazing on infected pastures → **Higher losses**	Improved vaccination cover

FLUKE (FASCIOLA)[ix]

- Trematode parasites (in Sahel especially *Fasciola gigantica*), adult stages parasitize the bile ducts of the liver in cattle; infective stage causes tissue damage due to migration; adult stage causes chronic loss of red blood cells and blood plasma resulting in persistent wasting disease (= typical clinical picture in cattle).
- Indirect transmission cycle includes environmental phase with developmental parasite stages living in water snails (= intermediate hosts). Released infectious larvae encyst on vegetation and re-enter cattle host during grazing on fluke-infested pasture.
- Occurs in localized aquatic habitats (near permanent water and in flood zones), including in irrigation schemes (*Fasciola gigantica* gains new habitats though construction of water reservoirs and dams).
- Chronic Fasciolosis leads to loss in condition, loss in carcass value, and persistently low milk yield; cattle on high plane of nutrition can tolerate a certain level of fluke infestation.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid CC scenario creates more suitable snail habitats that support parasite transmission
- Increased aridity reduces habitat range
- Under humid CC scenario, herds depend less on fluke infested grazing; with increased aridity herds are more likely to graze on fluke infested pastures

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in specific localized habitats (swamps, around ponds & water reservoirs, in irrigation areas)	Hot/Wet	Less time spent grazing risky pastures → **Lower losses**		
	Hot/Dry		Longer time spent grazing risky pastures → **Higher losses**	Strategic anti-parasite treatment

GASTRO-INTESTINAL HELMINTHS[x]

- Gastro-intestinal parasites. Adult stages live in the stomach or intestine; some species attach to the lining of the stomach or the intestine and suck blood. Pathogenicity varies depending on level of infestation and helminth species; they interfere with digestion and some can cause anemia.
- The transmission cycle includes environmental larval phase that live on pasture vegetation. Infective larvae are only active on pasture under humid conditions, and survive only for a rather limited period on pastures under hot and arid conditions; transmission in the semi-arid areas occurs seasonally during rains.
- High infection rate causes wasting disease and interferes with calf growth (stunting); adult cattle develop good resistance against gastro-intestinal helminths but will still be less productive.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid CC scenario lifespan and activity of infective helminth larvae on pasture increase, resulting in more efficient transmission; increased aridity reduces efficiency of transmission
- High herd mobility in pastoralist system is a modulating factor; humid CC impact felt more in semi-stationary and farm based systems

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in all cattle keeping regions	Hot/Wet		Heavier endoparasite burden → **Increased losses**	Anti-parasite treatment timed in relation to expected GI-Helminth high risk season
	Hot/Dry	Lighter endoparasite burden → **Reduced losses**		

SALMONELLOSIS[xi]

- Bacteria living in the gastro-intestinal tract of humans and animals; more than 2000 salmonella serotypes are known worldwide (including some few host specific types) and cause different clinical diseases, including septicemia, diarrhea, and abortions; mortality is seen mainly in young animals; important zoonosis.
- Fecal-oral transmission occurs via diseased and healthy salmonella carriers that contaminate the environment with their feces; salmonella survives for long periods in water and in wet shaded micro-environments.
- Salmonella is more prevalent under intensive husbandry conditions; transmission in extensive production systems in the semi-arid areas occurs mainly via crowded and contaminated night enclosures.
- No stable endemic immunity and the common presence of healthy carriers lead to persistent losses, especially in young animals; cumulative production losses are often overlooked.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid CC scenario results in enhanced pathogen survival and multiplication of pathogens in micro-environments and more frequent exposure of cattle to Salmonella; higher aridity would lead to reduced exposure
- Transmission via contaminated overnight enclosures in mobile pastoralist systems more affected by increased aridity (= reduced salmonella exposure) than transmission in housed farm animals and transmission on permanent pastures

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in all cattle-keeping regions of the Sahel	Hot/Wet		Enhanced pathogen survival in micro-environments → Slightly **increased losses**	Improved vaccination cover
	Hot/Dry	Slightly **reduced losses,** esp. under mobile management system		

ANIMAL-ANIMAL TRANSMITTED DISEASES

BOVINE BRUCELLOSIS[xii]

- Bacterial pathogen (*Brucella abortus*) causing abortion in cattle and also leading to persistent infections in adult cattle. It is excreted in the milk of healthy carriers (=persistently infected adult cows) – important zoonosis in areas with common raw milk consumption.
- Transmission occurs via the environment (stables, enclosures, paddocks), which is contaminated with *Brucella* during abortion; this route plays a by far greater role than occasional venereal transmission; *Brucella* can survive for a short period in humid, shaded micro-environments.
- Unless controlled, *Brucella* is common under intensive and extensive husbandry conditions; transmission in extensive production systems in the semi-arid areas occurs mainly via contaminated enclosures.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid CC scenario results in longer pathogen survival on pasture resulting in more efficient transmission; increased aridity leads to less efficient transmission via pasture
- Transmission via contaminated pastures and overnight enclosures in mobile pastoralist systems is more affected by aridity (= less efficient transmission) than transmission in housed farm animals on permanent pastures

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in the whole Sahel; reported in 2012 by Niger and Senegal	Hot/Wet	Not significant		Improved vaccination cover
	Hot/Dry	Not significant		

CONTAGIOUS BOVINE PLEURO-PNEUMONIA (CBPP)[xiii]

- Bacterial pathogen (*Mycoplasma mycoides*) causing an almost invariably chronic progressive respiratory disease in cattle leading to slow wasting. Acute respiratory disease is rare. Persistent infections in adult cattle can be clinically invisible for long intermittent episodes, but stress triggers flare-up of clinical respiratory disease (= chronic cough).
- Transmission occurs via aerosols containing infectious droplets and requires close contact.
- Unless controlled, CBPP is common under intensive and extensive husbandry conditions; animals gradually lose condition/draft power/trekking ability and have to be slaughtered.
- Interferes with national/regional/international trade in livestock.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid conditions favor pathogen survival in infectious aerosols, allowing for slightly more efficient transmission
- Arid conditions lead to poor nutrition status and low immunity in cattle; this reactivates the pathogen excretion by chronic carrier animals and results in more frequent transmission
- Under arid CC scenarios there is also a higher risk of pathogen transmission due to high concentration of livestock and more frequent animal contacts at fewer watering points and on overstocked pastures
- Major impact is rather to be expected from veterinary control measures than from CC

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in Sahel countries, ongoing national control efforts; reported in 2012 by Burkina Faso, Mauritania, and Senegal	Hot/Wet	Not significant		
	Hot/Dry	Not significant		Improved vaccination cover

DERMATOPHILOSIS[xiv]

- Bacterial pathogen (*Dermatophilus congolensis*) causing prolonged skin disease with scabs and sometimes generalized skin lesions in cattle; it is common after prolonged rainfall with intense wetting of the skin. It can occasionally occur in suckling calves in the absence of rainy conditions.
- Transmission occurs via direct contact, mostly seasonal.
- Normally no mortality, but has a debilitating effect. Affected cattle have lower milk yield and may lose their calves. Oxen cannot be used for draught power because skin lesions interfere with the yoke; healing takes several weeks.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid CC scenario would bring about prolonged intensive rainfall with excessive wetting of the skin, which favors more frequent infection and longer duration and intensity of the disease

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Present in the whole region, of importance in the Sahel in very wet years; reported last by Senegal in 2005	Hot/Wet		More common occurrence → **Significant increase** in production **losses**	
	Hot/Dry	Less common occurrence → **Decrease** in production **losses**		

FOOT-AND-MOUTH DISEASE (FMD)[xv]

- Viral pathogen causing acute fever and lesions in the mouth and on the feet, it interferes with feeding and walking. Sporadic deaths in small calves and abortions possible.
- The most contagious of all cattle diseases. Transmission via aerosols containing infectious droplets occurs over distances of many kilometers depending on atmospheric conditions. Entire local/national/regional cattle populations may become infected within a short period, and the virus can also be transmitted via milk and meat.
- Unless controlled, FMD outbreaks are common under intensive and extensive husbandry conditions; it disrupts production cycle and is a severe impediment to trade in livestock, meat and milk; **the most important of all trade-relevant diseases in cattle.**

Climate change influence on pathogen-transmission, livestock management, land use

- Humid conditions favor survival and long distance transmission (several km) of FMD virus in infectious aerosols
- Under arid conditions, transmission in pastoralist herds becomes more likely due to more frequent herd contacts at fewer watering points, on overstocked pastures, and along trekking routes (this effect is observed empirically, but not statistically confirmed)

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in all Sahel countries; reported in 2012 by Burkina Faso, Niger, and Senegal	Hot/Wet	Not significant		
	Hot/Dry	Not significant; but more frequent outbreaks possible in highly mobile pastoralist livestock (suspected for East Africa)		Improved vaccination cover

HEMORRHAGIC SEPTICEMIA (HS)[xvi]

- HS is caused by bacteria (specific capsular type of *Pasteurella multocida*) and presents as a peracute disease with sudden high fever, acute edema, severe respiratory distress, and hemorrhagic septicemia resulting in death within hours.
- Transmission via aerosols containing infectious droplets requires close contact; short-term survival of the pathogen in water and role of contaminated watering ponds is being discussed. In between outbreaks, bacteria are found in the respiratory tract of a small percentage of healthy carrier animals. Climatic stress (= sudden transition from hot and dry to wet and cool conditions at the onset of rainy seasons) coupled with poor body condition of cattle at the end of the dry season triggers local outbreaks (multi-factorial disease).
- Outbreaks occur seasonally, but are very sporadic in nature and do not re-occur every year; potentially high mortality.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid CC scenario episodes with sudden intensive rainfall (= trigger for outbreaks) occur more regularly, but regular exposure and good pasture also enhance the immune status of cattle
- Arid CC scenario would bring poor nutrition and low immunity in cattle, which makes them prone to more severe HS when exposed to sudden intensive rainfall

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in the Sahel with highly seasonal occurrence; reported in 2012 by Burkina Faso, Chad, Niger, and Senegal	Hot/Wet	Not significant		
	Hot/Dry	Not significant, potential risk of very sporadic severe outbreaks at long intervals		Improved vaccination cover

CAMEL

VECTOR-BORNE DISEASES

RIFT VALLEY FEVER (RVF)[xvii]

- Viral pathogen causing mass abortions (80 percent plus in camels), hepatitis, and massive deaths in newborn camel calves, and sporadic disease in older camels; very dangerous zoonosis.
- Transmitted by mosquitoes (*Aedes* & *Culex*), which can be carried by wind over long distances. RVF outbreaks in East Africa triggered by abnormally high rainfall with flooding and mass-reproduction of the mosquito vectors; there is no clear correlation between RVF epidemics and rainfall in West Africa.
- Periodic epidemics affect several countries, including in the semi-arid Sahel-Savanna.
- Sudden mass abortions lead to disruption of reproductive and production cycle; camels that lose their calves stop lactating and will only calve (and lactate) again one to two years later → massive disruption of milk production and shortage of milk for home consumption in semi-aid and arid regions. RVF can also cause potentially lethal disease in humans exposed to infected livestock (during abortions, at slaughter, and via consumption of raw milk).

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Abnormally high rainfall with flooding leads to mass-reproduction of mosquitoes and a surge in virus transmission
- Wind speed can affect long distance spread of infected mosquitoes
- In West Africa, expansion of irrigation agriculture has improved conditions for virus transmission, this may be less significant for camels because they are not kept in irrigation areas

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
In 2012 outbreaks in Mauritania, Niger, Senegal; regional outbreaks at intervals of several years	Hot/Wet		Expanded area at risk & increased risk of outbreaks → Could become **major livestock & human disease problem;** very **high** abortion **losses in camels**	Improved vaccination cover
	Hot/Dry	Reduced area at risk & decreased risk of RVF outbreaks		

SURRA[xviii]

- Protozoan blood parasite (*Trypanosoma evansi*) causes abortions, intermittent fever, immune-suppression, progressive anemia, chronic weight loss over months (in some cases up to two years) and eventually death; calves are less susceptible than adults.
- Transmitted by biting flies (especially Tabanids *and Stomoxys spp.)*, disease prevalence is linked to seasonal vector density and activity.
- Present in all camel-keeping regions of Asia and Africa, including semi-arid parts ("Sahel Savanna") of West Africa.
- There is no endemic stability; chronically infected camels become unproductive, can no longer be used for transport and have to be slaughtered. Long-standing infections are refractory to treatment. Economically, Surra is one of the most important diseases in camels

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Increased humidity prolongs activity period of biting flies in dry areas resulting in a longer transmission period for *T. evansi*; increased aridity shortens the period for efficient *T. evansi* transmission
- Camel herds are very mobile, under humid CC scenario camel-keeping can shift north; with increased aridity camel- keeping could move south

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in all camel-keeping countries (Africa and Asia); last (official) report from the Sahel was from Niger in 2009	Hot/Wet	No change provided that camel population can relocate; major surge if camel population cannot move		Avoid areas with high density of biting flies
	Hot/Dry	No major change; camel population relocates		

TRYPANOSOMOSIS[xix]

- In camels, tse-tse transmitted Trypanosomes (in West Africa, especially *Trypanosoma congolense and Trypanosoma brucei*) causes an acute disease that leads to death within days to a few weeks.
- It is transmitted by tse-tse flies in open savanna and in riverine habitats.
- Present wherever tse-tse flies are common.
- Under constantly high Trypanosome challenge losses occur very frequently; **camel- keeping in tse-tse infested areas is not viable**.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Increased humidity improves tree cover (long-term) and enhances range, reproduction, and feeding activity of tse-tse (*Glossina morsitans)*
- Increased aridity can lead to emergence of trypanosome transmission by biting flies in areas that become marginal for tse-tse
- Under arid CC scenario *Glossina morsitans* habitats disappear
- Camel herds are very mobile; under humid CC scenario camel-keeping can shift north; with increased aridity camel- keeping could move south

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Camels are not kept in tse-tse endemic areas of the Sahel	Hot/Wet	No major change; camel population relocates		Camel-keeping shifts north
	Hot/Dry	No major change; camel population relocates		Camel- keeping can expand into new tse-tse free areas (currently infected by tse-tse)

ENVIRONMENTALLY TRANSMITTED DISEASES

ANTHRAX[xx]

- Spore-forming bacteria (*Bacillus anthracis*) found in soil, and particularly in sediment of ponds and lakes. Anthrax spores survive in the environment for decades if not for centuries. When ingested during grazing or drinking, the spores germinate into bacteria and cause a peracute septicemia that leads to death within hours; important zoonosis.
- When carcasses are opened (e.g., by scavengers), bacteria form spores, which again contaminate the environment; spores can be carried by floods onto clean pastures.
- Sporadic outbreaks occur particularly in dry season when animals graze in dry flood zones and gather at overcrowded contaminated watering ponds; less common in camels as compared to cattle.

Climate change influence on pathogen-transmission, livestock management, land use

- With humid CC scenario, camels spend very short time grazing flood zones
- Increased aridity would see camel herds spend longer time in risky grazing areas

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic on localized infected pastures, esp. in flood zones; reported 2012 by Burkina Faso, Chad, Niger, and Senegal	Hot/Wet	Less time spent grazing on infected pastures → **Lower losses**		
	Hot/Dry		Longer time spent grazing on infected pastures → **Higher losses**	Improved vaccination cover

GASTRO-INTESTINAL HELMINTHS[xxi]

- Gastro-intestinal parasites, adult stages live in the stomach or intestine; some species attach to the lining of the stomach or the intestine and suck blood. Pathogenicity varies depending on level of infestation and helminth species; they interfere with digestion and some can cause anemia.
- Transmission cycle includes environmental larval phase that live on pasture vegetation; infective larvae are only active on pasture under humid conditions and survive only for a rather limited period on pastures under hot and arid conditions; transmission in the semi-arid areas occurs seasonally during rains (*Haemonchus longistipes* is specifically adapted to camels and to arid habitats).
- High infection rate causes wasting disease and interferes with camel calf growth (stunting); unlike cattle adult camels do not develop sufficient resistance against gastro-intestinal helminths → potentially high impact on milk production and body condition of camels.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid CC scenario lifespan and activity of infective larvae on pasture increase, resulting in more efficient transmission; can have major impact unless high camel herd mobility is maintained
- Increased aridity reduces efficiency of helminth larva transmission

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in all camel-keeping regions	Hot/Wet		Heavier endoparasite burden → **Increased** production **losses**; potentially higher impact than in cattle	Maintain high herd mobility; time anti-parasite treatment in relation to GI-helminth risk period
	Hot/Dry	Lighter endoparasite burden → **Reduced** production **losses**		

SALMONELLOSIS[xxii]

- Bacteria living in the gastro-intestinal tract of humans and animals; more than 2000 *Salmonella* serotypes are known worldwide (including a few host-specific types); these cause different clinical diseases, including septicemia, diarrhea, and abortions; mortality is seen mainly in young animals; high prevalence in camel herds; important Zoonosis.
- Fecal-oral transmission occurs via diseased and healthy salmonella carriers that contaminate the environment with their feces; salmonella survive for long periods in water and in wet shaded micro-environments.
- Transmission in semi-arid areas occurs mainly via crowded and contaminated night enclosures.
- Lack of stable endemic immunity and common presence of healthy carriers lead to persistent losses, especially in young camels; despite extensive management, salmonella is very prevalent in camels and a major cause of diarrhea and deaths in camel calves – thus limiting herd growth.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid CC scenario results in enhanced pathogen survival and multiplication of pathogens in micro-environments (overnight enclosures) and more frequent exposure of camels to salmonella
- Humid CC impact can be somewhat minimized by maintaining high camel herd mobility
- Arid CC would lead to reduced salmonella exposure via contaminated overnight enclosures, especially in very mobile camel herds

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in all camel-keeping regions, with high carrier rates in many camel herds	Hot/Wet		Enhanced pathogen survival in micro-environments → **Increased losses**	Improved vaccination cover, high mobility
	Hot/Dry	**Reduced losses** under mobile management system		

ANIMAL-ANIMAL TRANSMITTED DISEASES

BRUCELLOSIS[xxiii]

- Bacterial pathogen (*Brucella abortus* and *Brucella melitensis*) causing abortion in pregnant camels and leading to persistent infections in adults (= healthy carriers); important zoonosis in areas with common raw milk consumption.
- The most important *Brucella* transmission route via the environment is less efficient in arid regions where camels are kept.
- *Brucella* is less common in camels as compared to other livestock species.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid scenario results in better pathogen survival on pasture and more efficient transmission
- Increased aridity would reduce efficiency of transmission on pasture
- Transmission via pasture not very efficient in highly mobile camel herds

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in the whole Sahel; reported in 2012 by Niger and Senegal	Hot/Wet	Not significant		Improved vaccination cover
	Hot/Dry	Not significant		

CAMEL POX[xxiv]

- Viral pathogen (*Orthopoxvirus cameli*) causing fever, abortions, typical pox lesions on the skin, and lesions on the inner surfaces of the respiratory tract; self-limiting, but secondary respiratory infections can cause deaths in weaned young camels; occasionally a peracute form causing death within 24 hours occurs in adult camels that have not been exposed to pox virus before. Strains can differ in virulence.
- Transmitted by direct contact; under humid conditions biting insects transmit bacteria that super-infect skin lesions, which significantly prolongs the healing process and weakens the camel severely.
- Occurs in periodic epidemics that depend largely on the immune status of local camel herds.
- Economic importance because of loss in young camels and interference with breeding and lactation.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid conditions flies transmit bacteria that super-infect pox skin lesions and wet conditions also aggravate secondary respiratory infections that occur after primary pox infections
- In arid situation the poor nutritional status and low milk yield of lactating camels results in weaker camel calves that are more likely to undergo prolonged severe pox
- More frequent herd contact at watering points may enhance spread of virulent strains

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in all camel keeping regions of the Sahel,; reported last from Niger in 2010	Hot/Wet		More severe clinical disease → **higher losses**	Improved vaccination cover (vaccine currently only available in UAE)
	Hot/Dry	Less severe clinical disease → **lower losses** (modulating effect of nutritional status)		

DERMATOPHILOSIS[xxv]

- Bacterial pathogen (*Dermatophilus congolensis*) causing prolonged skin disease with scabs, and sometimes generalized skin lesions, after prolonged rainfall with intense wetting of the skin.
- Transmission is via direct contact; occurs only sporadically in camel-keeping regions after exceptionally strong rainfall.
- Normally no mortality, but has a strong debilitating effect on camels (more pronounced than in cattle).

Climate change influence on pathogen-transmission, livestock management, land use

- Humid CC scenario would bring longer periods with active infection and transmission over an expanded range

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Present in the whole Sahel; uncommon in camel keeping regions, only occurs in very wet years	Hot/Wet		More common occurrence → **Increase** in production **losses**	Migration into more arid area
	Hot/Dry	Less common occurrence → **Decrease** or even absence of production **losses**		

HEMORRHAGIC SEPTICEMIA (HS)[xxvi]

- In camels, a disease clinically similar to HS of cattle occurs in devastating outbreaks; climatic stress (= sudden transition from hot and dry to wet and cool conditions at the onset of rainy seasons) and poor body condition play an etiological role. HS in camels is peracute with sudden edema, respiratory distress, and hemorrhagic septicemia resulting in death within hours.
- There is a lack of information on the responsible pathogen and the transmission route; reportedly spread between herds requires close contact (e.g., at watering points).
- Outbreaks are very sporadic in nature with high mortality.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid CC scenario sudden intensive rainfall occurs more often, outbreaks could occur more frequently
- Arid conditions with poor nutrition lowers immune status and make camels more prone to severe disease
- Under arid conditions introduction of virulent strains is more likely due to more frequent herd contacts

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Not reported from countries west of Sudan; likely to be present in the Sahel	Hot/Wet		**More frequent** outbreaks in camel regions *(guesswork – no information on the etiology)*	Research into cause of camel HS
	Hot/Dry	**Less frequent** more severe outbreaks *(guesswork – no information on the etiology)*		

ORF (PUSTULAR DERMATITIS)[xxvii]

- Viral pathogen (*Parapoxvirus ovis*) is endemic in all camel-keeping regions. Lesions are similar to camel pox, but affecting mostly the head, lips, and mouth in young suckling camel calves. Healing is without problems unless calves are weak due to lack of milk; occasionally more severe form seen in weaners and sub-adult camels that have not been exposed to the virus before.
- Transmitted by direct contact; Orf virus in camels is possibly related to and shared with sheep and goats.
- Occurs regularly in relation to calving rhythm of the herd.
- Economic importance because of loss or stunting of camel calves.

Climate change influence on pathogen-transmission, livestock management, land use

- Under wet and unhygienic conditions, secondary bacterial infections prolong healing of Orf lesions resulting in more severe disease
- In arid situations there can be poor nutritional status and low milk yield of lactating camels resulting in weaker camel calves that suffer higher mortality

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Orf is endemic in all camel-keeping regions worldwide, including in the Sahel	Hot/Wet		More severe clinical disease → **higher losses**	Vaccination using sheep Orf vaccine
	Hot/Dry	Less severe clinical disease → **lower losses** (modulating effect of nutritional status)		

SHEEP AND GOATS

Compared to cattle, Small Ruminant flocks have shorter gestation intervals / higher birth rates and recover faster after drought. This has already led to over-proportional growth of goat/sheep populations. The result is an ever ***increasing relative importance of sheep and goat diseases****.*

VECTOR-BORNE DISEASES

BLUETONGUE[xxviii]

- Arthropod-borne viral pathogen ("Arbovirus") affecting particularly sheep; it causes severe inflammation of the nasal and oral cavity and of the coronary band above the hooves; there is strong muscle pain and swelling of the head and neck; extreme variability in clinical manifestation (almost invisible in endemic areas); mortality in sheep 2 to 30 percent; very mild in goats.
- Transmitted by midges (*Culicoides spp.*), which can be wind-carried over long distances; bluetongue episodes outside endemic humid to sub-humid areas occur in relation to seasonal high rainfall and strong winds; naïve sheep flocks moving from non-endemic arid into endemic sub-humid areas are at particularly high risk of severe disease.
- Severe clinical form: prolonged recovery period; renders sheep flock temporarily unproductive.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Higher rainfall leads to enhanced reproduction and biting activity of midges with an increase in virus transmission
- Wind speed affects long distance spread of infected midges
- Under arid conditions migration of naïve herds into endemically infected areas is more likely

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Virus very likely endemic in sub-humid parts of the Sahel, only reported by Algeria (camels suspected as silent carriers)	Hot/Wet		Endemic over expanded range → overall **higher losses**	Improved vaccination cover
	Hot/Dry	Smaller endemic area → overall **lower losses**		

HEARTWATER[xxix]

- Bacterial pathogen (*Ehrlichia ruminantium*, previously referred to as *Cowdria ruminantium*) causes fever, convulsion, central nervous symptoms (circling, loss of coordination), and sudden death in goats and sheep. Kids and lambs possess an age related innate resistance. Heartwater susceptibility is breed related, and regional strains can vary in virulence.
- Transmitted by ticks (*Amblyomma spp.* – this tick genus is very widely distributed over tropical Africa); good seasonal rains result in transient increase in heartwater transmission and prevalence.
- Economically more important in Eastern and Southern Africa than in the Sahel – possibly related to differences in virulence between regional *Ehrlichia ruminantium* strains.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Higher rainfall leads to enhanced reproduction and biting activity of ticks and an increase in pathogen transmission
- Under arid conditions migration of naïve herds into endemically infected areas is more likely to occur

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Present in the whole of Sub-Saharan Africa, wherever vector ticks occur; reported by Burkina Faso in 2012	Hot/Wet		Endemic over expanded range → overall **higher losses**	Increased use of resistant breeds
	Hot/Dry	Smaller endemic area → overall **lower losses**		

RIFT VALLEY FEVER (RVF)[xxx]

- Viral pathogen causing mass abortions, hemorrhagic hepatitis, and 70 percent-100 percent mortality in newborn lambs and kids, 10 percent-70 percent mortality in older sheep but less than 10 percent mortality in goats; very dangerous zoonosis.
- Transmitted by mosquitoes (Aedes & Culex), which can be wind-carried over long distances. RVF outbreaks in East Africa are triggered by abnormally high rainfall with flooding and mass-reproduction of the mosquito vectors, but no clear correlation has been established between RVF epidemics and high rainfall in West Africa.
- Occurs in periodic epidemics that affect several countries, including in the semi-arid Sahel Savanna.
- Sudden mass abortions and loss of a complete lamb/kid crop lead to complete disruption of reproductive and production cycles; in addition there is also the disruption of trade (slaughter ban). RVF can cause potentially lethal disease in humans exposed to infected livestock, especially sheep, during abortions and at slaughter.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Abnormally high rainfall with flooding leads to mass-reproduction of mosquitoes and a sudden surge in virus transmission
- Wind speed can affect long distance spread of infected mosquitoes
- In West Africa expansion of irrigation agriculture has improved conditions for virus transmission significantly

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
In 2012 outbreaks in Mauritania, Niger, Senegal; regional outbreaks occur at intervals of several years and affect predominantly sheep	Hot/Wet		Expanded area at risk & increased risk of outbreaks → Could become **major livestock & human disease problem; RVF impact on sheep is the highest of all livestock species**	Improved vaccination cover (new RVF vaccine has just become available)
	Hot/Dry	Reduced area at risk & decreased risk of RVF outbreaks; possibility of **new RVF foci** in irrigation areas		

TRYPANOSOMOSIS[xxxi]

- Protozoan blood parasites (in West Africa especially *Trypanosoma congolense and Trypanosoma vivax,* also *Trypanosoma brucei*) cause intermittent fever, lasting immune-suppression, chronic progressive anemia, progressive weight loss, and eventually death. Sheep breeds vary in susceptibility; trypano-tolerant sheep breeds kept in endemic sub-humid to humid regions are in general not suitable for semi-arid Sahel-Savanna conditions because they lack drought resistance and good trekking ability.
- Transmitted by tse-tse flies (*Glossina morsitans* group in open savanna habitats and *Glossina palpalis* group in riverine habitats); in adjacent areas without presence of tse-tse flies, transmission of Trypanosomes by biting flies can play a role (especially for *Trypanosoma vivax*).
- Present in all sub-humid regions ("Sudan Savanna") of West Africa where tse-tse flies occur.
- The negative effect on productivity of sheep populations is lower than in cattle because sheep are bitten by tse-tse less frequently than bovines; there is almost no impact on productivity of goats, which are only very sporadically bitten (and infected) by tse-tse flies.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Increased humidity favors increased tree cover (long-term) and enhances range, reproduction and feeding activity of tse-tse with more frequent trypanosome infection of sheep
- Increased aridity can lead to emergence of trypanosome transmission by biting flies in areas that become unsuitable for tse-tse
- Under humid scenario, shift towards trypano-tolerant sheep and goats
- In an arid CC scenario possibility of new localized tse-tse habitats in expanding irrigation areas

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Over the past three decades range of disease and its main vector (*G.morsitans)* has been shrinking, only of importance in southern (sub-humid) parts of the Sahel; reported in 2012 by Burkina Faso and Niger	Hot/Wet		**Higher losses** because of expanded range of tse-tse vector; lower impact than in cattle	Change to more trypano-tolerant sheep breeds or to goats instead of sheep
	Hot/Dry	**No losses**; tse-tse vector and disease may disappear		

ENVIRONMENTALLY TRANSMITTED DISEASES

ANTHRAX[xxxii]

- Spore-forming bacteria (*Bacillus anthracis*) found in soil and particularly in sediment of ponds and lakes; spores survive in the environment for decades, if not for centuries; when ingested during grazing or drinking the spores germinate into bacteria and cause a peracute septicemia that leads to instant death in sheep; important zoonosis.
- When carcasses are opened (e.g., by scavengers), bacteria form spores which again contaminate the environment; spores can be carried by floods onto clean pastures.
- Sporadic outbreaks occur particularly in dry season when sheep graze in dry flood zones and gather at overcrowded contaminated watering ponds; the disease is extremely aggressive and brief in sheep, which die suddenly in large numbers without showing clinical symptoms.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid CC scenario increased availability of grazing throughout the year with sheep and goats spending shorter time grazing in risky flood zones
- Increased aridity would see sheep and goat herds spend longer time in risky areas
- Increased flooding can spread infection onto new pastures, possible under both CC scenarios (sporadic flash floods also occur with arid CC)

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic on localized infected pastures, esp. in flood zones; reported 2012 by Burkina Faso, Chad, Niger, and Senegal	Hot/Wet	Less time spent grazing on infected pastures → **Lower losses**		
	Hot/Dry		Longer time spent grazing on infected pastures → **Higher losses**	Improved vaccination cover

CLOSTRIDIOSIS[xxxiii]

- Spore-forming anaerobic bacteria (*Clostridium spp.*) found in soil and in intestinal flora of mammals; spores survive in the environment and are regularly ingested during grazing; a sudden change in diet allows Clostridia in the guts to mass-multiply and produce lethal toxins that are rapidly absorbed from the intestine and kill especially young sheep/goats during their first grazing season within a few hours (sometimes animals are found dead); older animals develop good immunity.
- Following good rainfall with fast growth of young lush grass, the sudden change in diet destabilizes the animals' intestinal conditions and triggers mass-multiplication and toxin production of Clostridia; this does not represent a true infection because the pathogens are already part of the normal intestinal flora (= enterotoxaemia).
- Occurrence of pathogenic Clostridia in pastures is not uniform, but is affected by soil type (content of organic matter, pH); sporadic seasonal outbreaks occur more often in certain areas than in others; immunity of adult sheep/goats depends on previous exposure and cannot always be relied upon.
- Economically important because large numbers of young sheep/goats are lost suddenly.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid CC scenario, more frequent grazing of sheep on young lush growth, increases likelihood of outbreaks
- With humid CC scenario, sheep and goats could also move further north and infest currently arid pastures with Clostridia spores

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in sheep-keeping regions worldwide, occurs on soils that are rich in organic substance, regular seasonal outbreaks	Hot/Wet		Disease occurs more frequently → **Higher losses**	Improved vaccination cover
	Hot/Dry	Disease occurs less frequently → **Lower losses**		

FLUKE (FASCIOLA)[xxxiv]

- Trematode parasites (in the Sahel especially *Fasciola gigantica*), adult stages parasitize the bile ducts of the liver in ruminants. The infective larval stage causes tissue damage due to mass migration through the tissue of the liver and other internal organs, resulting in massive internal bleeding (not treatable) and sudden death especially in young sheep. The adult stage causes chronic loss of red blood cells and blood plasma resulting in a persistent wasting disease in older sheep, which is much more severe and progresses to a critical stage much faster than in cattle.
- Indirect transmission cycle includes environmental phase with developmental parasite stages living in water snails (= intermediate hosts), released infectious larvae encyst on vegetation and re-enter sheep host during grazing on fluke-infested pasture.
- Occurs in localized aquatic habitats (near permanent water and in flood zones), including in irrigation schemes (*Fasciola gigantica* gains new habitats though construction of water reservoirs and dams).
- Acute Fasciolosis can lead to significant losses of young sheep and severe loss in condition in adult sheep; unless strategic prophylactic treatments are applied, keeping sheep in fluke-infested areas is uneconomical.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid CC scenario creates more suitable snail habitats that support parasite transmission
- Increased aridity reduces snail habitats
- Under humid CC scenario herds depend less on fluke infested grazing; with increased aridity, herds are more likely to graze on fluke infested pastures

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in specific habitats (swamps, around water reservoirs, irrigation areas)	Hot/Wet	Less time spent grazing risky pasture → **Lower losses**		
	Hot/Dry		Longer time spent grazing risky pastures → **Higher losses**; higher impact than in cattle	Strategic anti-parasite treatment before losses occur

FOOTROT[xxxv]

- Bacterial pathogens (*Dichelobacter nodosus*) cause footrot in sheep and occasionally in goats, manifested by severe lameness with sheep being unable to walk and graze. Healing of the hooves is very protracted and often incomplete. Susceptibility is breed-dependent.
- Transmission does not require direct contact and occurs mostly via contaminated environment (pasture, trekking routes); the duration of survival of the pathogen in the environment is closely controlled by climatic conditions (humidity, ultraviolet radiation); unprotected watering points important for transmission under arid conditions.
- Causes severe drop in body condition and productivity as well as the need to cull many sheep that remain with malformed hooves.
- Footrot is common and economically very important in most sheep-keeping regions; in semi-arid regions brief seasonal outbreaks can affect large numbers of sheep.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid pastures are an absolute precondition for pathogen transmission and disease
- Management can mitigate humid CC effect on ranches and in closed farms, but this is very difficult under communal grazing

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in sheep worldwide, outbreaks are strictly linked to wet conditions	Hot/Wet		Disease occurs much more frequently → significantly **increased** production **losses**	Improved vaccination cover, foot baths
	Hot/Dry	Disease absent over long periods → significantly **reduced** production **losses**		

GASTRO-INTESTINAL HELMINTHS[xxxvi]

- Gastro-intestinal parasites, adult stages live in the stomach or intestine. Some species attach to the lining of the stomach or the intestine and suck blood. Pathogenicity varies depending on the level of infestation and on helminth species. They interfere with digestion and some can cause severe anemia (in sheep, especially *Haemonchus contortus*).
- Transmission cycle includes environmental larval phase that lives on pasture vegetation. Infective larvae are only active on pasture under humid conditions, and survive only for a rather limited period on pastures under hot and arid conditions; transmission in the semi-arid areas occurs seasonally during rains.
- High infection rate causes wasting disease and interferes massively with lamb growth (deaths possible); adult sheep and goats do not develop resistance and are severely affected by high burdens of gastro-intestinal helminthes. This is the single most important disease factor affecting productivity of sheep and goat flocks worldwide – but is of less economic importance under extensive highly mobile management in arid regions.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid CC scenario lifespan and activity of infective larvae on pasture increase, resulting in more efficient transmission
- Increased aridity reduces efficiency of transmission
- Herd mobility is a modulating factor; humid CC impact is felt more in stationary farm based animals grazing on permanent pastures

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic worldwide in all sheep keeping regions, a **major productivity factor** in sheep and goat herds	Hot/Wet		Heavier endoparasite burden → **Increased** production **losses**; much higher impact than in cattle – likely to gain **even more importance** in sheep/goats	Anti-parasite treatment timed in relation to expected GI-helminth risk; breed helminth-resistant sheep
	Hot/Dry	Lighter endoparasite burden → **Reduced** production **losses**		

SALMONELLOSIS[xxxvii]

- Bacteria living in the gastro-intestinal tract of humans and animals; more than 2000 salmonella serotypes (incl. a sheep specific type *Salmonella abortis ovis*) cause different clinical diseases incl. septicemia, diarrhea, and abortions; affect mainly young animals; important zoonosis.
- Fecal-oral transmission via diseased and healthy salmonella carriers that contaminate the environment with their feces; salmonella can survive for long periods in water and in wet shaded micro-environments.
- Salmonella is more prevalent under intensive husbandry conditions; transmission in extensive production systems in the semi-arid areas occurs mainly via crowded and contaminated night enclosures.
- Lack of stable endemic immunity, and common presence of healthy carriers, leads to persistent losses through abortions and from deaths in young animals. Cumulative production losses are often overlooked.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid CC scenario results in enhanced pathogen survival and multiplication of pathogens in micro-environments leading to a higher salmonella infection rate in sheep and goats
- Increased aridity reduces exposure of animals to salmonella
- Transmission via contaminated overnight enclosures in mobile pastoralist systems is more affected by increased aridity than transmission in housed farm animals grazing on permanent pastures

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in the whole Sahel	Hot/Wet		Enhanced pathogen survival in micro-environments → Slightly **increased losses**	Improved vaccination cover
	Hot/Dry	Slightly **reduced losses** under mobile management system		

ANIMAL-ANIMAL TRANSMITTED DISEASES

CONTAGIOUS CAPRINE PLEURO-PNEUMONIA (CCPP)[xxxviii]

- Bacterial pathogen (*Mycoplasma capricolum ssp. capripneumoniae,* previously referred to as *Mycoplasma* strain F38) causes a severe respiratory disease in goats with 100 percent morbidity and 80 percent mortality upon exposure of non-immune naïve herds; surviving goats develop chronic progressive pneumonia that does not respond well to antibiotic treatment and are often unable to maintain sufficient lactation for raising their kids.
- Transmission takes place via aerosols containing infectious droplets and requires close contact; does not infect sheep.
- Unless controlled, CCPP is common under intensive and extensive husbandry conditions; affected animals and **whole goat herds become unproductive and have to be slaughtered**.
- CCPP interferes with pastoralist milk production and severely affects cash income through loss in market value and reduced sales of goats.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid conditions favor pathogen survival in infectious aerosols with more efficient transmission
- Arid conditions with poor nutrition lower the resistance of goats to this infection
- Under arid CC, scenario higher risk of pathogen transmission due to more frequent herd contacts at fewer watering points and on overstocked pastures

Current Disease Status in the Sahel	Climate Change Scenario	Expected Climate Change Impacts by 2025		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in most of the Sahel, reported by Niger in 2010 and by Chad in 2012	Hot/Wet	No clear CC impact		Improved vaccination cover
	Hot/Dry	No clear CC impact; more frequent outbreaks possible in highly mobile pastoralist livestock		Improved movement control and systematic vaccination campaign

ORF (PUSTULAR DERMATITIS)[xxxix]

- Viral pathogen (*Parapoxvirus ovis*) endemic in all sheep-keeping regions; pox-like lesions form mostly on the head, lips, and mouth in young suckling lambs and kids. Healing is without problems unless lactating ewes / goats are underfed and give little milk → lack of milk results in weak lambs/kids and potentially high losses.
- Transmitted by direct contact; Orf virus of sheep goats and camels may be identical and infection can be transmitted and shared between the three livestock species.
- Orf occurs regularly in relation to lambing rhythm of the herd.
- Economic importance because of loss or stunting of lambs and kids.

Climate change influence on pathogen-transmission, livestock management, land use

- Under wet unhygienic conditions secondary bacterial infections complicate healing of Orf lesions resulting in prolonged and more severe disease
- In arid situations, there can be poor nutritional status and low milk yield of ewes and goats with weaker lambs and kids that suffer higher mortality

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in all sheep-keeping regions worldwide	Hot/Wet		More severe clinical disease → **higher losses**	Improved vaccination cover
	Hot/Dry	Less severe clinical disease → **lower losses** (modulating effect of nutritional status)		

OVINE BRUCELLOSIS[xl]

- Bacterial pathogen (*Brucella melitensis*) causing abortion in sheep and goats and also leading to persistent healthy adult carriers; it is excreted in the milk of healthy carriers (=persistently infected adult goats and sheep) – important zoonosis in areas with common raw milk consumption.
- Transmission via the environment (stables, enclosures, paddocks) which is contaminated with *Brucella* during abortion; this route plays a by far greater role than occasional venereal transmission; *Brucella* can survive for a short period in humid shaded micro-environments.
- Unless controlled, *Brucella* is common under intensive and extensive husbandry conditions; transmission in extensive production systems in the semi-arid areas occurs mainly via contaminated night enclosures.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid scenario results in better pathogen survival on pasture and more efficient transmission
- Increased aridity reduces transmission on pasture
- Transmission via contaminated pastures and overnight enclosures in mobile pastoralist systems is more affected by increased aridity than transmission in housed farm animals on permanent pastures

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in the Sahel, reported by Niger in 2012	Hot/Wet	No clear CC impact		Improved vaccination cover
	Hot/Dry	No clear CC impact; slightly reduced transmission possible in highly mobile pastoralist herds		

PESTE DES PETITS RUMINANTS (PPR) (A.K.A. GOAT PLAGUE)[xli]

- Viral pathogen endemic to West Africa, casuing acute pneumo-enteritis (respiratory tract and intestine affected → diarrhea and pneumonia) in goats and sheep; more severe in goats than in sheep; in naïve herds infected for the first time, morbidity in goats is 100 percent and mortality 90 percent; potentially high losses also occur in sheep (40-60 percent mortality). In endemic situation losses are much lower, affecting especially young animals.
- Historically more common in sub-humid and humid parts of West-Africa, now occurs in all parts of the Sahel from Atlantic to the Indian Ocean and in Asia.
- Transmitted by close direct contact; the virus is very sensitive to heat and to sunlight, and it does not survive outside the host.
- The most deadly and economically the most important infectious disease and the most important single cause of disease and death in small ruminants (especially goats); currently targeted by OIE/FAO for worldwide eradication (similar to Rinderpest).
- Poses a serious threat to livestock dependent pastoralist and agro-pastoralist livelihoods, especially where PPR epidemics affect non-endemic regions.

Climate change influence on pathogen-transmission, livestock management, land use

- Under arid conditions, transmission becomes more likely due to much more frequent herd contacts at watering points and on overstocked pastures; arid scenario also favors introduction into new areas via unusual long distance herd migration
- Humid conditions and shade (lower temperature) favor transmission of virus

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
PPR range covers the whole Sahel; endemic with sporadic outbreaks, reported in 2012 by Burkina Faso, Mauritania, Niger, Senegal, and Chad; eradication efforts in Africa are beginning in 2014	Hot/Wet	No clear CC impact		Worldwide eradication of PPR foreseen → disease will hopefully disappear from the Sahel and Africa in the future
	Hot/Dry	No clear CC impact; more frequent outbreaks possible in highly mobile pastoralist goats and sheep		

SHEEP & GOAT POX[xlii]

- Viral pathogen causing fever, abortions, typical pox lesions on the skin, and lesions on the inner surfaces of the respiratory tract; self-limiting, but secondary respiratory infections can cause multiple deaths especially in weak lambs and kids (this is directly related to nutritional status and milk yield of lactating ewes/goats).
- Transmitted by direct contact; under humid conditions biting insects transmit bacteria that super-infect skin lesions, which significantly prolongs the healing process and weakens lambs/kids severely.
- Occurs in periodic epidemics that depend largely on lambing cycle and on the immune status of the sheep/goat herd.
- Economic importance is due to loss and stunting in young lambs/kids.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid conditions flies act as mechanical transmitters of bacteria that super-infect pox lesions and secondary respiratory infections can kill lambs/kids
- In arid situations, there can be poor nutritional status and low milk yield of ewes/does with weaker lambs/kids that suffer more from pox
- With arid CC scenario, there can be more frequent herd contact at watering points and enhanced spread of more virulent strains

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in the whole Sahel; reported by Burkina Faso, Niger, and Senegal in 2012	Hot/Wet		More severe clinical disease → **higher losses**	Improved vaccination cover
	Hot/Dry	Less severe clinical disease → **lower losses** (modulating effect of nutritional status)		

CHICKENS

While trade in chickens, in one-day-chicks and in eggs plays a major role in pathogen transmission the distinction between vector-borne, environmental, and animal-to-animal transmission is not always as clear cut in chickens as it is in other livestock.

VECTOR-BORNE DISEASES

FOWL POX[xliii]

- A chicken-specific pox virus causing typical pox lesions and also generalized disease in chicken of all age groups; protracted outbreaks; generalized form causes mortalities.
- The infection is transmitted by mosquitoes (*Culex spp.),* which, once infected, harbor infectious virus for months; disease prevalence is linked to seasonal vector density and activity; virus is also spread by direct contact.
- Stress leads to flare-up of latent pox infection.
- Important mainly because of production losses over extended periods.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Heat stress → flare-up of latent pox infection;
- Higher rainfall → enhanced mosquito reproduction & activity → increase in virus transmission;
- Increased aridity → reduced mosquito population (e.g. *Culex quinquefasciatus*) → less frequent and less efficient pox transmission
- Increased aridity → reduced availability and increased prices of chicken feed → chicken in poor body condition & more susceptible

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Present in the whole Sahel	Hot/Wet		Increased risk of outbreaks and **higher** production **losses**	Improved vaccination cover
	Hot/Dry	Reduced risk of outbreaks → **lower** production **losses**		Ensure adequate quantity and quality of chicken feed

ENVIRONMENTALLY TRANSMITTED DISEASES

AVIAN COCCIDIOSIS[xliv]

- Decreased growth rate, severe diarrhea, and also high mortality (depends on infection level) caused by 50 coccidia (*Eimeria spp.*), intestinal protozoan parasites that are universally present in chicken flocks. Coccidia can survive for very long periods in contaminated environment depending on environmental conditions (50 coccidia are resistant to disinfection). Disease only occurs after ingestion of large numbers of coccidia.
- Important because it cannot be eradicated from chicken flocks; requires frequent medication, poses permanent mortality threat, especially to younger birds, and causes constant production losses.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid CC scenarios, there is a longer survival and higher buildup of coccidia in the environment
- Increased aridity → recued availability and increased prices of chicken feed → chicken in poor body condition and more susceptible

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in all chicken-keeping regions worldwide	Hot/Wet		More frequent disease → **higher losses**	Prophylactic anti-coccidial drugs
	Hot/Dry	Less frequent disease → **lower losses** (modulating effect of poor body condition)		Ensure adequate quantity and quality of chicken feed

GASTRO-INTESTINAL HELMINTHS[xlv]

- Gastro-intestinal parasites, helminths are especially important in free ranging chickens; adult stages live in the gizzard, trachea, esophagus, and small and large intestine; pathogenicity varies considerably depending on the level of infestation and on helminth species; they interfere with digestion and some can cause anemia and death.
- Transmission cycle includes environmental larval phase many of which require an intermediate host for their life-cycle (ants, cockroaches, snails, earthworms, beetles, grasshoppers etc.); life-cycles to produce infective larvae are sensitive to hot and arid conditions.
- High infection rates cause wasting disease and even death → potentially high and continuous negative impact on production.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid CC scenario lifespan and activity of infective larvae and intermediate hosts increases → more efficient transmission
- Increased aridity reduces efficiency of transmission → reduced exposure

Current Disease Status in the Sahel	Climate Change Scenario	Expected Climate Change Impacts by 2025		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in free ranging chickens worldwide	Hot/Wet		Heavier endoparasite burden → **increased losses**	Anti-parasite treatment
	Hot/Dry	Lighter endoparasite burden → **reduced losses**		

GUMBORO DISEASE[xlvi]

- Viral pathogen is endemic in all chicken-keeping regions; causes severe long lasting immune-suppression (subclinical form) or weakness, in-coordination, and diarrhea (acute form).
- Mortality can be as high as 20 percent, Transmitted by direct and indirect contact, very stable in the environment → difficult to eradicate from infected premises.
- Economic importance because of suppressed production and mortalities.

Climate change influence on pathogen-transmission, livestock management, land use

- The effect of both humid and arid CC scenarios is limited because the virus survives for long periods in contaminated premises

Current Disease Status in the Sahel	Climate Change Scenario	Expected Climate Change Impacts by 2025		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in chicken-keeping regions	Hot/Wet	No clear CC impact		Improved vaccination cover
	Hot/Dry			

SALMONELLOSIS[xlvii]

- Bacteria living in the gastro-intestinal tract of humans and animals; more than 2000 *Salmonella* serotypes are known worldwide (incl. some few host specific types) and cause different clinical diseases incl. poor growth; weakness; diarrhea; septicemia & mortality is seen mainly in young chicken; high prevalence in chicken flocks; important zoonosis and of major food safety concern.
- Fecal-oral transmission occurs via salmonella carriers that contaminate the environment with their feces; salmonella can survive for long periods in water and in wet shaded micro-environments.
- Transmission in chickens is mainly via crowded and contaminated premises.
- Persistent losses are seen, especially in young chickens, as is contamination of chicken products entering the food chain.

Climate change influence on pathogen-transmission, livestock management, land use

- Humid CC scenario results in enhanced pathogen survival and multiplication inside premises → higher salmonella exposure in chicken;
- Increased aridity → reduced exposure of chicken to salmonella
- Increased aridity → poor availability and increased prices of chicken feed → chickens in poor body condition are more susceptible

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in chickens worldwide	Hot/Wet		**Higher losses**	Improved hygiene on premises
	Hot/Dry	**Reduced losses** (modulating effect of poor body condition)		Ensure adequate quantity and quality of chicken feed

ANIMAL-ANIMAL TRANSMITTED DISEASES

NEWCASTLE DISEASE (ND)[xlviii]

- Occurs in periodic epidemics that depend largely on the immune status of the local chicken population and/or introduction of highly virulent virus strains; produces mostly acute respiratory symptoms, but also nervous signs and diarrhea; mortality varies extremely and depends on virus strain – velogenic (= highly virulent) Newcastle disease is endemic in many parts of Africa and regularly destroys whole village chicken populations.
- Fecal-oral and aerosol transmission occur; aerosol transmission accelerated by wind results in much faster and wider spread within localities.
- Velogenic (= highly virulent) Newcastle disease is the most important infection in chicken and the single most important obstacle to improved chicken productivity in Africa.

Climate change influence on pathogen-transmission, livestock management, land use

- Wind speed affects local transmission
- In a more arid scenario there are reduced habitats for overwintering migratory birds that would concentrate in smaller wetlands with increased risk of spread of velogenic virus strains
- Arid and humid CC scenarios can both alter routes of migratory birds

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in chicken keeping regions worldwide, in Africa presence of very pathogenic (velogenic) ND virus strains; reported in 2012 from Burkina Faso, Niger, Senegal, and Chad	Hot/Wet	No clear impact		
	Hot/Dry		More frequent Newcastle Disease outbreaks likely → **increased losses**	Improved vaccination cover

HIGHLY PATHOGENIC AVIAN INFLUENZA (HPAI)[xlix]

- Occurs in worldwide periodic pandemics; clinical picture extremely variable depending on the HPAI strain; varies from acute febrile respiratory disease with very high losses to clinically almost inapparent mild infections; high zoonotic potential capable of causing worldwide human influenza pandemics – mild and acute forms are both very dangerous for humans.
- Transmission occurs through trade in live chicken and eggs and by wild migratory birds; migratory routes of wild birds are affected by CC; co-evolution has allowed different species of wild birds to resist and tolerate HPAI infection without impediment of their migratory range and ability.
- Direct losses related to high mortality/destruction of infected flocks, reduced egg production, and decreased weight gains.
- Indirect costs include clean-up, complete disruption of trade, disruptions in production schedules, costs for restocking, and lost income.

Climate change influence on pathogen-transmission, livestock management, land use

- More arid climate → reduced wetland habitats for over-wintering migratory birds that concentrate in smaller areas with increased risk of spread of HPAI
- Arid & humid CC scenario can both alter routes of migratory birds
- Housing chicken reduces transmission risk; main spread of HPAI is through trade

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
A threat to chickens and humans worldwide; reported during last global outbreak by Burkina Faso and Niger	Hot/Wet	**No** major **change**		Raised alertness and prompt stamping out of infected flocks to prevent further spread
	Hot/Dry		**Increased risk** because of higher concentration of migratory birds in fewer over-wintering habitats	

PULLORUM DISEASE[I]

- Host specific salmonella (*Salmonella pullorum*) causes very high loses (up to 100 percent) in chicks and young chicken.
- This is transmitted primarily through the egg (chick already infected at hatching); also transmitted by direct contact; shed by carriers.
- Occurs in all chicken-rearing regions where it has not been eradicated.
- Great economic importance because of high mortality.

Climate change influence on pathogen-transmission, livestock management, land use

- Transmission via eggs not affected by CC
- Heat stress in housed chicken could potentially increase disease severity

Current Disease Status in the Sahel	Climate Change Scenario	Expected Climate Change Impacts by 2025		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in chicken keeping regions worldwide	Hot/Wet	Apart from heat stress in housed chicken no clear CC impact		Improved vaccination cover
	Hot/Dry			

MAREK DISEASE[Ii]

- Viral pathogen endemic in all chicken-keeping regions worldwide; strains vary widely in virulence; can cause tumors and mortality in up to 80 percent of young birds; causes transient paralysis, depression, and death.
- Easily transmitted by direct contact; virus can also survive in litter for months; stress leads to resurgence of occult infection.
- Economic importance because of mortality.

Climate change influence on pathogen-transmission, livestock management, land use

- Transmission not affected by CC
- Heat stress can reactivate occult infections in housed chicken

Current Disease Status in the Sahel	Climate Change Scenario	Expected Climate Change Impacts by 2025		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in chicken-keeping regions worldwide	Hot/Wet	Slightly **increased risk** of outbreaks in housed chicken (increased heat stress)		Improved vaccination cover
	Hot/Dry			

AVIAN INFECTIOUS BRONCHITIS[lii]

- Viral respiratory pathogen (a Corona-virus) endemic in all chicken-keeping regions worldwide; outbreaks occur in relation to flock/population immunity; strains vary widely in virulence; some strains can cause kidney failure and high mortality
- Easily transmitted by direct contact and infectious aerosols; stress affects severity of outbreaks
- Economic importance because of severe loss in production while 100 percent of the flock suffers from respiratory disease

Climate change influence on pathogen-transmission, livestock management, land use

- Transmission not affected by CC; heat stress exacerbates clinical disease in housed chicken

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in chicken-keeping regions worldwide	Hot/Wet Hot/Dry	More severe outbreaks (heat stress) → **higher** production **losses** in housed chicken		Improved vaccination cover

AVIAN MYCOPLASMOSIS[liii]

- Bacterial respiratory pathogen (especially *Mycoplasma gallisepticum*) endemic in all chicken-keeping regions worldwide; causes chronic respiratory disease in chicken flocks; strains vary in virulence.
- Transmission occurs via infected eggs, but it is also easily transmitted by infectious aerosols; stress affects severity of outbreaks.
- Economic importance because of severe loss in egg production and frequent condemnation of carcasses of birds that have recovered from respiratory disease.

Climate change influence on pathogen-transmission, livestock management, land use

- Heat stress exacerbates clinical disease in housed chicken

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in chicken-keeping regions worldwide	Hot/Wet Hot/Dry	More severe outbreaks (heat stress) → **higher** production **losses** in housed chicken		Improved vaccination cover

FOWL CHOLERA[liv]

- Various bird specific *Pasteurella mulocida serotypes* cause sporadic sudden septicemia ("sudden death") with very high losses (up to 100 percent) in chicken; survivors become chronic carriers.
- Transmitted primarily through direct contact; shed by carriers.
- Occurs in all chicken rearing regions.
- Economic importance because of sudden high mortality.

Climate change influence on pathogen-transmission, livestock management, land use

- Outbreaks triggered by introduction of virulent Pasteurella serotypes into unprotected flocks; no CC impact; trade is a major risk

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Endemic in chicken keeping regions worldwide	Hot/Wet	No clear CC effect		Improved vaccination cover (difficult due to multiplicity of serotypes)
	Hot/Dry			

DONKEYS, MULES, AND HORSES

VECTOR-BORNE DISEASES

AFRICAN HORSE SICKNESS[lv]

- Arthropod-borne viral pathogen (an "Arbovirus") affecting particularly horses (mortality 70 percent to 95 percent) – but also mules (mortality 50 percent to 70 percent) and donkeys (different breeds possess different levels of resistance; very mild in local donkeys in endemic areas); it causes severe inflammation of the lungs and severe respiratory distress (peracute pulmonary form → death within hours) or swelling of the head and neck and stiffness (death after three to six days). Extreme variability is seen in clinical manifestation (mild in endemic areas in animals in good body condition).
- It is transmitted by midges (*Culicoides spp.*), which can be wind-carried over long distances; the virus is remarkably heat-stable and survives in tissues of dead animals for very long periods; disease in endemic areas is seasonal directly related to vector activity. AHS episodes outside endemic areas have occurred in relation to movement of infected horses/donkeys, high rainfall, and strong winds causing high mortalities in naïve horses, mules, and donkeys in North Africa and also in Spain.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Higher rainfall enhances reproduction and biting activity of midges and increases virus transmission
- Wind speed affects long distance spread of infected midges
- Concentration of donkeys/mules in irrigation areas offers favorable conditions for midges and for disease transmission

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
AHS is only present in some countries of the Sahel; reported by Mauritania in 2010 and by Senegal in 2012	Hot/Wet		**Increased** risk of disease introduction and spread	Movement control at borders for disease free countries; improved vaccination cover in infected countries
	Hot/Dry	**Reduced** risk of disease introduction		

TRYPANOSOMOSIS (INCL. TRYPANOSMA EVANSI)[lvi]

- The tse-tse transmitted *Trypanosoma vivax* and *Trypanosoma brucei*, to a lesser extent also *Trypanosoma congolense,* infect horses and donkeys and cause intermittent fever, lasting immune-suppression, progressive anemia, progressive weight loss, and eventually death. In horses and donkeys *Trypanosoma brucei* can cause death within one to three weeks; the Tabanid transmitted *Trypanosma evansi* causes a chronic disease in horses similar to the one observed in camels. Chronic Trypanosomosis cases do not respond well to treatment; they cannot be used for traction or for any other work, and are often culled.
- Transmitted by tse-tse flies (*Glossina morsitans* group in open Savanna habitats and *Glossina palpalis* group in riverine habitats) and by biting flies (Tabanids); frequency of transmission and disease is directly related to seasonal increase in vector population / biting activity.
- Present in all sub-humid and semi-arid parts of the Sahel.
- Can pose a threat to crop production because increased vector activity overlaps with the planting and growing season.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Increased humidity enhances range, reproduction, and feeding activity of tse-tse and other biting flies (*Tabanus, Stomoxys*) → donkeys will be more often infected with trypanosomes
- Under arid scenario and/or more intensive land cultivation *Glossina morsitans* is likely to disappear

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Tse-tse transmitted trypanosomes only found in southern parts of the Sahel (shrinking range); *T. evansi* is endemic in the whole Sahel	Hot/Wet		Higher transmission risk in wider area → **Increased loss of traction power**	Improved tse-tse control (traps) and use of repellents
	Hot/Dry	Lower transmission risk for *T. evansi;* tse-tse transmitted trypanosomes may disappear → **Reduced loss of traction power**		

ENVIRONMENTALLY TRANSMITTED DISEASES

GASTRO-INTESTINAL HELMINTHS AND LIVER FLUKE[lvii]

- Can affect horses in a similar way as other herbivorous livestock. Lung-worms transmitted via pasture can play an important role in donkeys, but require cool highland climate for efficient transmission.

Climate change influence on pathogen-transmission, livestock management, land use

- Under humid CC scenario lifespan, activity and transmission of flukes and helminths increases

Current Disease Status in the Sahel	Climate Change Scenario	Expected Climate Change Impacts by 2025		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
GI-Helminths are common in the whole Sahel, Flukes found only in specific habitats (swamps, water reservoirs, ponds)	Hot/Wet		Higher exposure → **Increased loss of traction power**	Anti-parasite treatment against helminths/ flukes
	Hot/Dry	Lower exposure → **Reduced loss of traction power**		

GLANDERS[lviii]

- Bacterial pathogen causes severe lung and also skin disease in horses and donkeys. Donkeys are more susceptible than horses and more likely to develop the acute form with high mortality, while horses develop a more chronic form. Horses may recover, but there is no stable immunity (depends on body condition).
- Transmission takes place mainly via contaminated environment (pathogen survives in water for up to 20 days) and through very close contact.
- Movement of sub-clinically infected horses is the most important means of spreading the infection.
- Dangerous zoonosis.

Climate change influence on pathogen-transmission, livestock management, land use

- Effect of humid and arid CC scenario both limited because pathogen is mainly spread by sub-clinically infected carriers
- Donkeys are more important for plowing and are also much more susceptible than horses

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
In the Sahel, so far only reported in Mauritania	Hot/Wet	**No CC related impact**		Improved cross-border movement control for imported horses to prevent spread to other countries in the Sahel
	Hot/Dry			

PIGS

VECTOR-BORNE DISEASES

AFRICAN SWINE FEVER (ASF)[lix]

- Tick-borne viral pathogen affects domestic pigs, causing mostly acute disease (mortality up to 100 percent within two to nine days). Local African domestic pig breeds are more resistant, and chronically infected survivors can occur in endemic areas. ASF causes mass abortions and death.
- A natural reservoir exists in wild warthogs that do not develop overt disease (the role of bushpigs as reservoir is less clear); it is transmitted between warthogs and free ranging domestic pigs by soft ticks (*Ornithodorus spp.*). Transmission between domestic pigs is entirely by direct contact; once the infection is established in domestic pigs the tick vector no longer plays a role in transmission; the virus survives only three days in pig houses. In West Africa ASF has not been found in warthogs, but outbreaks in domestic pigs do occur at intervals. ASF has spread outside endemic areas to Southern Europe and to Russia
- This is the most deadly infection in domestic pigs.

Climate change influence on vector, pathogen-transmission, livestock management, land use

- Higher rainfall → enhanced reproduction and activity of vector ticks → increased risk of virus transmission between wild warthogs and free ranging domestic pigs
- Adequate housing fully disrupts transmission between reservoir in the wild and domestic pigs

Current Disease Status in the Sahel	Climate Change Scenario	**Expected Climate Change Impacts by 2025**		Possible mitigation strategy
		Disease unlikely to gain in importance	**Disease likely to gain in importance**	
Distribution in the Sahel rather localized and not 100 percent clear; reported by Burkina Faso, Chad, and Senegal	Hot/Wet		**Increased risk** of transmission in free ranging domestic pigs	Development of an ASF vaccine (research currently ongoing)
	Hot/Dry	Reduced risk of transmission and **reduced importance** of pig industry (rising feed costs!)		

Note on sources: In addition to the texts listed in the endnotes, the author relied upon the following websites of the World Organisation for Animal Health (OIE) for additional information (all OIE websites accessed August, 2013): OIE World Animal Health Information Database (WAHID), http://www.oie.int/wahis_2/public/wahid.php/Wahidhome/Home; and OIE WAHID Country Timelines, http://www.oie.int/wahis_2/public/wahid.php/Countryinformation/Countrytimelines.

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U.S. Agency for International Development
1300 Pennsylvania Avenue, NW
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