Impacts of climate change adaptation pathways in agriculture on soil services and Sustainable Development Goals

The MACSUR regional case studies

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Introduction

- Soil systems are fundamental for food security and for sustainable development
  - provides biomass for food, feed, energy and fibre
  - serves as habitats for organisms and gene pools (biodiversity)
  - contributes to carbon sequestration
- Effects of climate change associated with extreme events, such as heavy rainfall, heat waves, drought and landslides, however, threatens to increase the potential for soil erosion and soil compaction

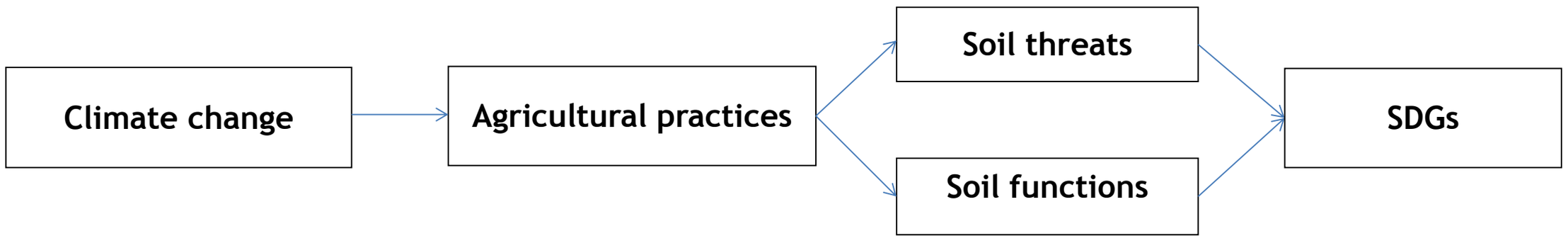
Source: http://www.wur.nl/en/show/Preventing-and-remediating-degradation-of-soils-in-Europe-through-land-care.htm

Introduction

- Climate change may affect soil functions and services in two ways, directly and indirectly
  - e.g. soil erosion rates may increase because of increased frequencies of high intensity rainfalls → direct
  - irrigation regimes, crop rotation changes, or soil tillage practices as adaptation measures may improve or deteriorate soil quality → indirect
- Comprehensive evidence exists for the first case of direct effects, knowledge about the indirect effects of agricultural adaptation pathways is more scattered
- Meanwhile, improving soil functions play an important role in achieving a number of Sustainable Development Goals (SDGs), particularly (Montanarella & Alva 2015; Bouma & Montanarella 2016):
  - SDG 2: achieve food security and promote sustainable agriculture
  - SDG 13: take action to combat climate change and its impacts
  - SDG 15: reverse land degradation and halt biodiversity loss

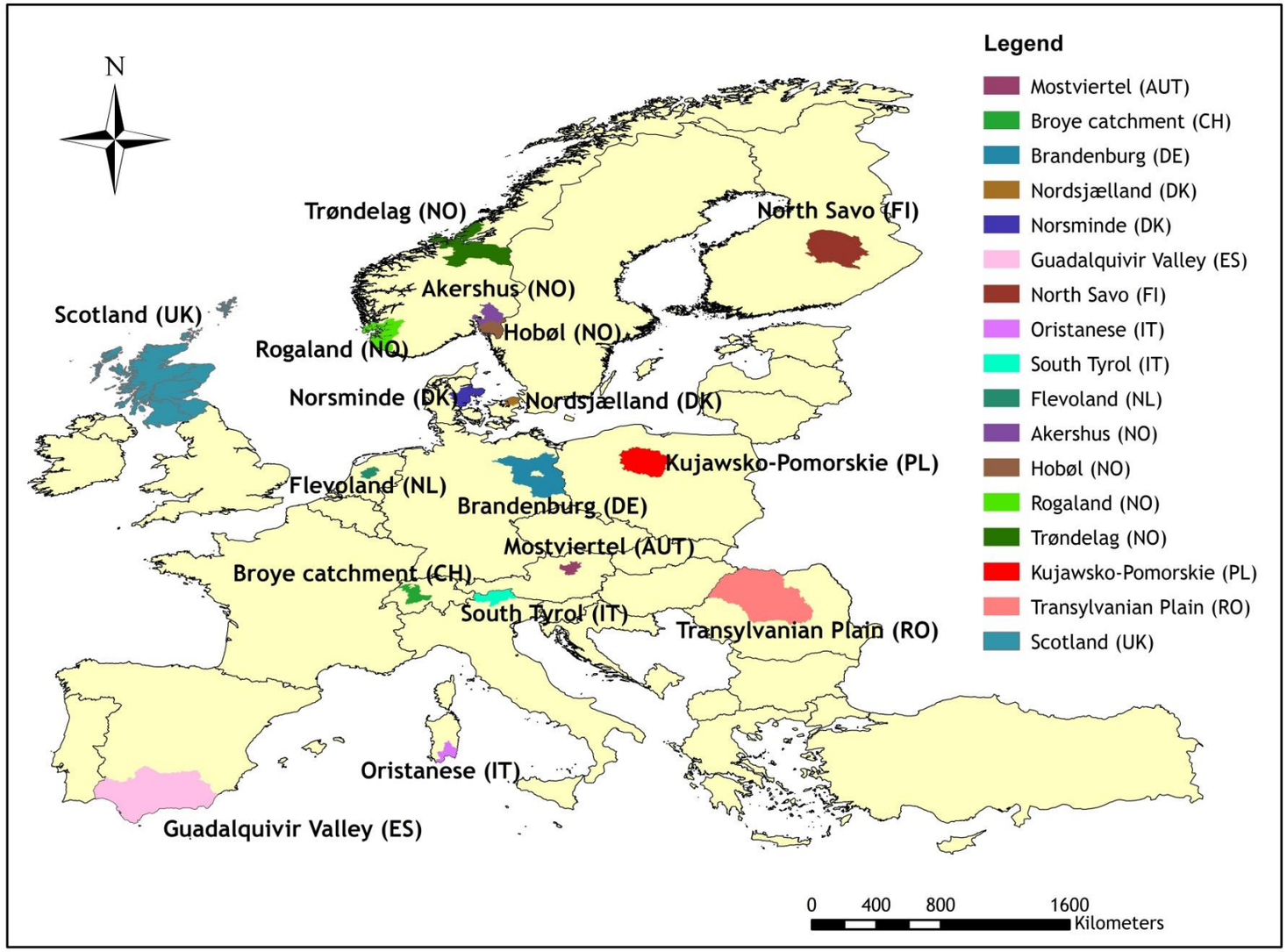
Research objective

- Conduct meta-analysis of case studies for identifying the impacts of climate change adaptation practices in agriculture on soil services and their relevance for the SDGs, using MACSUR regional pilot case studies
- By building upon this meta-analysis, we further aim to identify existing knowledge gaps and the need for future research on sustainable soil use



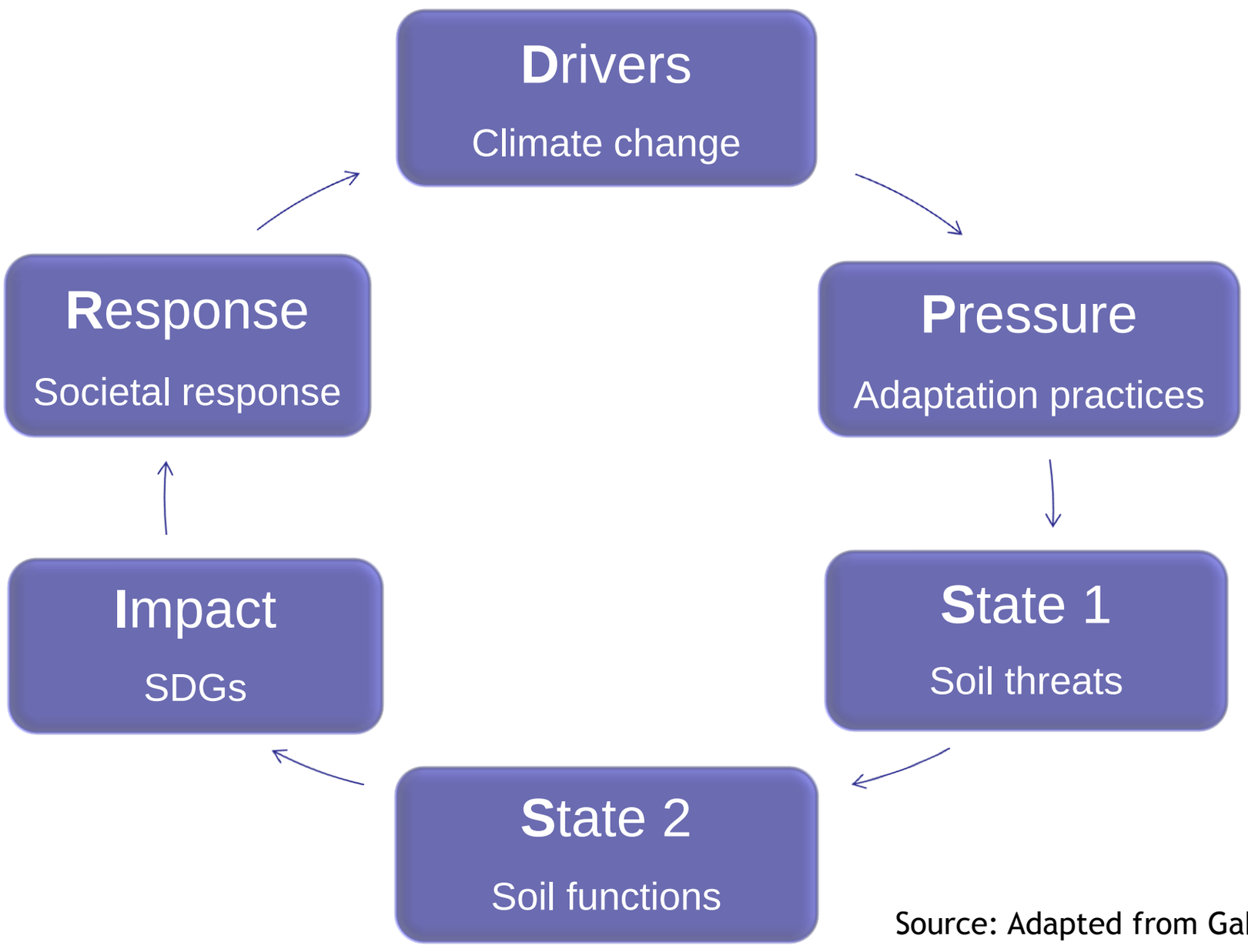
Methods: Location of study areas

- Qualitative research by nature
- Semi-structured questionnaire was developed and circulated among the partners
- 17 responses (regional pilot case studies), representing NUTS-2/3 levels, have been received
- Non-MACSUR project members also showed an interest in contribution



The DPSIR framework

- Can help us better understand cause-effect relationships between the natural environment and human systems



Source: Adapted from Gabrielsen and Bosch (2003)

Soil threats

Erosion

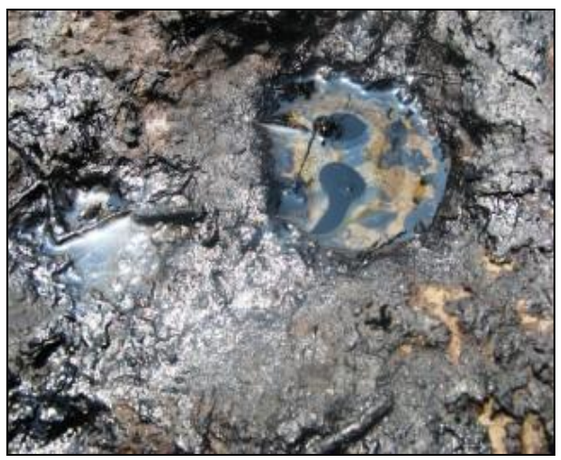
Organic matter decline

Compaction

Salinization

Biodiversity loss

Contamination



Sealing

Source: EC (2002)

Soil functions

Food / Fibre

Storing / filtering

Habitat & gene pool

Carbon pool

Raw material

Physical/cultural env.

Archaeological sites

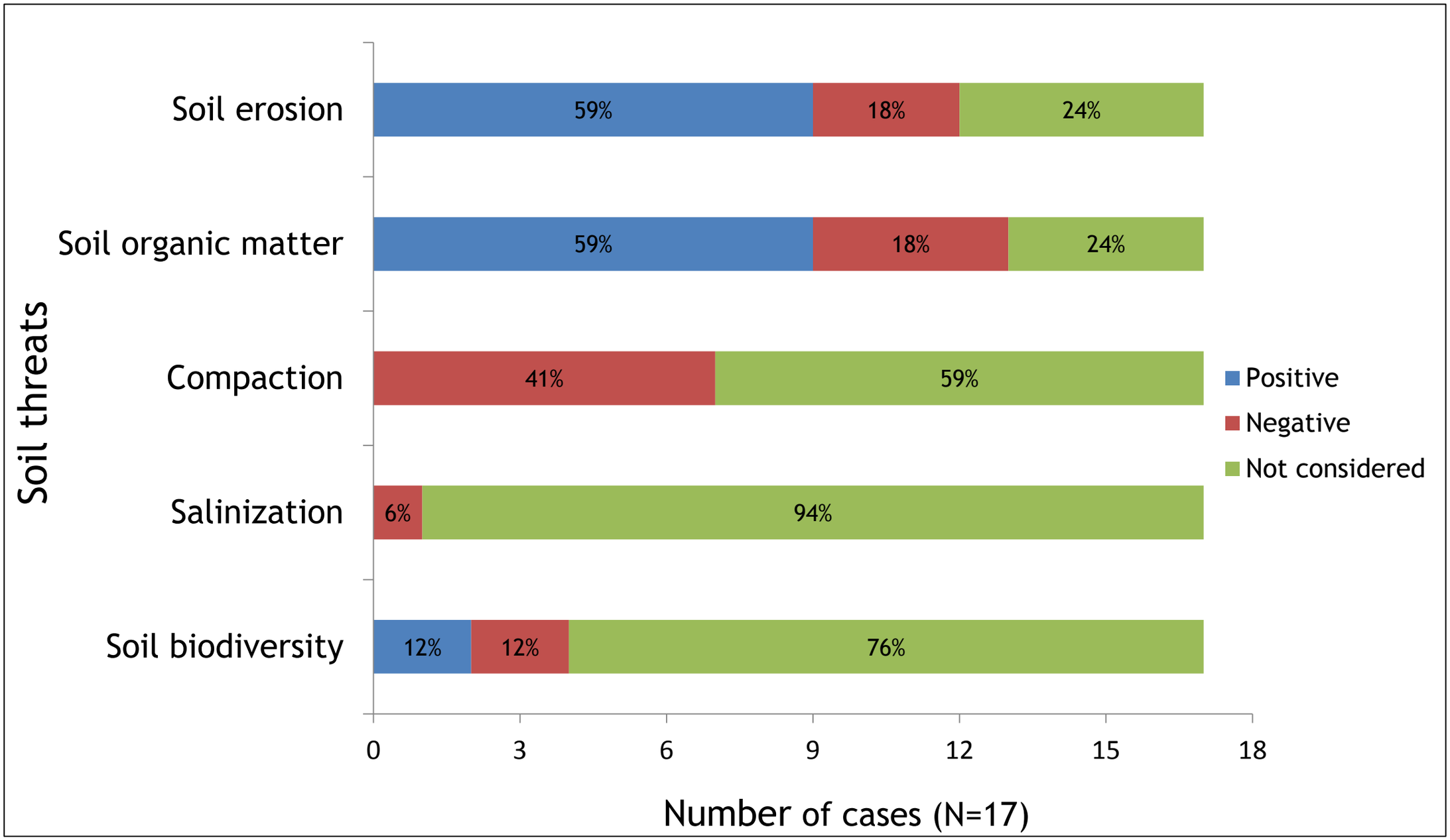
Source: EC (2006)

Preliminary results

- Findings indicate that the impacts of climate change adaptation practices on soil threats and soil functions have produced mixed results
- Soil threats: adaptation practices show improvements in soil erosion and soil organic matters, whereas soil compaction remain the main challenge (little knowledge is available about soil biodiversity)
- Soil functions: similarly, adaptation practices reveal rather positive effect on food and biomass production as well as improvement of carbon sequestration in soil (storing more carbon in soils)

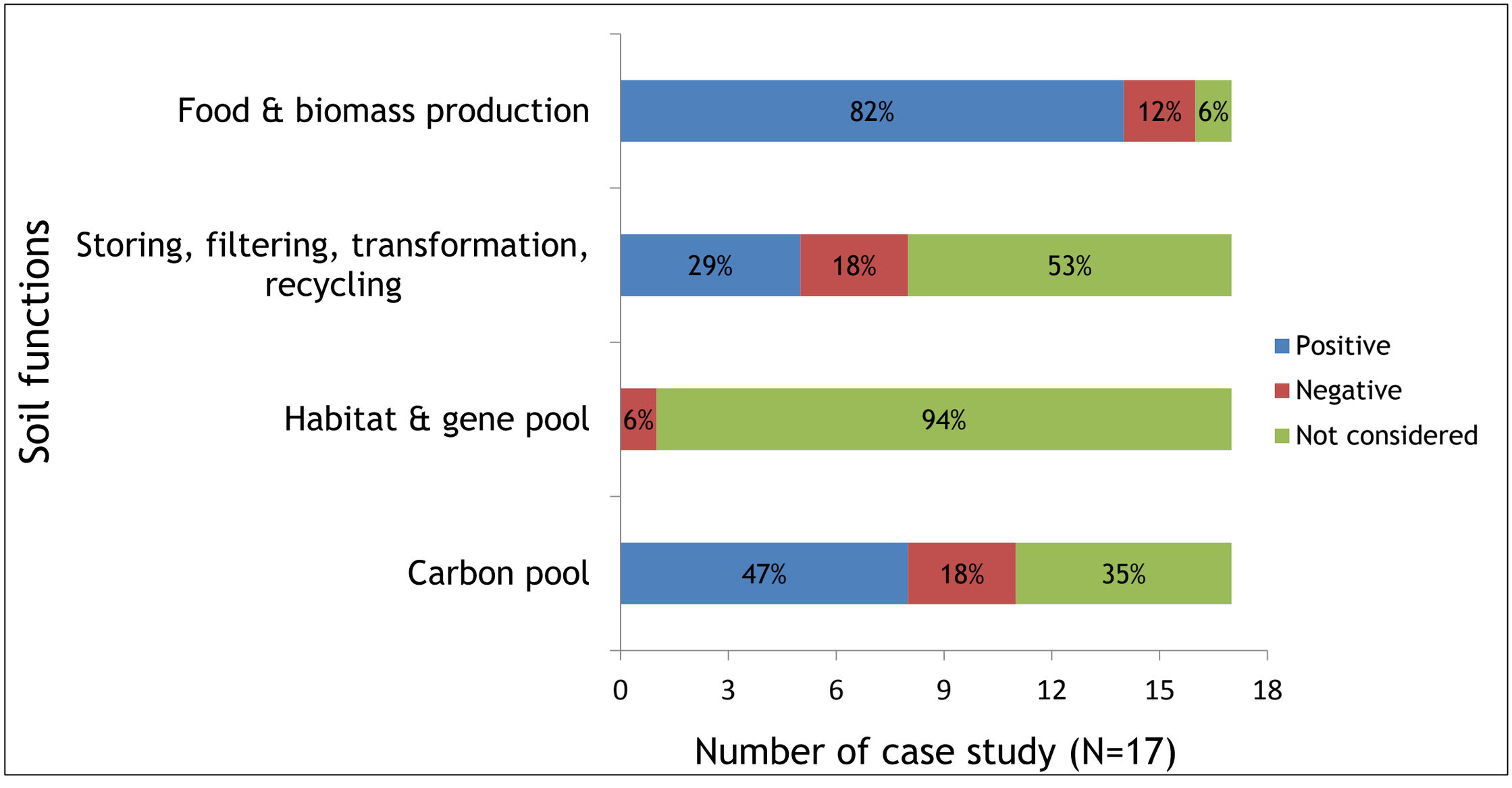
Impact of adaptation on soil threats

- Study findings from the European cases:



Impact of adaptation on soil functions

- Interestingly, climate change adaptation pathways in agriculture have positive effect on food and biomass production



Example No.1: Brandenburg case

- Specifications of drivers of change:
  - less rainfall during vegetation period
  - more frequent drought
- Adaptation practices:
  - changed crop rotation
  - irrigation of key crops
- Effects on potential soil threats:
  - increase of soil erosion on arable land
  - increase of soil compaction because of heavy machinery and irrigation
- Soil functions:
  - biomass production increases
  - improved soil organic carbon (carbon pool)

Example No.2: Mostviertel case

- Specifications of drivers of change:
  - higher mean T (+1.6ºC by 2050): dry periods in spring and warmer winter
  - extreme precipitation expected during winter
- Adaptation practices:
  - changed crop rotation
  - different soil management options (reduced tillage & planting cover crops)
  - implementation of irrigation
- Effects on potential soil threats:
  - soil erosion has slightly increased
  - decrease of vascular plant species richness
- Soil functions:
  - limits biomass production
  - decreases soil biodiversity richness
  - reduces GHG gas emissions from soils

Example No.3: South-eastern Norway (Akershus)

- Specifications of drivers of change:
  - increased rainfall during summer and spring
  - T has increased by 2°C
- Adaptation practices:
  - change to other crops like grass and sell it as forage to western part of Norway
  - change tillage at areas prone to erosion risk
  - repair hydro-technical installations
- Effects on potential soil threats:
  - change tillage and repairing water structures reduce soil erosion
  - change tillage practices increases SOM
  - driving on wet soil gives risk of compaction
- Soil functions:
  - food and biomass production improves
  - changed tillage and control of surface runoff influences possibilities of storage, filtering
  - changed tillage and grassed waterways also influences possibilities of carbon pool

Relevance for the SDGs

- In terms of the relevance of soil functions to the SDGs, we used Montanarella & Alva (2015)'s proposed linkage:

Soil functions	Linkage to the SDGs
Food and other biomass production	SDG 2: achieve food security and promote sustainable agriculture
Storage, filtering, transformation, recycling	SDG 15: reverse land degradation and halt biodiversity loss
Habitat & gene pool	SDG 15: reverse land degradation and halt biodiversity loss
Carbon pool	SDG 13: take action to combat climate change and its impacts

- Results indicate towards the achievement of SDG 2 and 13 targets, whereas the achievement of SDG 15 seem to be under the radar at the moment

Conclusion

- While comprehensive evidence exists for direct effect of climate change on soil services, there has yet to be a study that has investigated the indirect linkage
- This study seeks to address this gap so as to improve the scientific knowledge on sustainable soil management
- Although adaptation practices show improvements in soil erosion and soil organic matters, the main challenge remains to combat soil compaction
- Adaptation practices reveal rather positive effect on food and biomass production as well as improvement of carbon sequestration in soil (storing more carbon in soils) but other two functions seem to be less focus
- Achievement of SDG 2 and 13 targets are currently underway with positive link, however the achievement of SDG 15 need to be the focus going forward

Going forward and discussion

- We hope to get completed information from all case studies to improve the robustness of the findings
- We feel rather biased approach towards the northern part of Europe (N=7)
- The study aimed to understand and find out the impacts of climate change adaptation practices on soil services. Appropriate "response" policy tools could be an additional interesting research
- How climate change impacts soil function in the absence of adaptation → perhaps, would reveal the value of adaptation knowledge and action

References

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Thank you for your attention !

Questions?