Modelling common-pasture-based transhumant livestock husbandry under weather risk in Ferlo

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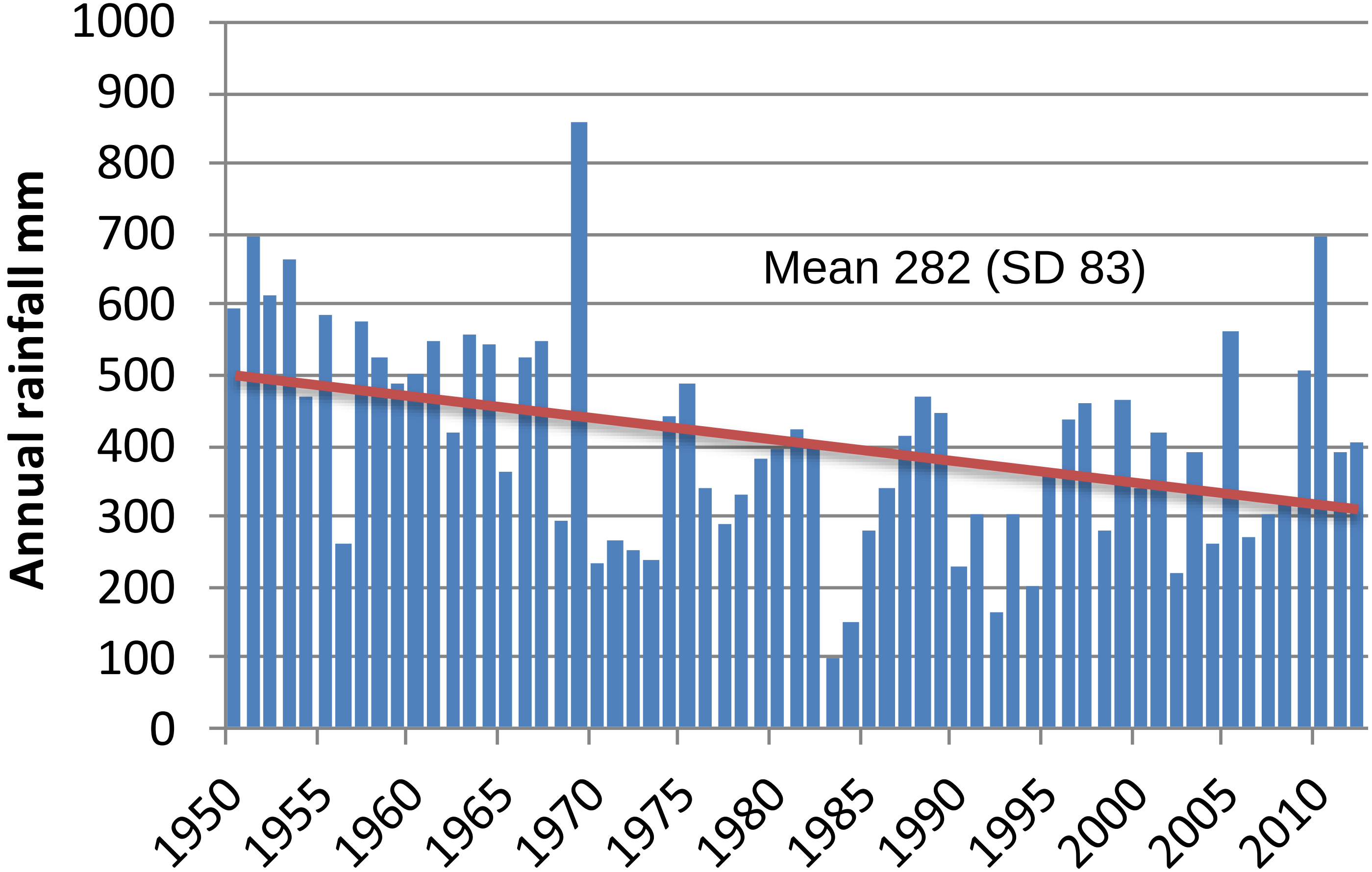
Background

- In Ferlo area household or part of it often moves seasonally with animals from a common pasture to another.

- Spatial pattern of rainfall is a key driver of the movement
  ➔ Climate change can have a major impact

- Historical perspective since 1950s from Ferlo
  - Human population has more than tripled
  - Animal population has increased accordingly
  - The amount of rainfall has decreased

Rainfall in Dahra has decreased but since 1970s the trend has been more stable



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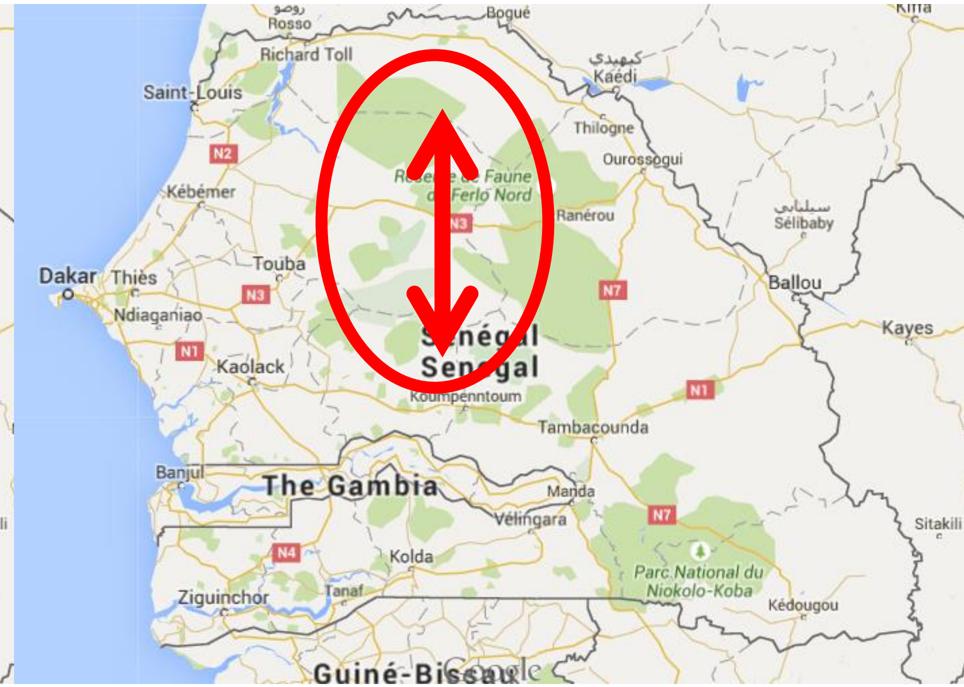
Transhumance in the 1950's and in 2000's

1950's

2000's



An example based on Cesaro *et al.*

➔Increased environmental pressure & competition on feed

➔Longer distances are travelled today than in the past

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Looking at the livestock sector

- Due to the increased vulnerability of dryland areas to climate shocks, we have invested considerable effort in understanding how pastoralists adapt to climate-driven fluctations in feed availability
- Capturing decisions around transhumance has required the use of specialized modeling techniques that can take the dynamics into account
- This allows us to model how decisions on stocking rates and animal movements might be affected by climate shocks
- We can also compare the effectiveness of moving animals versus feed across space (transhumance vs. feed markets)

Two-region model

DP model

- Uses some of the elements reported by Weikard & Hein (2011)
- Maximises the total value of livestock operations in two regions

$$V_t(\mathbf{S}_t, \mathbf{m}_t, \mathbf{r}_t) = \max_{\mathbf{h}_t}(\pi_t(\mathbf{S}_t, \mathbf{m}_t, \mathbf{r}_t, \mathbf{h}_t) + \delta V_{t+1} E((\mathbf{S}_{t+1}, \mathbf{m}_{t+1}, \mathbf{r}_{t+1})))$$

V=max value, S=stocking density, m=soil carbon content, r=annual rainfall, h=decision variables,π=one-period return, δ =discount factor

- Solves three decision variables for each year
  1. Which share of animals will participate in transhumance?
  2. What is the number of animals sold in Ferlo?
  3. What is the number of animals sold in Kaffrine?

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Study areas

- Ferlo
  - Little cultivated land, low rainfall and poor soil
  - Transhumance is a common form of animal husbandry
- Outside Ferlo
  - Kaffrine selected to represent more humid region
  - Byproducts from agriculture are available to feed the animals
- Modeled areas are assumed to be equally large

Animal stock dynamics

Dry area | **More humid area**

Year 1

Rainy season begins

Observe rainfall

Begin transhumance

Dry season

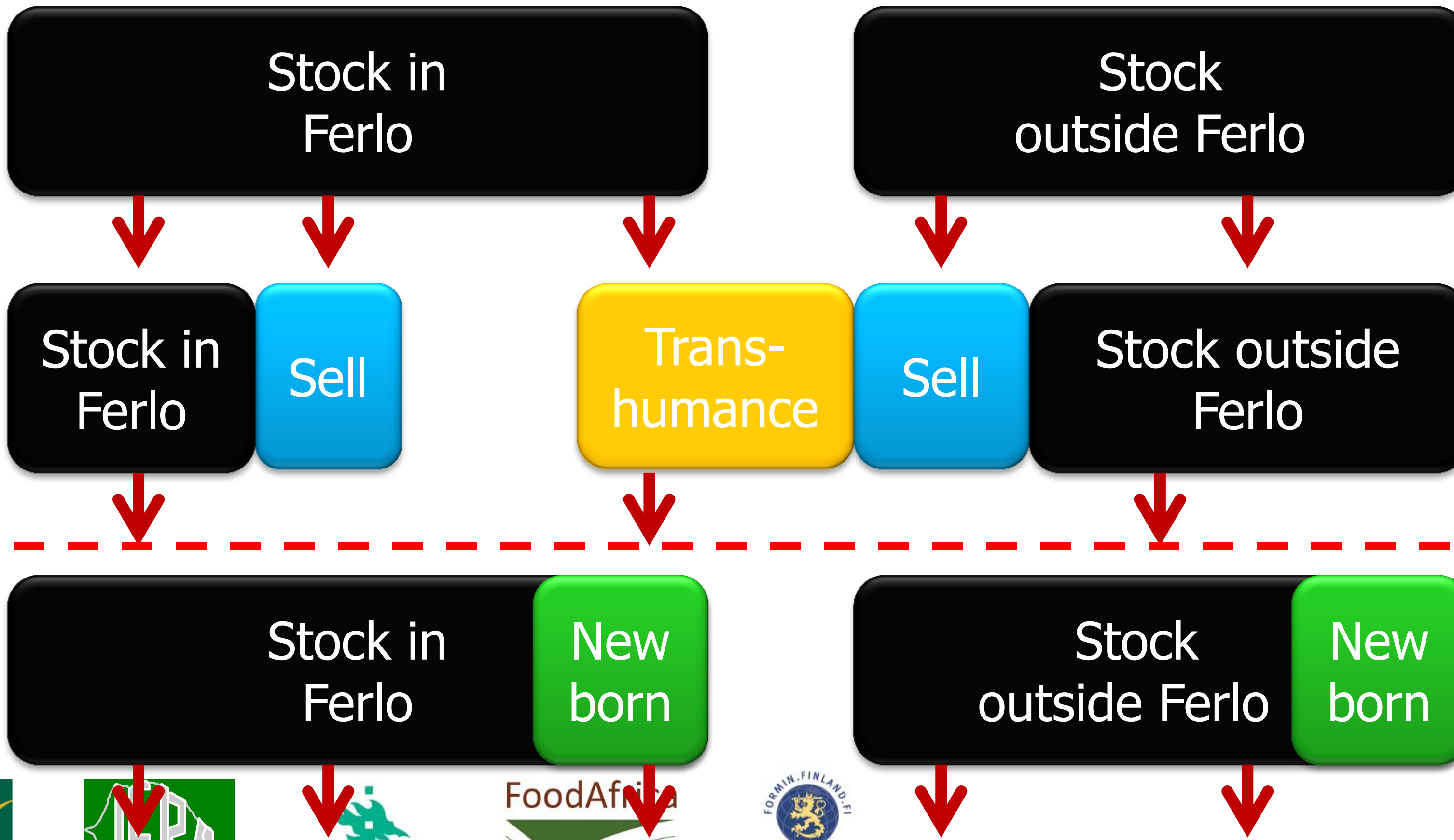
Decide sales

Return to Ferlo

New animals born

Year 2

Rainy season begins



Availability of biomass is determined by soil carbon and rainfall

Annual grass production = Impact of reduced carbon content × Soil carbon content ratio × Rain use efficiency × Rainfall

- Rainfall is considered as a stochastic factor
- Rain use efficiency is a parabolic function of observed rainfall

Soil carbon dynamics

Soil organic matter *t*+1 = Soil organic matter *t* + Annual grass production - Feed needed per animal × Stocking rate TLU per ha

The effects are very small in the short term

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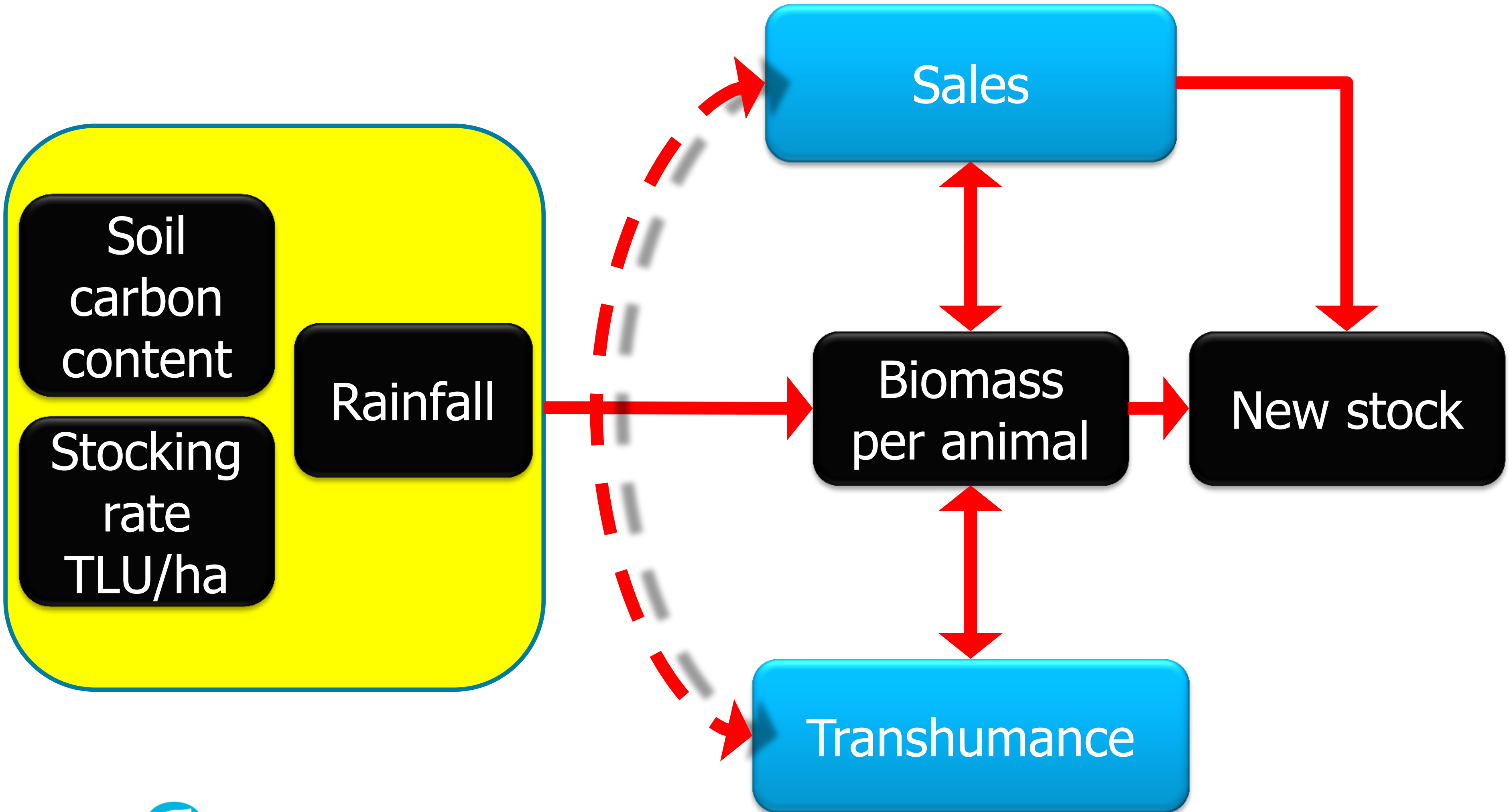
Model dynamics



Other assumptions

- Higher meat price is available outside Ferlo during the dry season than in Ferlo
- We change parameter values of the model one by one and examine how it affects the results!
- Use the change in animal stock, % livestock participating in transhumance and the value of livestock activity as indicators

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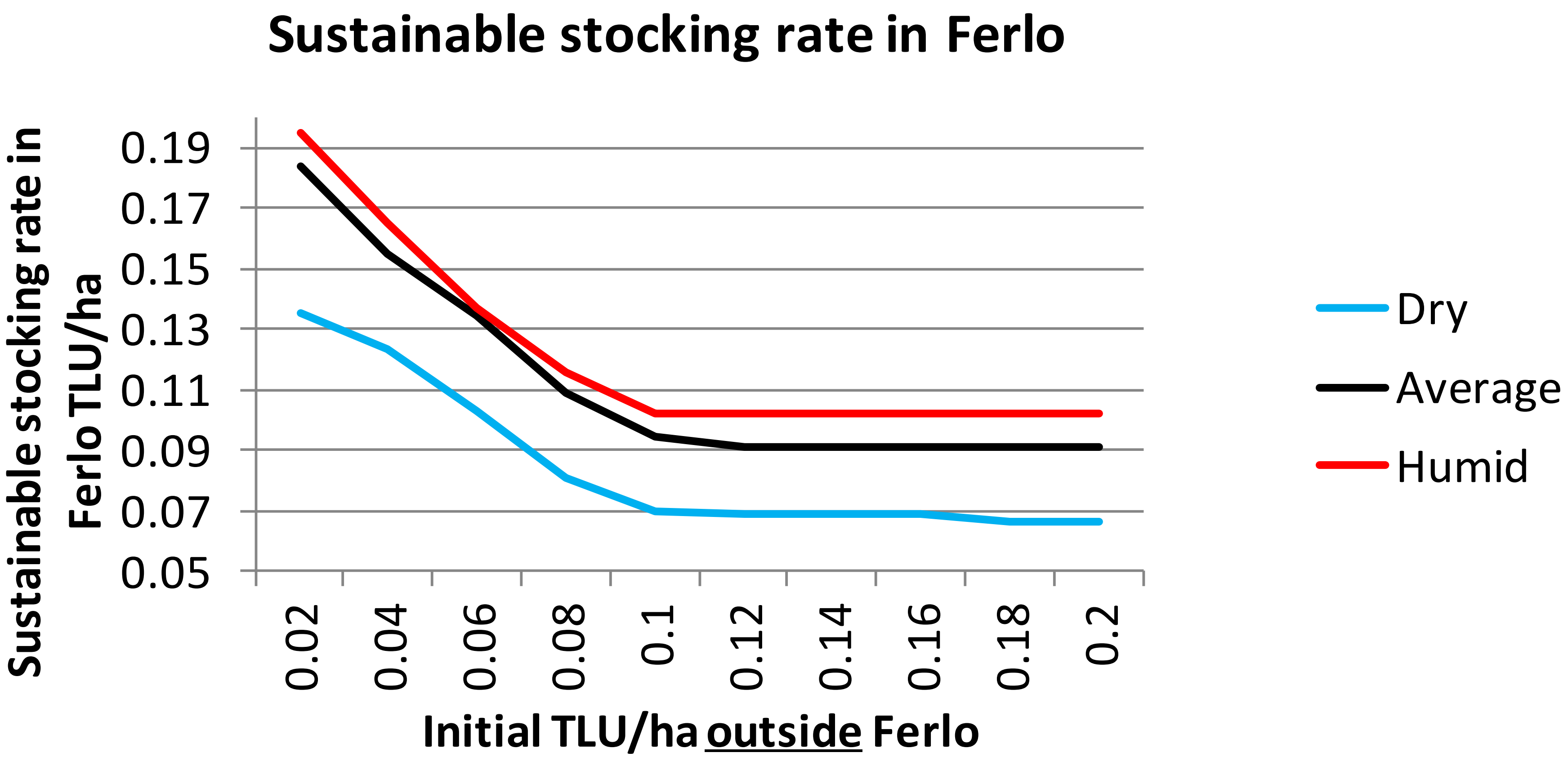
RESULTS

Change (%) in value function when the baseline scenario and alternative scenarios are compared

Scenarios	Percentage change in the value function[1)]
Mean rainfall -3% per decade*	-1 %
Standard deviation of rainfall +30%	-3 %
Meat price +20%	21 %
Meat price +2% per year*	21 %
Discount rate doubled	-37 %

*Impact becomes more prominent over time.

Sustainable stocking rate depends on the case



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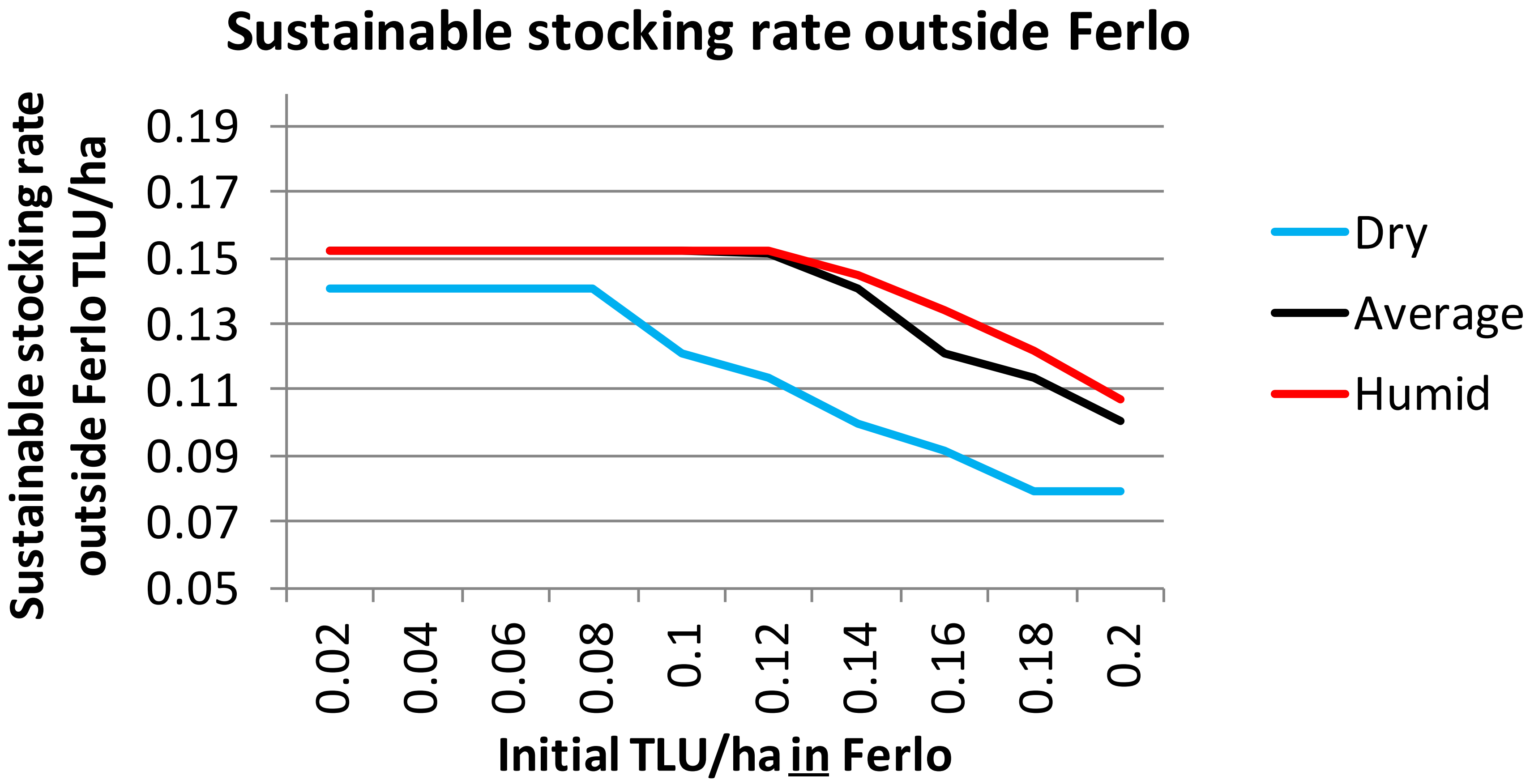
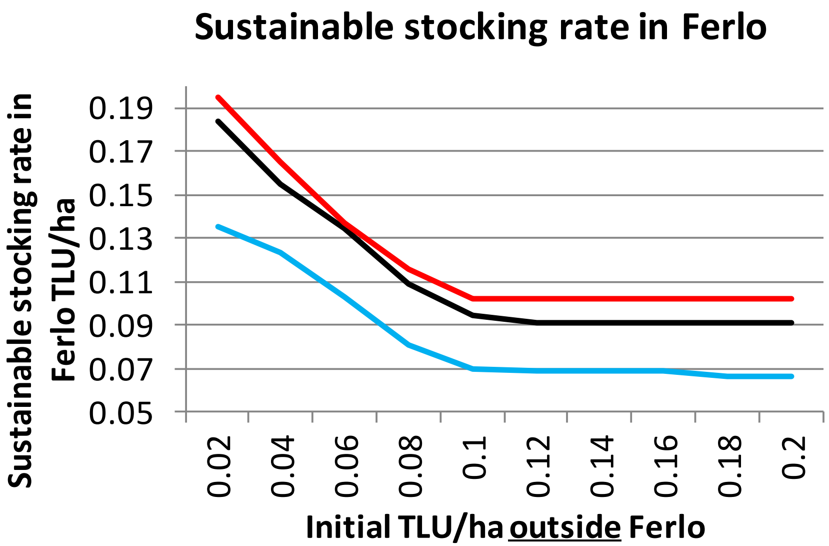
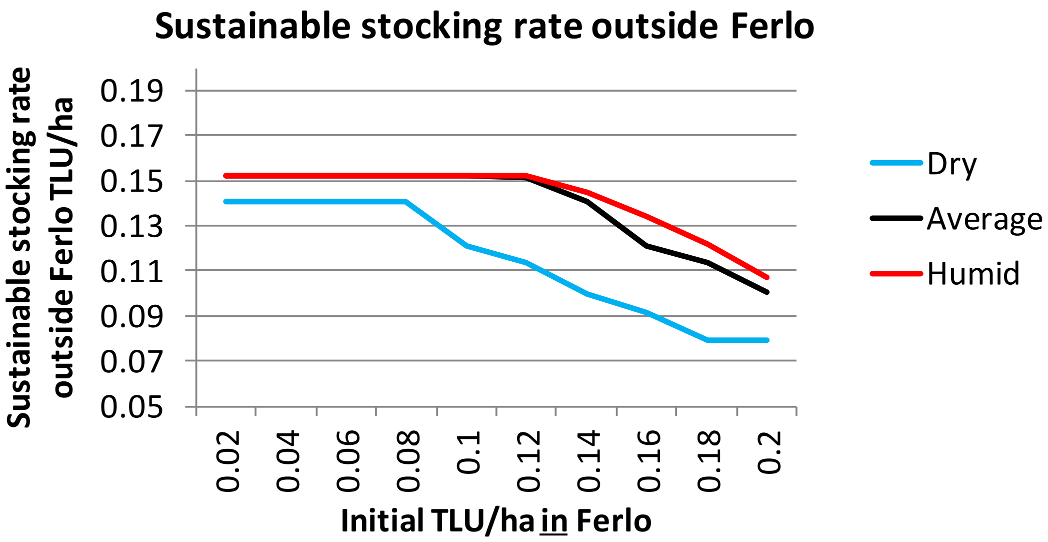


10 Dec 2015, Dakar, Senegal

Humid region can have a larger stock/ha than Ferlo





- Dry year ➔ increased sales, smaller stock in the next year
- The larger animal stock, the more animals are sold during a year
- Average vs. dry year have larger difference than average vs. humid year

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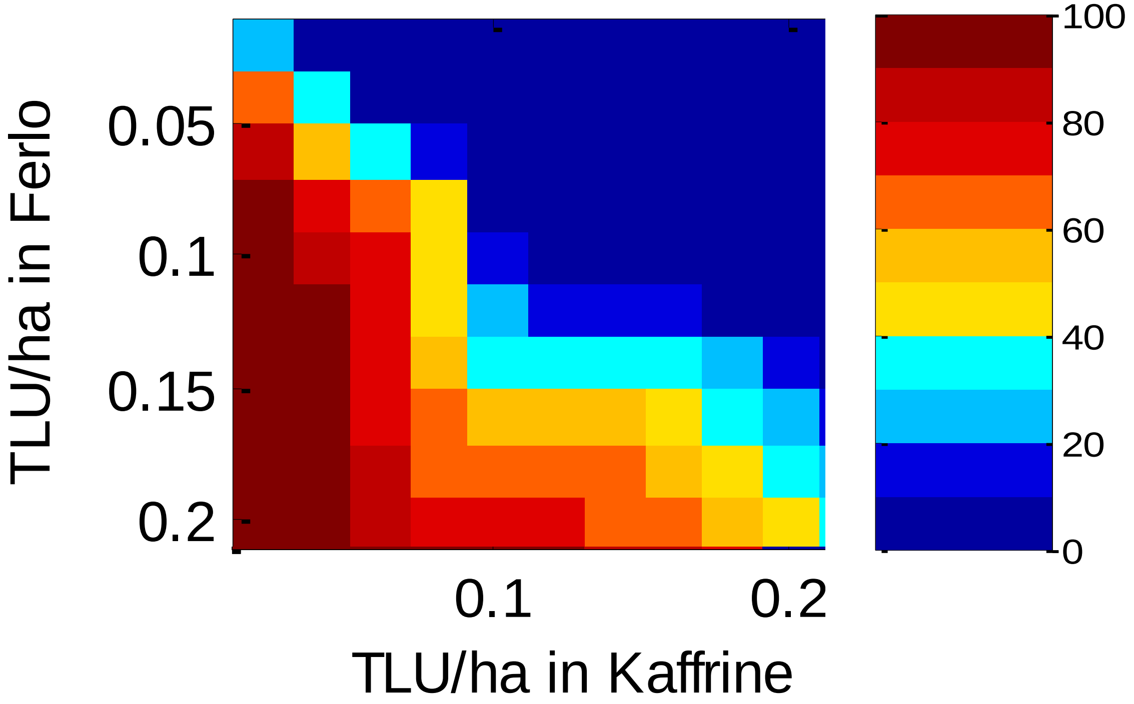
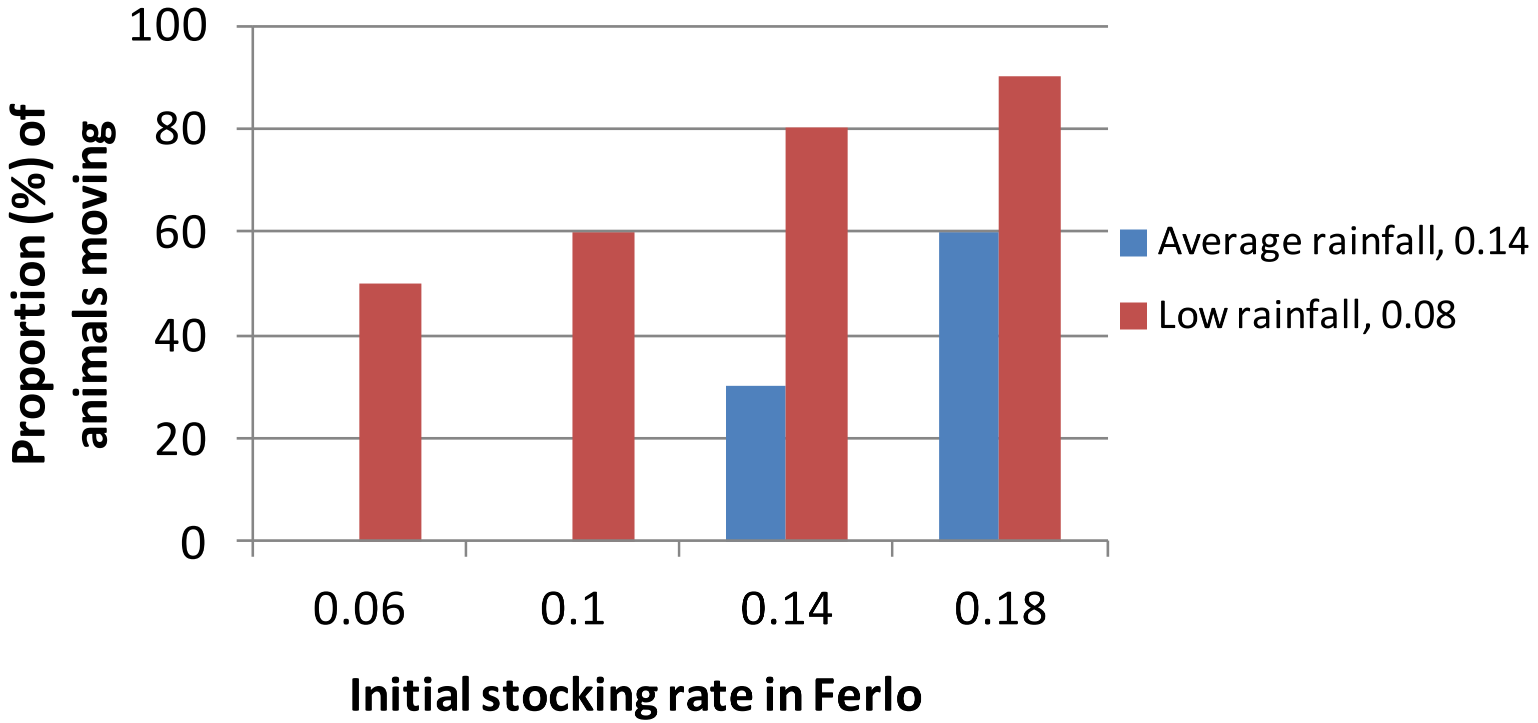
Rate of transhumance in an average-rainfall year



- Changes in the market parameters had much smaller impact on results than rainfall ➔ Stocking rates and animal movements are driven by weather

The rate of transhumance varies by case



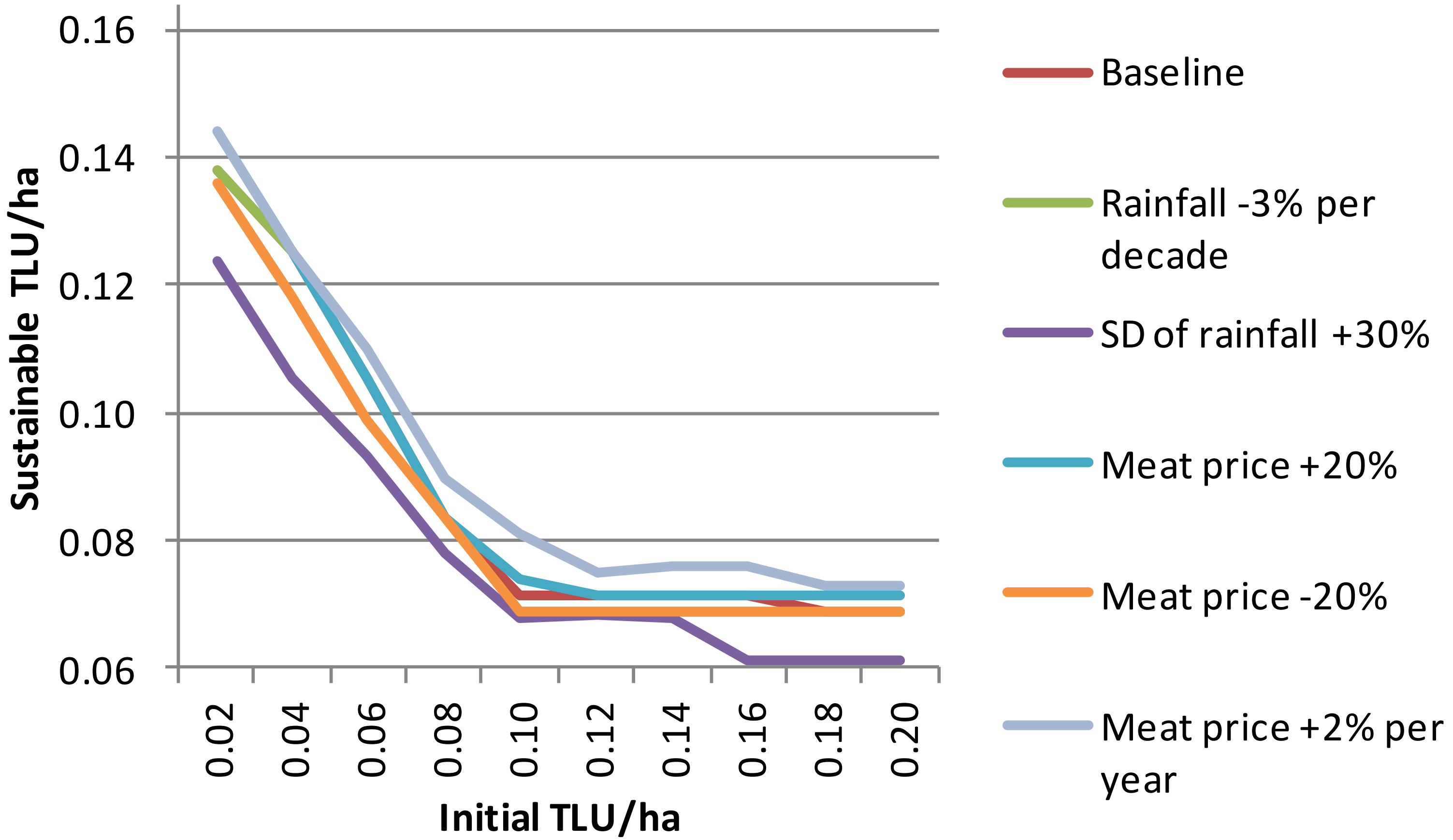
What if transhumance would not be possible?

➔Stock size could decrease in Ferlo by maximum 20% and increase in Kaffrine by maximum 5%

➔Impact on the value of livestock activity approximately 5%.

➔The role of rainfall becomes more important because transhumance is a way to adapt to weather (resilience)

Sustainable stocking rate in Ferlo in different scenarios and at different initial stocking rates outside Ferlo in a dry year.



The role of feed markets

- Substituting 10% of feed consumed in Ferlo (@ no cost) could increase stocking rate in Ferlo by 5 to 15% (depending on the situation) and the value of livestock assets by 2-4%
- If costed @100 CFA/kg, stocking rate in Ferlo could decrease by 20 to 30% and the value function by about 15 to 20%
- If costed @25 CFA/kg, small positive effect on stocking rate in Ferlo and a small negative effect on the value function
- Impacts are smaller outside Ferlo than in Ferlo

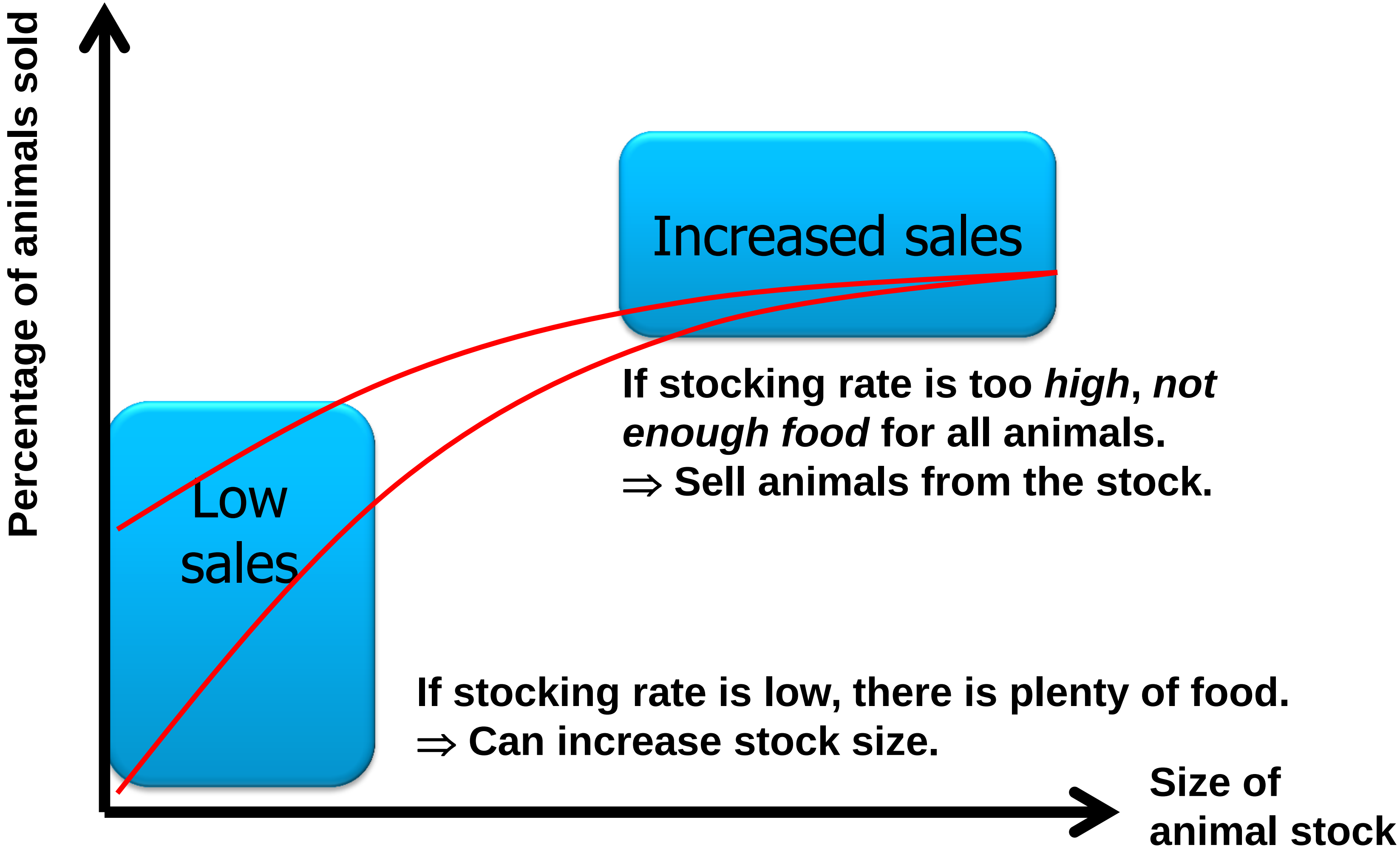
→ Substitution effects

→ The price is an issue because common pasture is costless to the herder

Factors which increase transhumance

- High stocking rate in the dry region
- Little stock in the more humid region
- Drought in the dry region
- Low costs of travel
- High meat price
- Low discount rate
- No feed markets

Feed is a determinant of adaptation



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Discussion

- Transhumance and stocking rate in the more humid region are *buffers*
  - Ferlo benefits as it can accommodate more animals

- Rainfall has a major impact on the optimal stocking rate
  - If the availability of *feed is a constraint*, it determines the sales

- Population growth and climate change are major trends

  ⇒ Impacts are fortified over time

  ⇒ Need to increase feed production or to reduce animals

  ⇒ Regional spillovers - Ferlo becomes even more dependent on other regions

Household model

Features of the model

- A household maximises the net utility from having livestock
- Model the dynamics of household's assets
- Savings & consumption
- Stochastic weather & three seasons
- Biophysical features resemble previous model, but are more detailed (e.g. livestock cohorts, dynamics, feed use efficiency, biomass accumulation)
- In the current model version we still assume that the household's decisions rules are fixed over time

The dynamics of household's assets

Household's assets @ *t*+1

= Household's assets @ *t*

- Consumtion

+ Income (from animals)

- Expenditures due to animals

- There is a minimum consumption (subsistence)
- Assets must be non-negative each year
- Negative assets imply that a household in bankcrupt

Other dynamics

- Herd dynamics:
  - Adults can 1) remain in the herd, 2) be sold, 3) produce offspring or 4) die
  - Younger animals can enter older cohorts if they do not die or are not sold
  - More detailed modelling of animal stocks
- Model three seasons
- Dynamic model but currently not DP

Some basic results

- Too low or too high animal sales decrease utility
- High rate of transhumance increase the utility of household under current parameter values
- Low savings rate and high proportion of animals sold, as well as low rate of transhumandcecombined with high usage of purchased feeds increase the probability of bankcruptcy
- The following slides provide some insights on three policy measures

Policy aspects

- A public relief aid (subsistence allowance) provided at harsh times can at best, eliminate the possibility of HH bankcrupcy
  - High levels of culling the cattle become less beneficial and using high levels of supplementary feed becomes more beneficial
- Subsidised fodder transport can decrease the probability of bancrupcy substantially
  - Substantial increases in the utility aspecially at low transhumance rates and intensive use of supplementary feeds
- Public planting of fodder trees increased fodder availability during the dry season and decreased the risk of bancrupcy
  - Substantial benefit when little transhumance, particularly if herder has simultaneously used a lot of supplementary feed

MERCI BEAUCOUP!
QUESTIONS? COMMENTAIRES?

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