Implications of climate change on small ruminant systems in Europe


69th Annual Meeting of the European Federation of Animal Science
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Impacts of climate change on sheep and goat systems

Innovation for Sustainable Sheep and Goat Production in Europe
Taking a holistic approach to achieve sustainable sheep & goat production across Europe

1. Holistic sustainability assessment
2. Socio-economics, demographics and consumer trends
3. Climate Change assessment
4. Holistic production system
5. Innovative system solutions managing sheep and goat resources
6. Multi-actor internal and external communication

Sustainability assessments will be carried out with an adapted version of the PG tool. Interactions of economic, environmental and social outcomes and their effects on farm resilience (to climate change, market instability, etc.) will be analysed.

Consumer trends will be established in conversation with farmers, consumers and retailers to guide market direction and advise best-practice supply chains.

Climate change effects on pasture and livestock will be modelled, alongside different adaptation responses.

Production system innovations to tackle identified challenges will be investigated with on-farm case studies and modelling. A whole farm model will be built and used to develop user-friendly tools giving farm-specific best practice.

Sheep & goat resources will be maximized by developing breeding strategies based on phenotypes and gene profiles associated with resilience, adaptability and sustainability. Local breeds will be looked to as a valuable genetic source.

Multi-actor communications will ensure that the work of the project translates into wide-spread industry change. Workshops, demonstrations, conferences and training will be provided and a knowledge exchange network established.

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Impacts of climate change

1. Changes in temperature: Hotter
2. Changes in rainfall patterns: Extremes
   - Heatwaves
   - Droughts
   - Heavy precipitation

Increased risk of fires and floods
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Grapes shrivel as Spanish farmers lament a relentless drought

Animals and plants struggle to survive as severe heat dries up the land

Diego García de la Peña, a 65-year-old former bullfighter, has seen climate change affect his land near Malpartida de Plasencia in the western Spanish region of Extremadura. Photograph: Sam Jones for The Observer

A taunting peal of thunder rings out overhead as Diego García de la Peña studies one of his ponds and wonders whether its water will see his cattle through until October.
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Heatwave forces UK farmers into desperate measures to save cattle

Water shortages cause alarm over crop yields and keeping livestock alive

Sunscreen for cows: UK farmers struggle to cope with heatwave

Farmers are struggling to water their cows in the heatwave. Photograph:...}

Drought

Crop failure and bankruptcy threaten farmers as drought grips Europe

Abnormally hot temperatures continue to wreak devastation across northern and central parts of the continent

UK farmers allowed to take more water from rivers as heatwave continues

Environment secretary holds drought summit with farmers to address series issues of crop failure and lack of fodder for animals
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Effects of CC on small ruminants

Effects at animal level

- Increased temperature & radiation
  - Heat stress
  - Behavioural & metabolic changes

- Productivity & product quality
- Reproduction
- Animal health & welfare

Effects on feed supply

- Increased temperature. Changes in precipitation. Extreme events

- Heat & water stress. Changes in growing season length & water availability

- Changes in crop & pasture growth

- Productivity & quality of forage
- Pests & diseases
- Availability of concentrates

Effects on small ruminant systems

Regional implications for small ruminant production systems in Europe and adaptation measures
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Effects of CC on small ruminants: 
- Productivity and quality (milk+meat)
  - Sheep and goat subject to heat stress often show reduction in feed intake and impaired productivity
    - Lamb impaired growth rate
    - Reduction milk production
    - Milk quality (e.g. reduction of protein)
    - Meat quality: abnormal odour and taste, greater water holding capacity and susceptible to spoilage by microorganism

Salama et al., 2014
Ramon et al., 2016
Effects of CC on small ruminants:

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- **Reproduction (fertility)**
  - Females: impacts ovarian function, duration of gestation, conception rate and birth weight of lambs.
    - Males: reduced quantity and quality of sperm, changes in sexual activity.

- **Animal health & welfare**
  - Warmer conditions may increase the incidence of infectious diseases (gastrointestinal nematode, udder)
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**Effects of CC on forage production:**

- Increase in CO$_2$ may promote greater production in grasslands (0-30%).

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**Figure 1** Variability in the annual herbage dry matter (DM) yield response of temperate pastures to elevated CO$_2$ (600–700 ppm) under optimal nutrient supply, displayed as ranges (whiskers), 25th percentile to the 75th percentile (boxes) and the median line. Created using 44 annual means from control and elevated CO$_2$ treatments from Newton et al. (1994), Casella et al. (1996), Soussana et al. (1996), Hebeisen et al. (1997) and Schneider et al. (2004).

**Figure 2** Effect of doubled ambient CO$_2$ on above-ground biomass production plotted against above-ground biomass production at the current CO$_2$ concentration for different pasture and rangeland systems: (a) percentage effect; (b) absolute effect. Numbers refer to studies listed in Table 1: (1) M. Jones, unpublished; (2) Hebeisen et al. (1997); (3) Tuba et al. (1998); (4) Casella et al. (1996); (5) Newton et al. (1994), Clark et al. (1997); (13) J. Morgan, unpublished; (14) Owensby et al. (1999).

Lee et al., 2013

Campbell et al., 2010
Effects of CC on forage production

- Increase in CO\(_2\) may promote greater production in grasslands (0-30%).
- Higher temperature and annual precipitation enhance plant growth of many grass species.

Figure 3.1 The ‘classical’ responses of net photosynthesis of leaves (A) to temperature (cf. Larcher, 1969, 2003). (a) Typical response curves for a temperate plant species measured at different light levels.
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Effects of CC on forage production

- Overall effect depends on complex interacting processes between CO₂, temperature and water availability in the soil-water-plant system
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**Effects of CC on forage quality**

- Enhanced CO$_2$ concentration tend to decrease forage nitrogen (N) content and increase total non-structural carbohydrates, though there does not appear to be any significant effect on forage digestibility (Dumont et al., 2015).
Effects of CC on forage quality

- Enhanced CO$_2$ concentration tend to decrease forage nitrogen (N) content and increase total non-structural carbohydrates, though there does not appear to be any significant effect on forage digestibility (Dumont et al., 2015).
- Warming and high CO$_2$ levels favour species that fix N$_2$ (i.e. legumes) over non-fixing species.
- The protein content of C3 grasses is expected to decrease in non-leguminous plants, but this may be partially counteracted by the expected increase in the legume content of swards.
Regional implications for small ruminant production systems in Europe:

• Climate change impacts will vary among the different European sub-regions

- **Northern Europe**
  - Temperature rise larger than global average
  - Decrease in snow, lake and river ice cover
  - Increase in heavy precipitation events
  - Increasing damage risk from winter storms

- **Central and Eastern Europe**
  - Increase in warm temperature extremes
  - Decrease in summer precipitation
  - Increasing risk of forest fires
  - Increasing risk of river floods

- **Alpine regions**
  - Temperature rise larger than global average
  - Decrease in mountain permafrost areas
  - Upward shift of plant species
  - Increasing risk of soil erosion

- **Atlantic region**
  - Increase in warm temperature extremes
  - Increase in heavy precipitation events
  - Increasing damage risk of floods & winter storms
  - Increasing risk of droughts

- **Mediterranean region**
  - Large increase in heat extremes
  - Decrease in precipitation
  - Increasing risk of droughts
  - Increasing risk of forest fires

Figure - General trends of several climate variables for European sub-regions. Indices represent changes for 2071-2100 with respect to 1971-2000 based on RCP4.5 and RCP8.5 scenarios (Pardo et al 2017 based on Jacob et al, 2014).
Regional implications for small ruminant production systems in Europe:

- Climate influences distribution of vegetation and small ruminant systems across Europe

Fig. 1 - Climate change projections

Fig. 2 - Distribution of small ruminant livestock in Europe

Fig. 3 - Distribution of grasslands and scrublands in Europe
Regional implications:
A) Northern (Boreal) region

- Increase in forage annual yields (timothy, perennial ryegrass) due to higher temperatures, longer growing season, decreased risk of winter damage.
- Potential expansion of grass species (perennial ryegrass) to new areas.
- Ozone exposure and long photoperiod can lead to significant foliar injury and growth reductions in certain forb and grass species.
- Adaptation: Changes in management due to future warming:
  - Adult ewes outside in winter
  - Ewes and offspring will come out some weeks earlier
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Regional implications:

B) Atlantic region

- Potential increase annual grass productivity and growing season
- Changes in livestock management: Increased grazing season length
- Incidence of heat stress (higher temperatures + wet weather) on animal productivity, health issues and welfare
- Adaptation:
  - Presence of trees at low density (shelter & longer growing season by reducing evapotranspiration)
  - Infrequent mowing, reducing tillage, key pasture reseeding time
  - New grass breeds (Adapt+mitigation) or existing forages (e.g. maize)
Regional implications:

C) Continental region

- Potential increase in productivity in managed grasslands
- Increased variability in climate and extreme events may constrain increase in forage production under certain conditions (e.g. summer droughts)

Adaptation:

- Enhancing the genetic diversity within populations of species is generally recommended to cope with extreme hot and dry summer conditions
- Dairy goat industry development may be favoured
Regional implications:
D) Alpine region

- Low biomass response to elevated CO$_2$, constrained by nutrient limitations.
- Warming trends may extend the growing season, enhancing grassland productivity. Projected decrease in summer rainfall may partially counteract this effect.
- Increase of heatwaves frequency: Alpine breeds are specially sensitive to extreme heat events.
- Adaptation:
  - Mountainous habitats are very sensitive to anthropogenic activities and management decisions (grazing pressure).
Regional implications:

E) Southern (Mediterranean) region

- Reduction in forage yields and quality due to less rainfall and risk of drought projection
- Grazing season is expected to be shortened. Grazing will suffer from irregular patterns due to extreme events.
- Adaptation:
  - Flexible grazing and access to feed (e.g. by-products, crop residues...)
  - Nutrition for heat stress periods: e.g. high energy density, increasing number of meals, shifting meals to evening, supplements...
  - Features in barns/landscape for shelter, ventilation, spraying, shade...
  - Diverse pastures to enhance resilience. Animal and plant breeding
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Thank you!

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General strategies for forage production to face CC

- Increasing mixed legume-grass pastures to adapt to potential shortages of global protein sources in Europe, or to face the expected decreased of protein content.
- Grazing/fodder management to cope with increased inter and intra-annual variability in forage quantity and quality.
- Underutilized feedstuffs from agro-industry by-products
- Reduced tillage for soil moisture conservation and increased long-term productivity
- Improved plant breeding (long-term)
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**General strategies to cope with heat stress:**

- **General management**: physical protection (shading), ventilation, adequate stocking density and airspace
- **Genetic selection of heat resistant breeds**: breeds from tropical and arid areas are more efficient and resilient under heat stress conditions.
- **Nutritional management**: use of high energy density diets, reduce rumen degradability, strategic feeding, the use of supplements
- **Reproductive technologies**