Description, adoption and diffusion of innovative soil management practices across Europe

Frédéric Vanwindekens, Olivier Heller, Claudia Di Bene, Pasquale Nino

CLIMASOMA and i-SoMPE webinar – 12 May 2022

EJP SOIL
European Joint Programme

EJP SOIL has received funding from the European Union's Horizon 2020 research and innovation programme: Grant agreement No 862695

Agroscope

Wallonie recherche CRA-W

afbi AGRI-FOOD & BIOSCIENCES INSTITUTE

AGES

AARHUS UNIVERSITY

Eesti Maaülikool
Estonian University of Life Sciences

NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

ILVO
Instituut voor Landbouw- en Visserijonderzoek

Instituto Nacional de Investigação Agrária e Veterinária, I.P.

IUNG
Institute of Soil Science and Plant Cultivation State Research Institute

LAMMC
LITHUANIAN RESEARCH CENTRE FOR AGRICULTURE AND FORESTRY

Institute for Soil Sciences
Centre for Agricultural Research

CSIC
Consejo Superior de Investigaciones Científicas

CZU
Czech University of Life Sciences Prague

INRAE

Luke
NATURAL RESOURCES INSTITUTE FINLAND

NPC
NATIONAL AGRICULTURAL AND FOOD CENTRE

SLU

TAGEM
R&D AND INNOVATION

teagasc
Agriculture and Food Development Authority

Univerza v Ljubljani
Biotehniška fakulteta

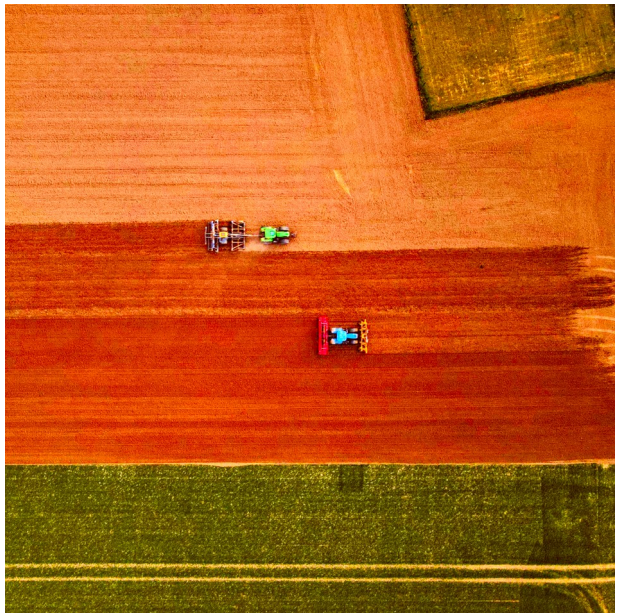
THÜNEN

UNIVERSITY OF LATVIA

WAGENINGEN
UNIVERSITY & RESEARCH

i-SoMPE explored four main axes around soil management practices

2 – Current adoption



1 – Inventory

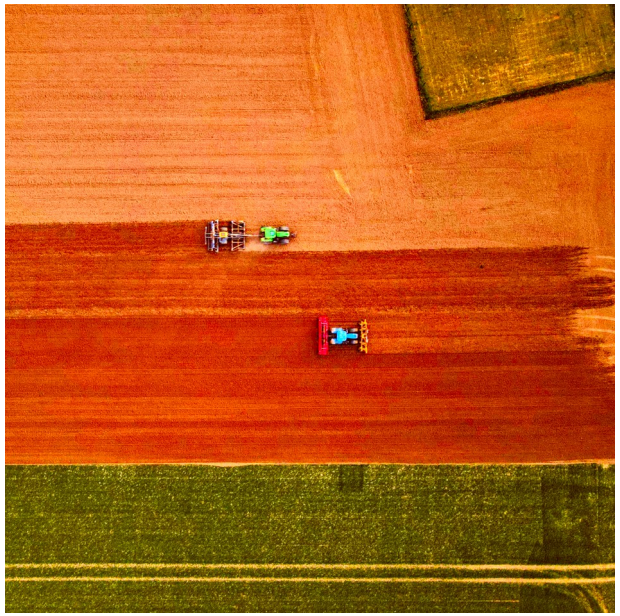
3 – Bio-physical limitations

4 – Barriers & opportunities

i-SoMPE explored four main axes around soil management practices

2 – Current adoption

1 – Inventory



3 – Bio-physical limitations

4 – Barriers & opportunities

1 – Inventory of innovative soil management practices

EJP SOIL
European Joint Programme

EJP SOIL has received funding from the European Union's Horizon 2020 research and innovation programme: Grant agreement No 862695

Inventory of soil management practices

Projects

Categories

4	Agricultural systems
4	Buffer strips and small landscape elements
7	Crop protection
13	Crops and crop rotations
8	Organic matter and nutrient management
13	Tillage and traffic
7	Water management
2	Other
58	**Total**

Methods

- Reviewing EU Projects
- Considering other sources
- Ignore double entries
- Land-management categories

Results

- 58 pre-identified soil management practices

Inventory of soil management practices

A - Pre-identified practices

1 - Conservation Agriculture
2- Organic Farming
3 - Buffer strips
4 - ...
5 - ...
6 - ...
7 - ...
8 - ...
.
.
.
.
.
.
.
.
.
58 - Water harvesting practices

Maps (58)
Screening of current application in main environmentale zones

Part A (49) :
Characterisation and potential diffusion

B - Innovations, experiences, spécifive practices

?
?
~5

Part B (51) :
Characterisation and potential diffusion

?
?
?
?

1 – Inventory of soil management practices : content

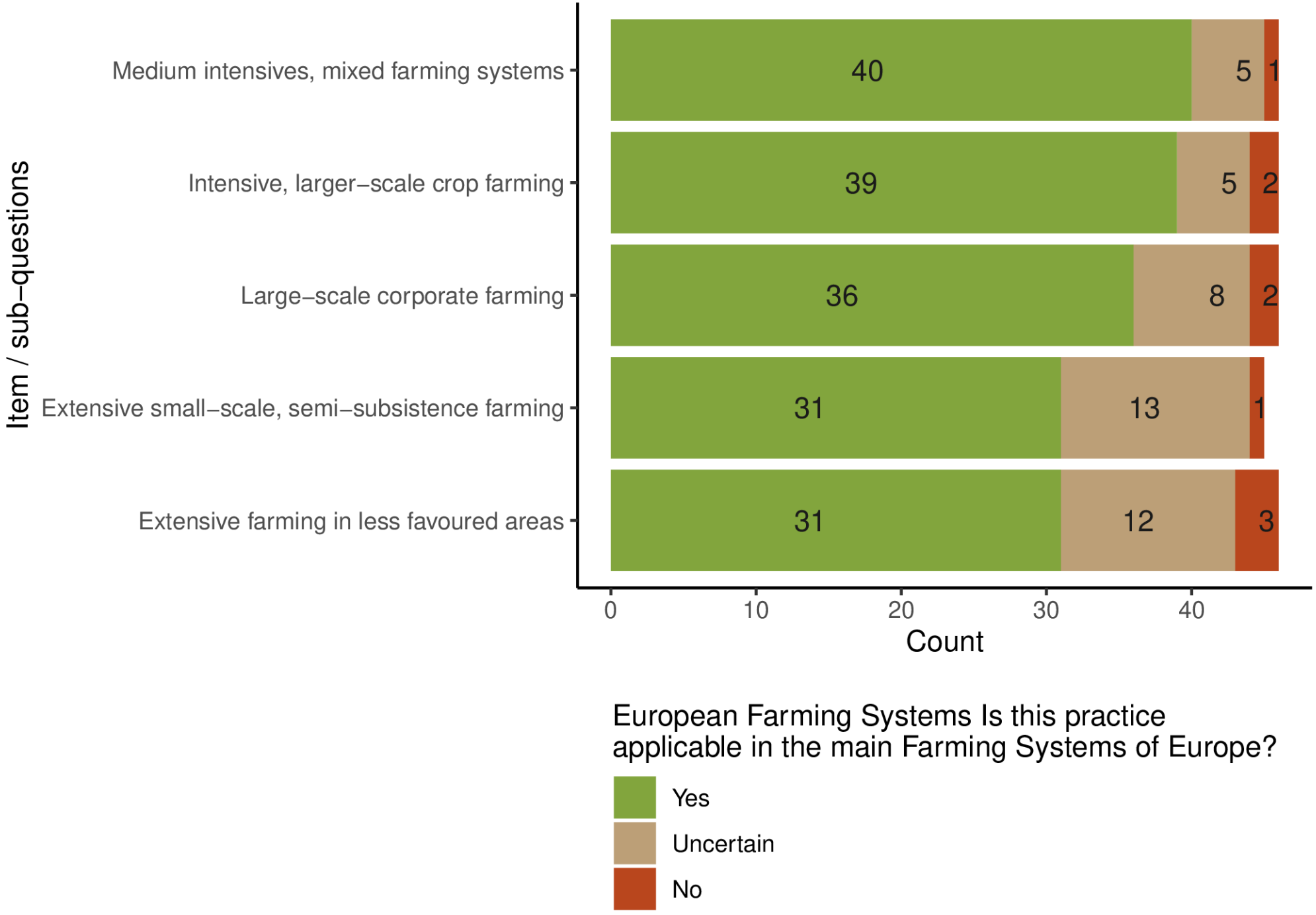
- General **description**

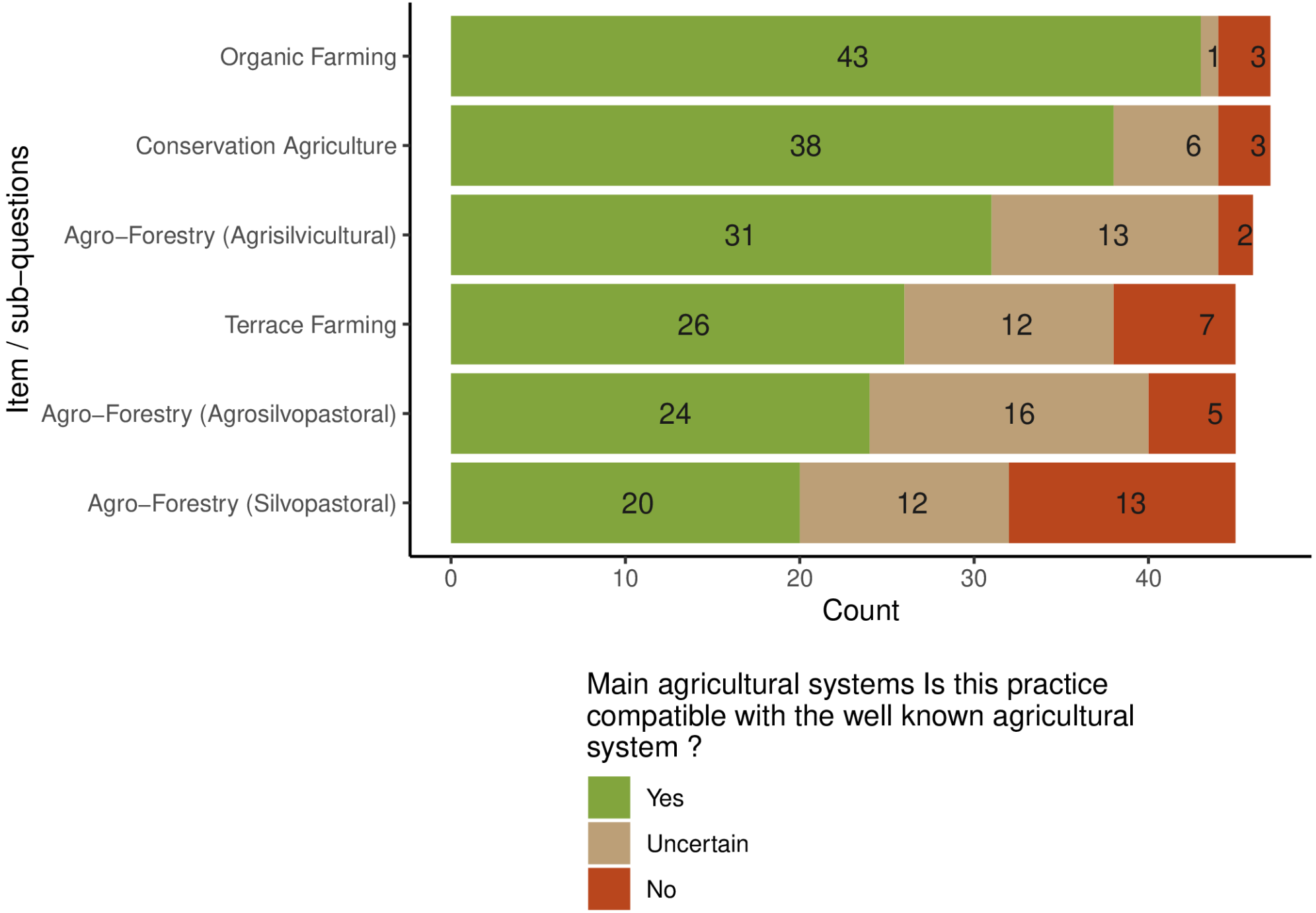
- **Current** application (~ mid 2021)

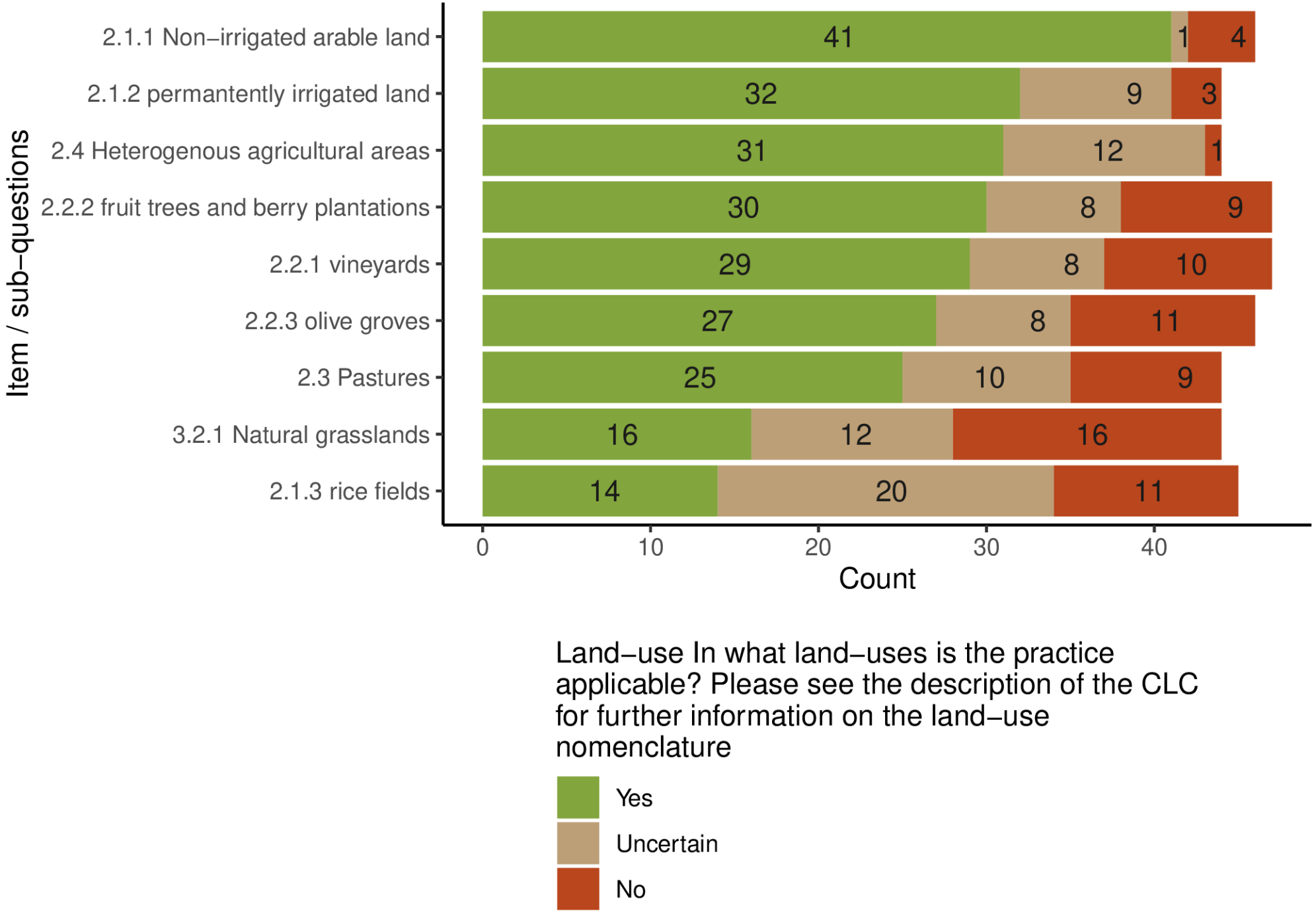
- **Potential area of application** of a practice
  - Climate factors
  - Site and soil factors (slope, organic soil)
  - Land use and farming systems

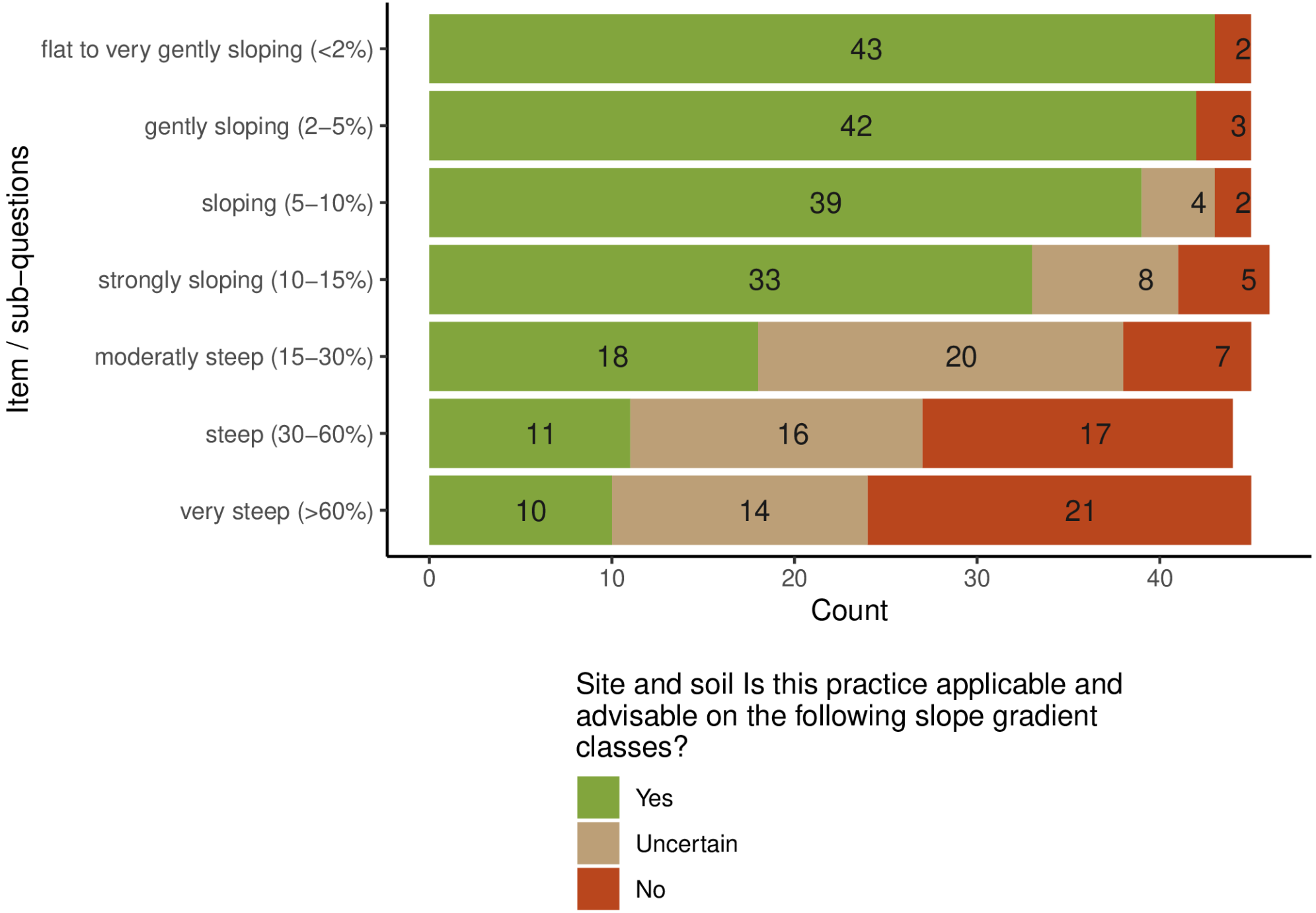
- **Impacts** of the practice
  - EJP SOIL soil challenges & other impacts

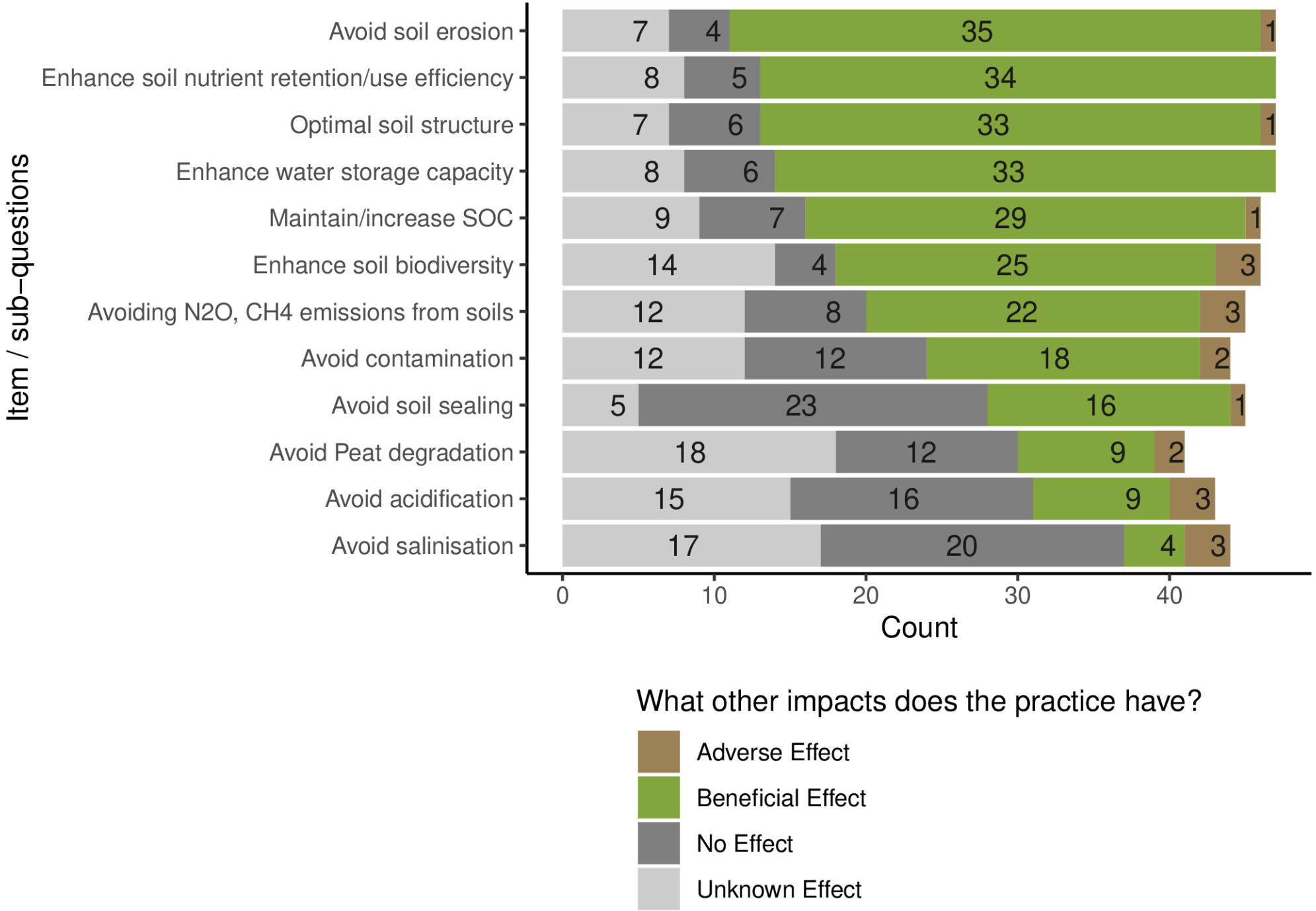
- Comments, references and other information

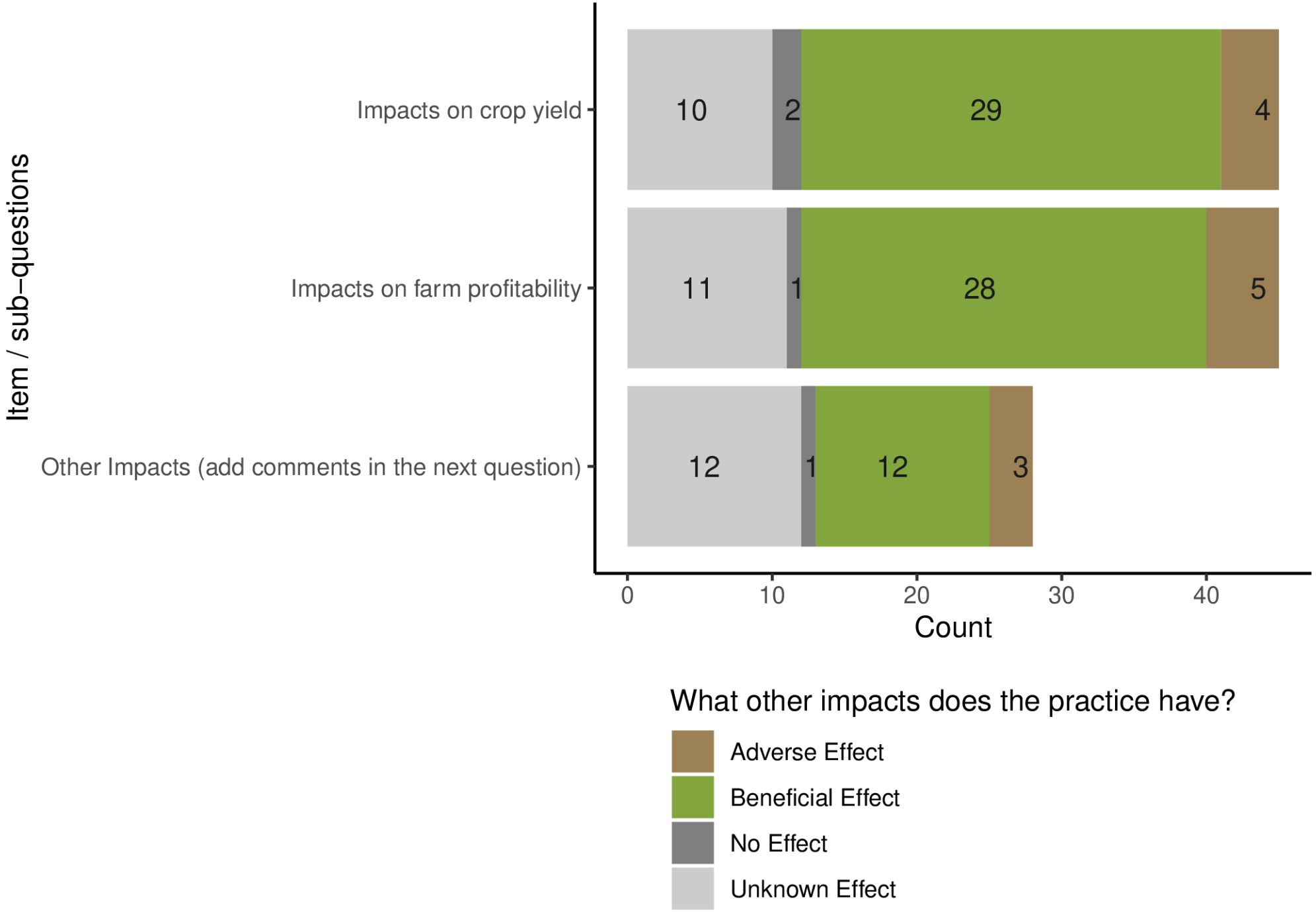

Item / sub–questions
Medium intensives, mixed farming systems
Intensive, larger–scale crop farming
Large–scale corporate farming
Extensive small–scale, semi–subsistence farming
Extensive farming in less favoured areas
40
5
1
39
5
2
36
8
2
31
13
1
31
12
3
0
10
20
30
40
Count
European Farming Systems Is this practice applicable in the main Farming Systems of Europe?
Yes
Uncertain
No


Item / sub−questions
Organic Farming
Conservation Agriculture
Agro−Forestry (Agrisilvicultural)
Terrace Farming
Agro−Forestry (Agrosilvopastoral)
Agro−Forestry (Silvopastoral)
43
1
3
38
6
3
31
13
2
26
12
7
24
16
5
20
12
13
0
10
20
30
40
Count
Main agricultural systems Is this practice compatible with the well known agricultural system ?
Yes
Uncertain
No


Item / sub−questions
2.1.1 Non−irrigated arable land
2.1.2 permantently irrigated land
2.4 Heterogenous agricultural areas
2.2.2 fruit trees and berry plantations
2.2.1 vineyards
2.2.3 olive groves
2.3 Pastures
3.2.1 Natural grasslands
2.1.3 rice fields
41
1
4
32
9
3
31
12
1
30
8
9
29
8
10
27
8
11
25
10
9
16
12
16
14
20
11
0
10
20
30
40
Count
Land−use In what land−uses is the practice applicable? Please see the description of the CLC for further information on the land−use nomenclature
Yes
Uncertain
No

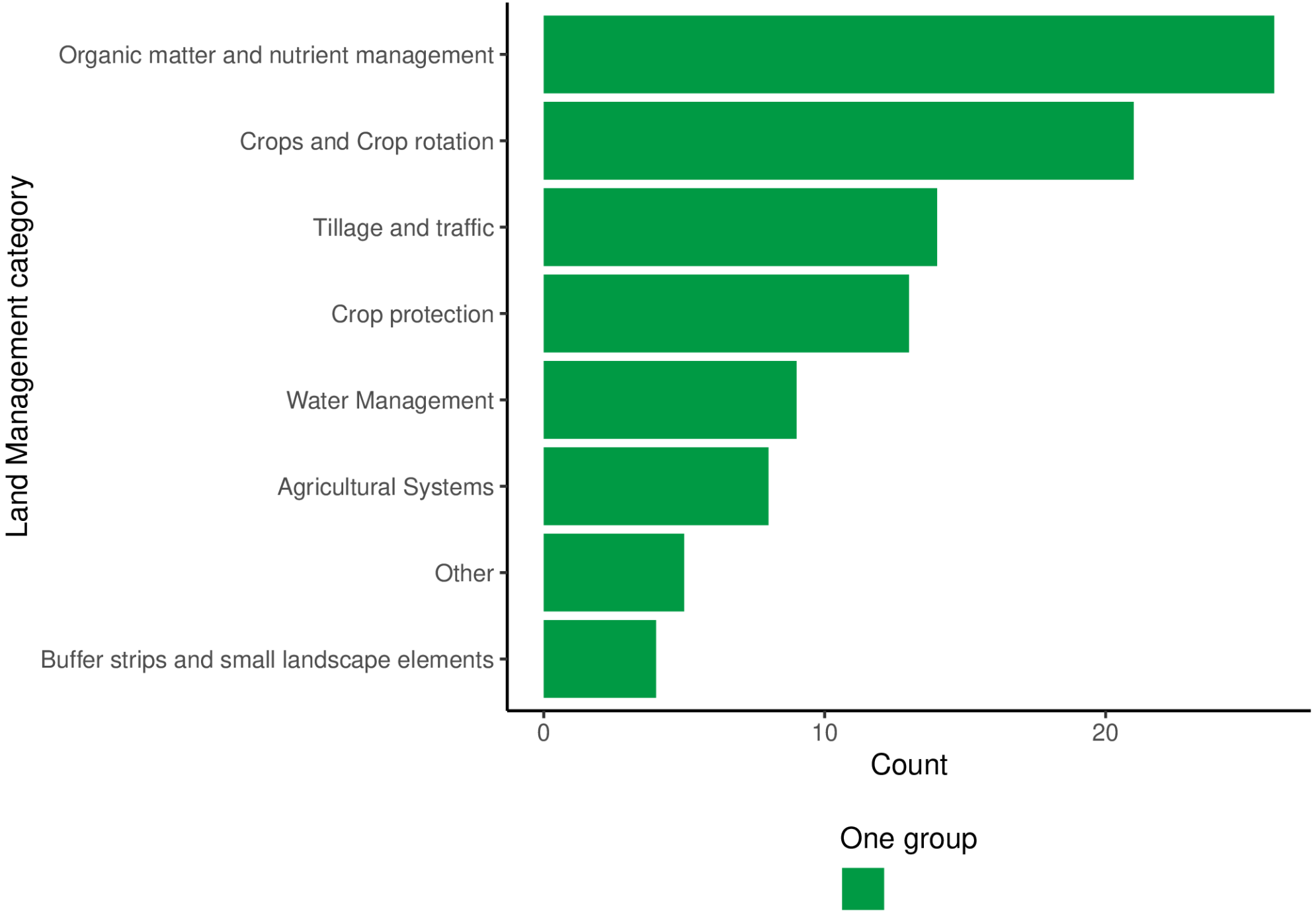

flat to very gently sloping (<2%)
gently sloping (2–5%)
sloping (5–10%)
strongly sloping (10–15%)
moderatly steep (15–30%)
steep (30–60%)
very steep (>60%)
Item / sub–questions
43
2
42
3
39
4
2
33
8
5
18
20
7
11
16
17
10
14
21
0
10
20
30
40
Count
Site and soil Is this practice applicable and advisable on the following slope gradient classes?
Yes
Uncertain
No


Item / sub−questions
Avoid soil erosion
Enhance soil nutrient retention/use efficiency
Optimal soil structure
Enhance water storage capacity
Maintain/increase SOC
Enhance soil biodiversity
Avoiding N2O, CH4 emissions from soils
Avoid contamination
Avoid soil sealing
Avoid Peat degradation
Avoid acidification
Avoid salinisation
7 4 35 1
8 5 34
7 6 33 1
8 6 33
9 7 29 1
14 4 25 3
12 8 22 3
12 12 18 2
5 23 16 1
18 12 9 2
15 16 9 3
17 20 4 3
0 10 20 30 40
Count
What other impacts does the practice have?
Adverse Effect
Beneficial Effect
No Effect
Unknown Effect


Item / sub−questions
Impacts on crop yield
Impacts on farm profitability
Other Impacts (add comments in the next question)
10
2
29
4
11
1
28
5
12
1
12
3
0
10
20
30
40
Count
What other impacts does the practice have?
Adverse Effect
Beneficial Effect
No Effect
Unknown Effect

1 – Inventory of soil management practices : part B

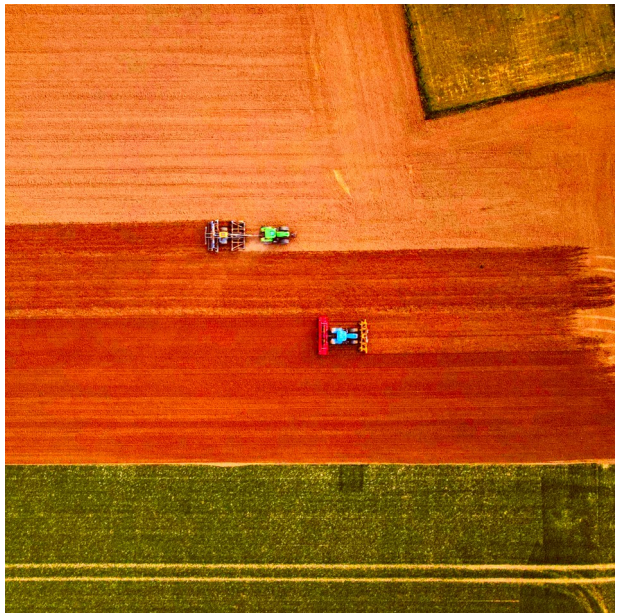
- **Some examples**
  - pea - winter rye relay intercropping
  - Arable field flower strips
  - Three new species of triticale (X. Triticosecale Wittm.) at Szeged, in Hungary, with 'added values'
  - Spot spraying
  - Regenerative agriculture in almond farms
  - Use of pulp mill and paper mill by-products as soil amendments
- Improved nitrogen fertilization with precision farming based on sensor and satellite technologies
- Use of soil nematodes as biocides
- Rotavation of grassland before ploughing
- Bio-subsoiling
- Lightweight autonomous field robot
- Rotovated band seeding
- Humus Balance Calculator
- Biofumigation against plant-pathogens
- Associated rapeseed
- ...


Organic matter and nutrient management
Crops and Crop rotation
Tillage and traffic
Crop protection
Water Management
Agricultural Systems
Other
Buffer strips and small landscape elements
Land Management category
0
10
20
Count
One group

i-SoMPE explored four main axes around soil management practices

2 – Current adoption

1 – Inventory

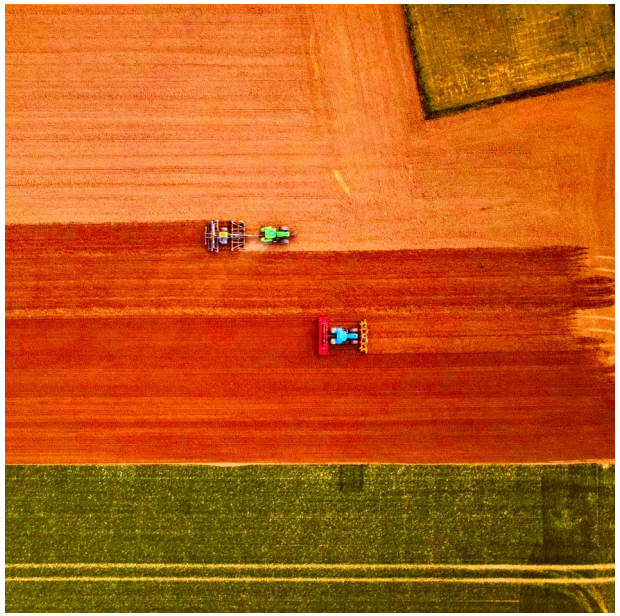


3 – Bio-physical limitations

4 – Barriers & opportunities

i-SoMPE explored four main axes around soil management practices

2 – Current adoption



1 – Inventory

3 – Bio-physical limitations

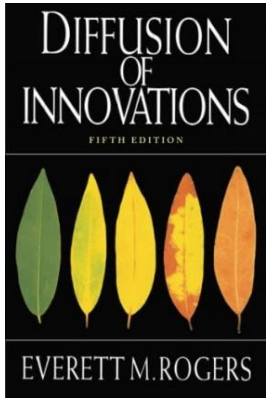
4 – Barriers & opportunities

2 – Current application of soil management practices

EJP SOIL
European Joint Programme

EJP SOIL has received funding from the European Union's Horizon 2020 research and innovation programme: Grant agreement No 862695

2 – Current adoption of soil management practices



- Diffusion of innovations (Rogers, 2003)
- Diffusion may be limited by **bio-physical** and/or **socio-economic factors**
- i-SoMPE wants to assess current and potential diffusion, as well as limiting factors

Rogers (2003)

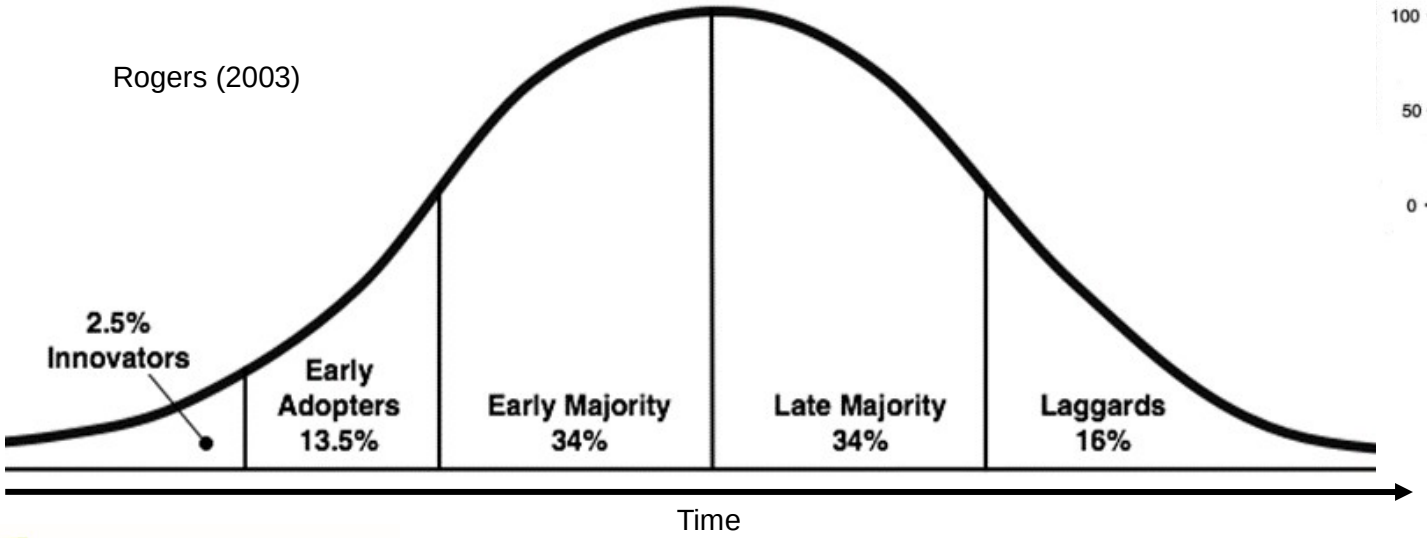
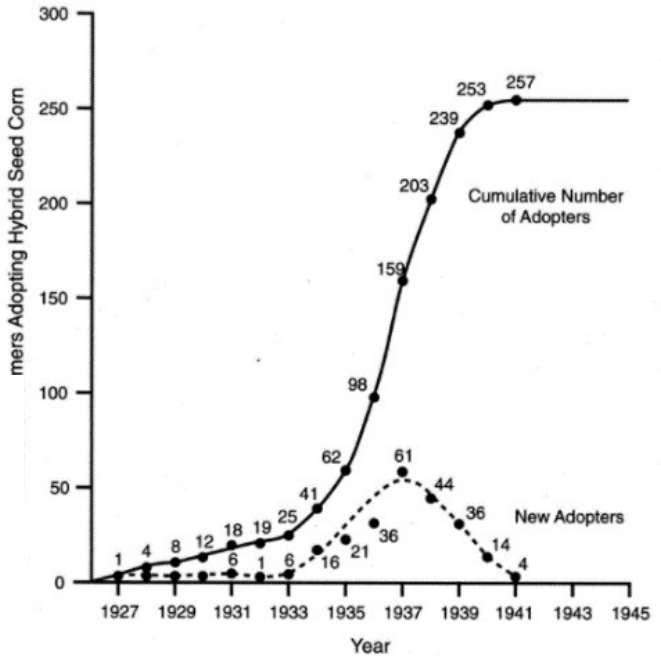


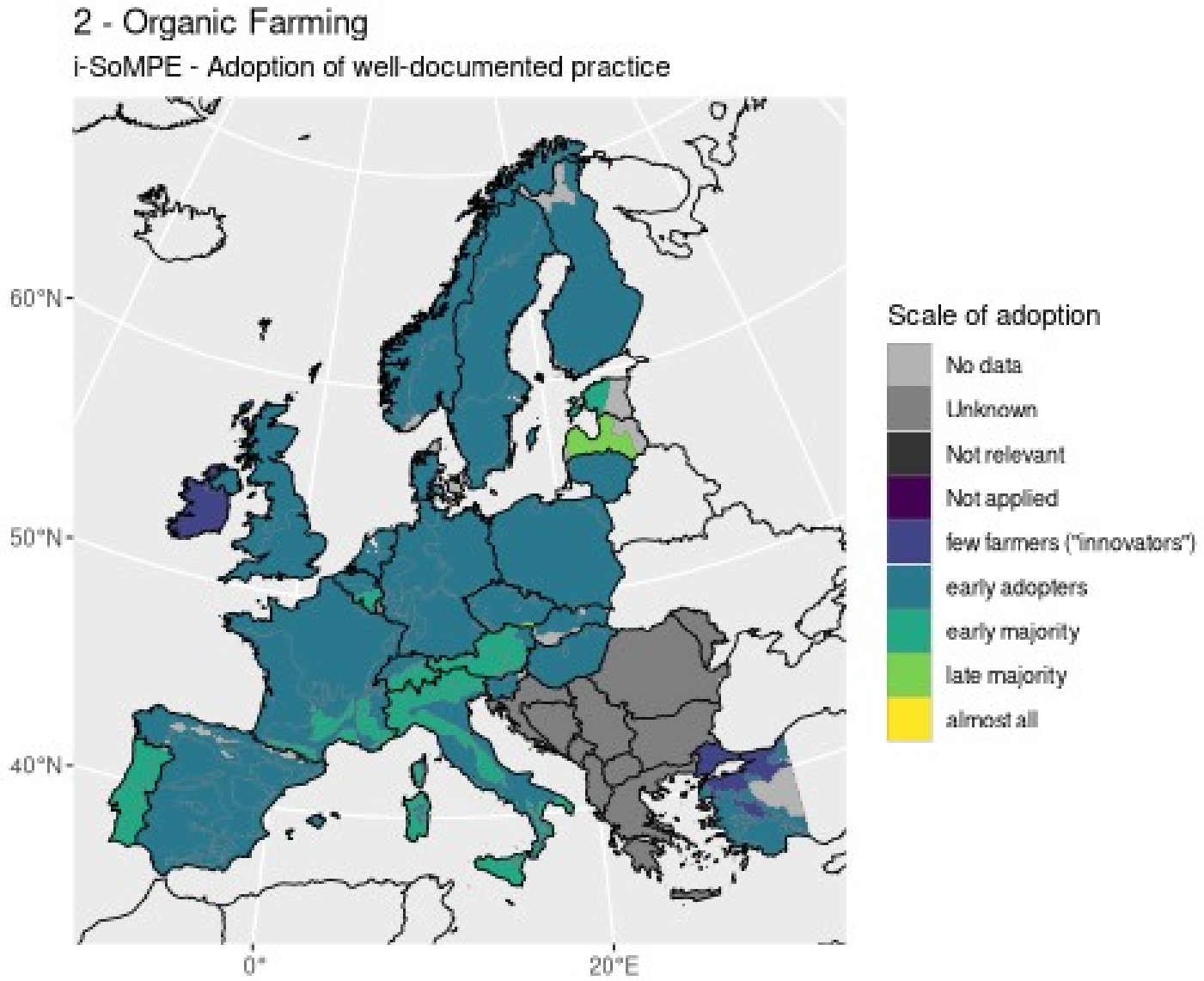
Figure 7-1. The Number of New Adopters Each Year, and the Cumulative Number of Adopters, of Hybrid Seed Corn in Two Iowa Communities



EJP SOIL European Joint Programme

i-SoMPE

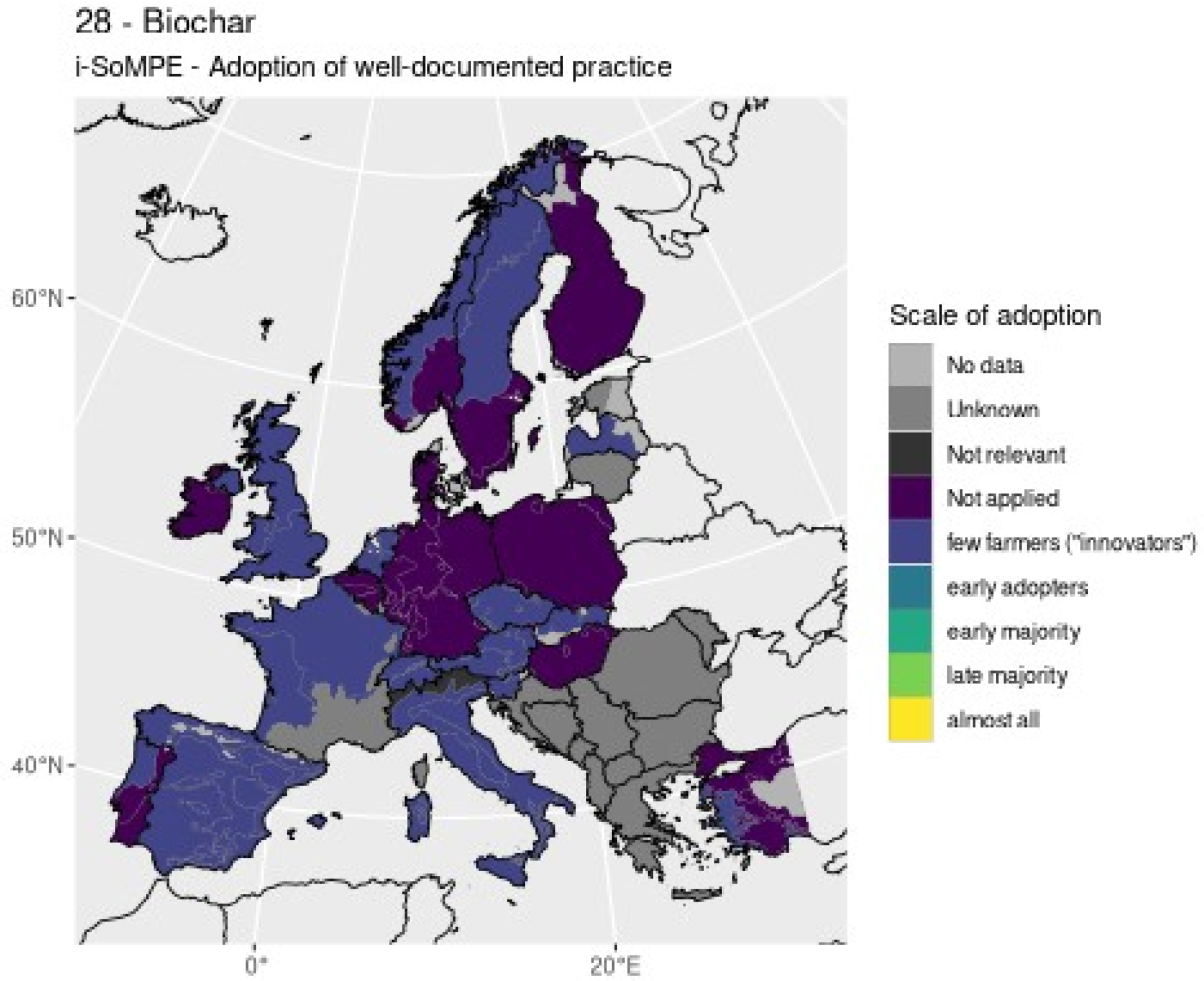
2 – Current adoption of soil management practices



EJP SOIL
European Joint Programme

i-SoMPE

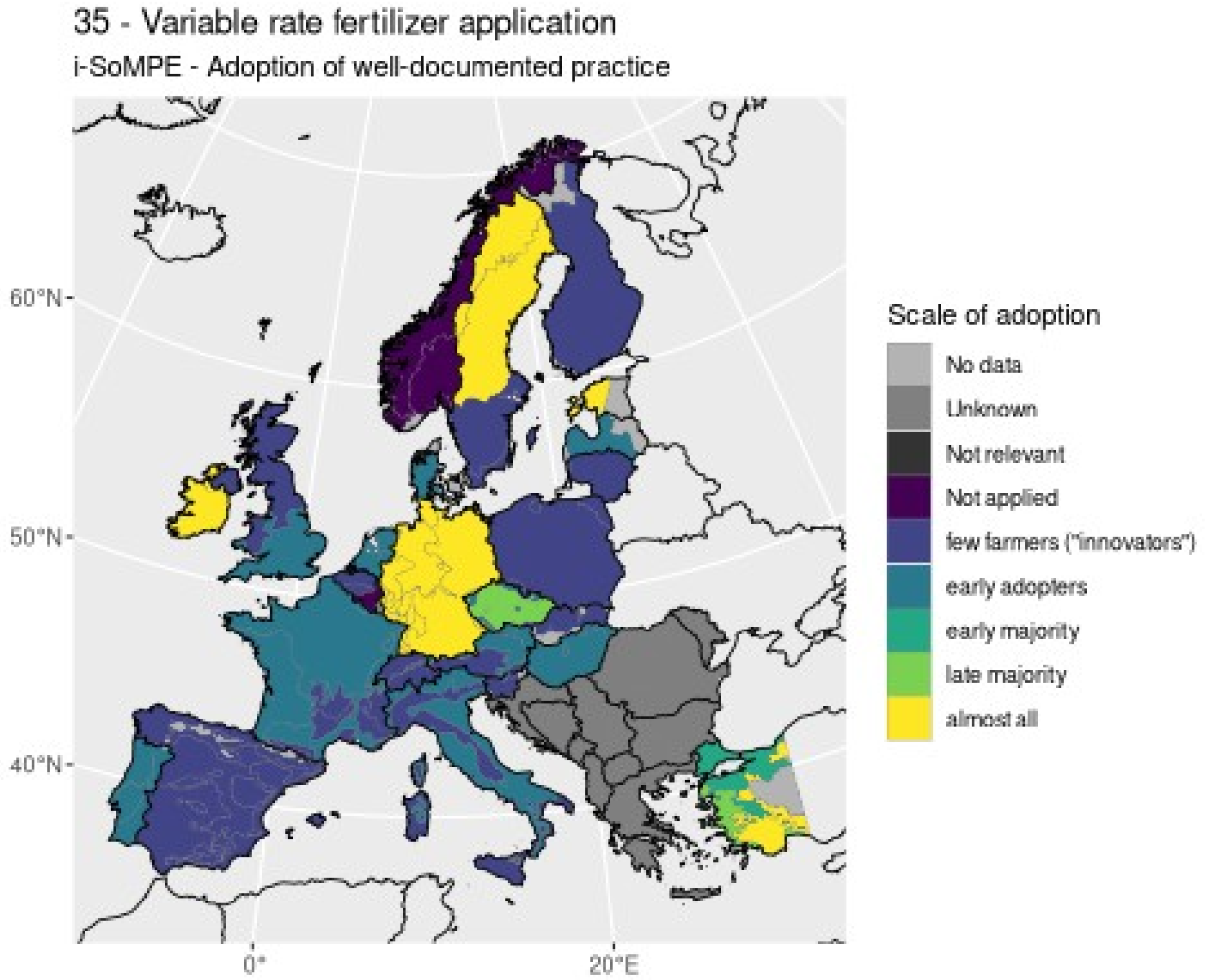
2 – Current adoption of soil management practices



EJP SOIL
European Joint Programme

i-SoMPE

2 – Current adoption of soil management practices



EJP SOIL
European Joint Programme

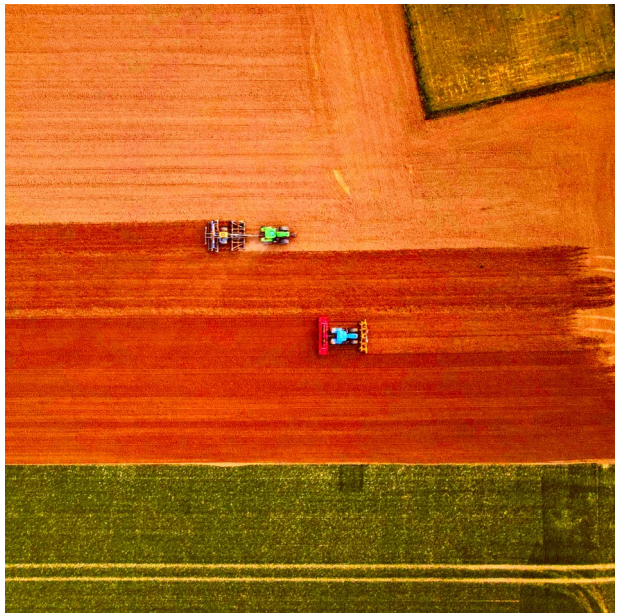
i-SoMPE

2 – Current adoption of soil management practices

- Data base of **3960 records** (excl. « No data »)
- Available in **static maps** (images), **reactive maps** (app) & **open data** (data frame with raw data)
- Can be « versioned » for further update

i-SoMPE explored four main axes around soil management practices

2 – Current adoption



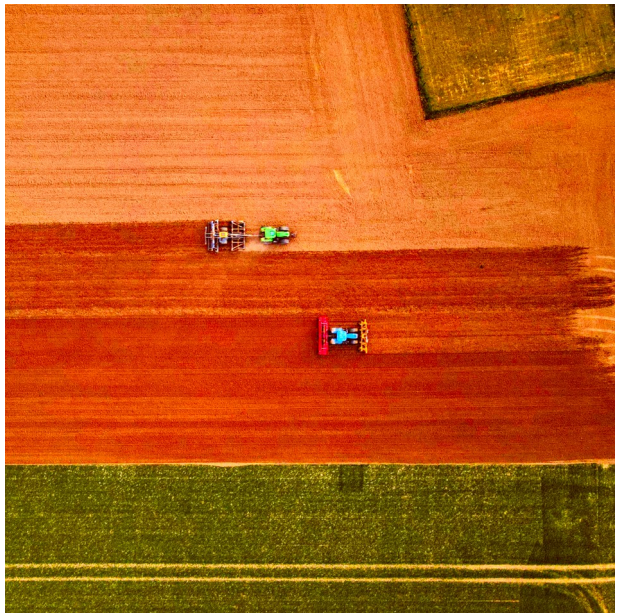
1 – Inventory

3 – Bio-physical limitations

4 – Barriers & opportunities

i-SoMPE explored four main axes around soil management practices

2 – Current adoption



1 – Inventory

3 – Bio-physical limitations

4 – Barriers & opportunities

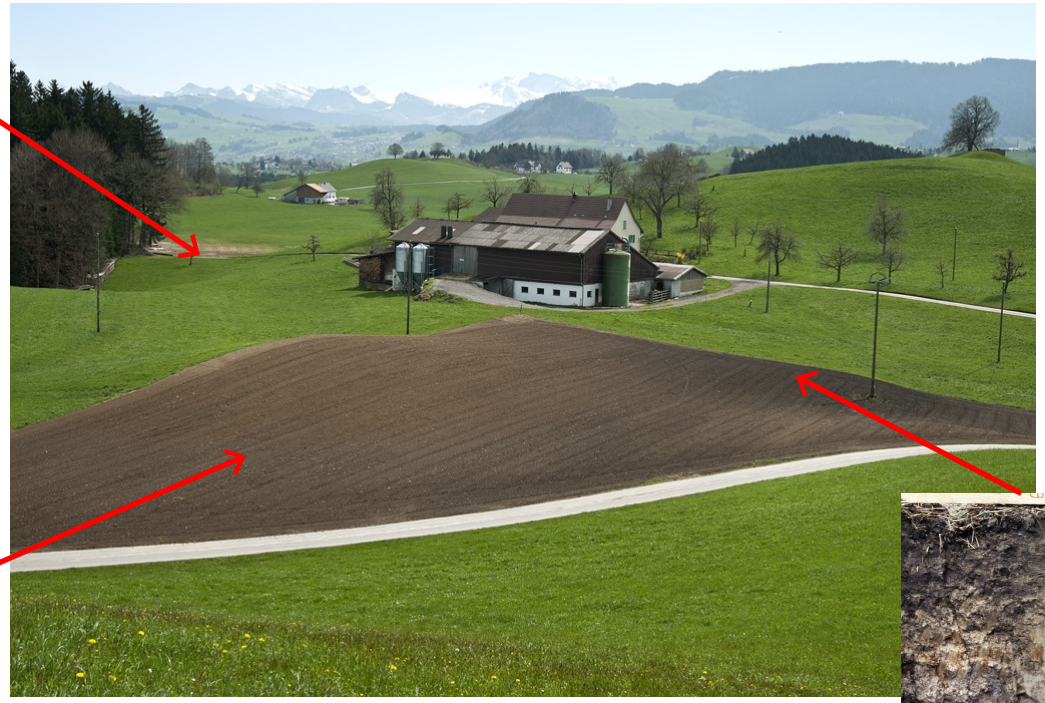
3 – Framework to assess the bio-physical limitations of practice application

EJP SOIL
European Joint Programme

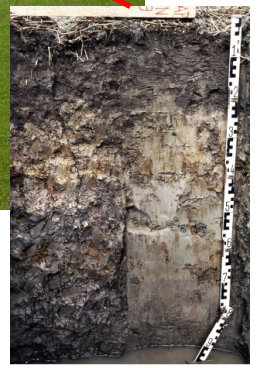
EJP SOIL has received funding from the European Union's Horizon 2020 research and innovation programme: Grant agreement No 862695

Introduction

Histosol



Cambisol



Gleysol

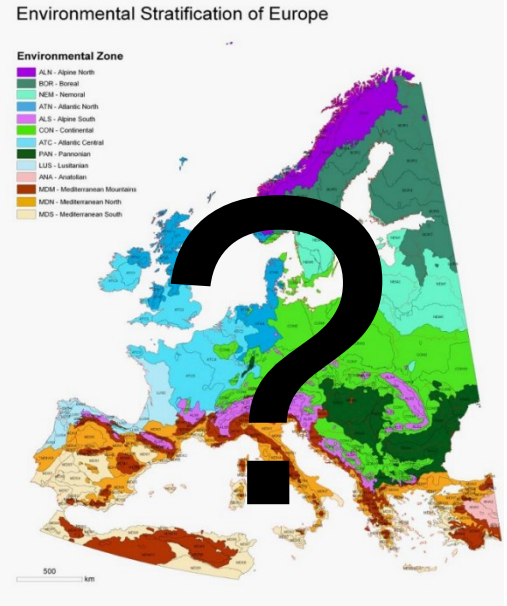
Bio-physical limits to SMP application

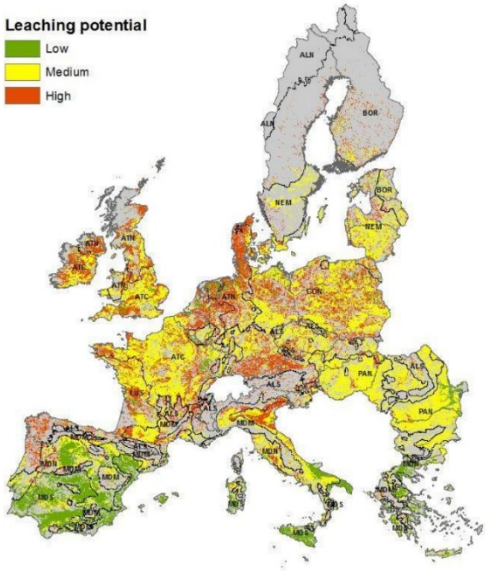
- Land-use
- Climate
- Topography (e.g., slope)
- Soil properties

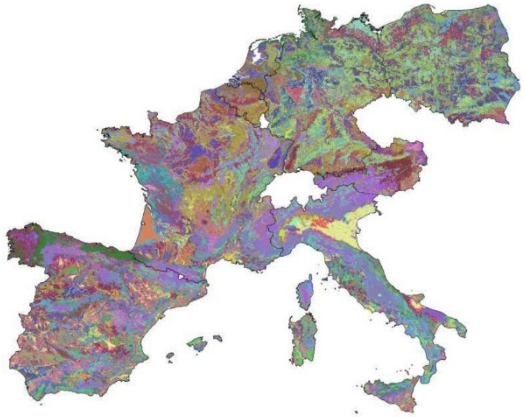
Assessment of bio-physical limits

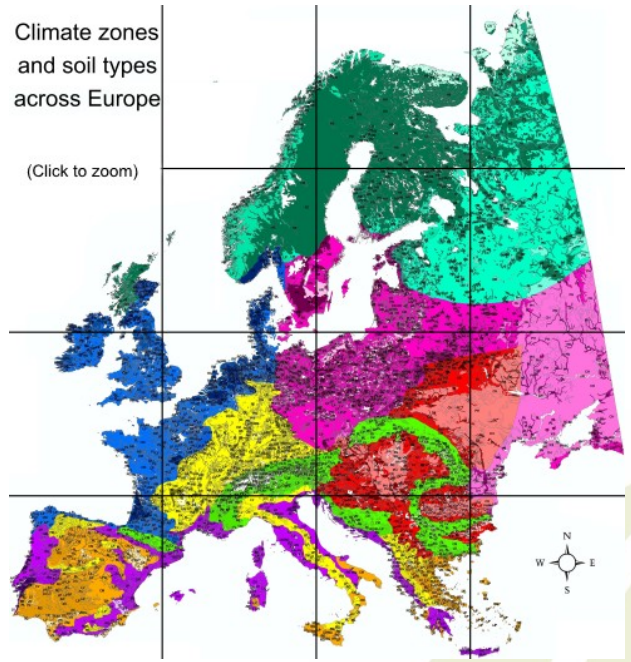
- Based on geo data
- On the level of agro-ecological zones (AEZ)

Agro-ecological zonation of Europe: Definition and Characterization









seamless

Nitrate Directive
DG ENV (2011)

Catch-C

iSQAPER
Interactive Soil Quality Assessment

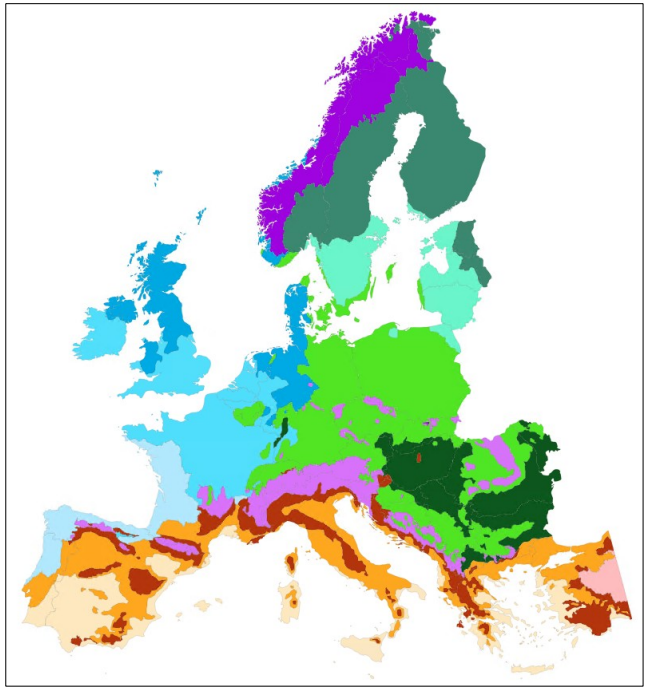
EJP SOIL
European Joint Programme

Agro-ecological zonation of Europe: Definition and Characterization

Project	Climate	Topography	Soil	Land-Use	Coverage	# of zones
SeamLess (2010)	EnZ	Slope, Elevation GTOPO30 (1996)	SOC (OCTOP)	3 suitability classes	EU27, NO, CH	252
Nitrate directive (2011)	EnZ, Worldclim, CRU TS 2.0 (1901 – 2000)	Slope GTOPO30 (1996)	Texture, SOC, Rooting depth (ESDB)	CLC 2000	EU27	52
Catch-C (2013)	EnZ	Slope GTOPO30 (1996)	Texture (ESDB)	FADN	AT, BE, DE, ES, FR, IT, NL, PL	23
i-SQUAPER (2017)	Env. Zones (Hartwich et al., 2005)		Reference soil groups (ESDB)		Europe west of Ural, excl. Turkey	133
i-SoMPE (2021)	**EnZ**, **Agri4Cast LTA** (1990 – 2020)	**Slope** EU-DEM 1.0 (2013)	**Organic soils**, (Tanneberger et al., 2017) **reference soil groups** (+) (ESDB)	**CLC** 2018	45 European Countries	146 (EnZ x Countries)

EnZ: Environmental Zonation by Metzger et al. (2005); CLC: Corinne Land Cover

AEZ of i-SoMPE: Definition



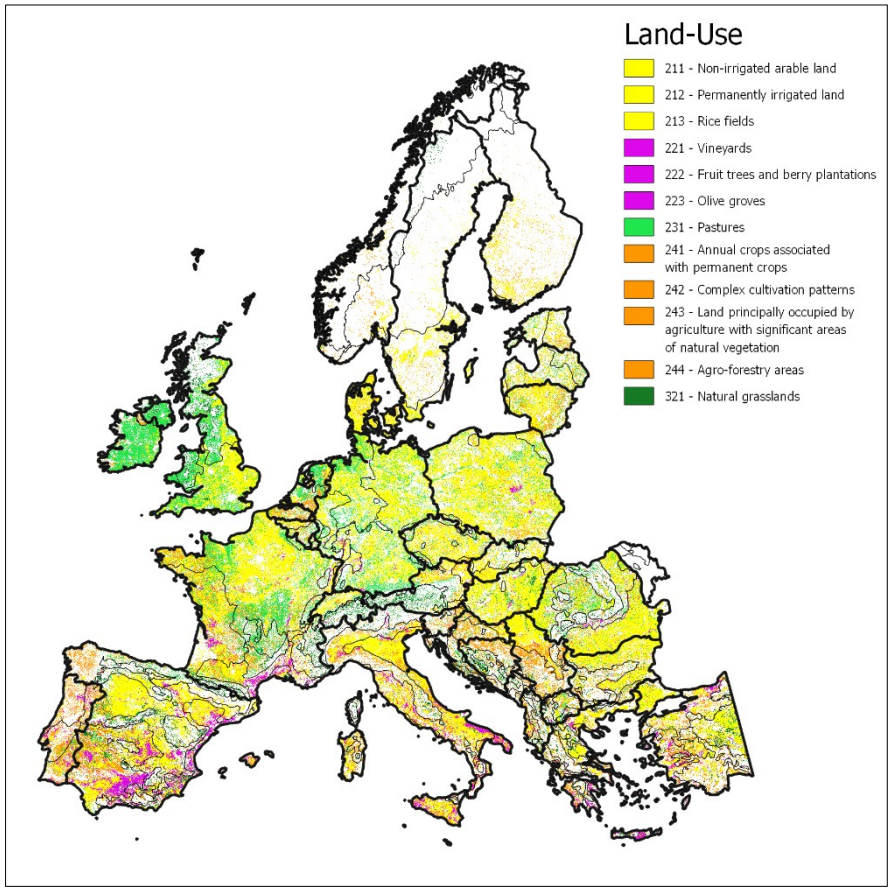
13 EnZ
by Metzger et al. (2005)

X

46 Countries
(incl. 2 BE regions)

146 AEZ

AEZ of i-SoMPE: Characterization – Land-use



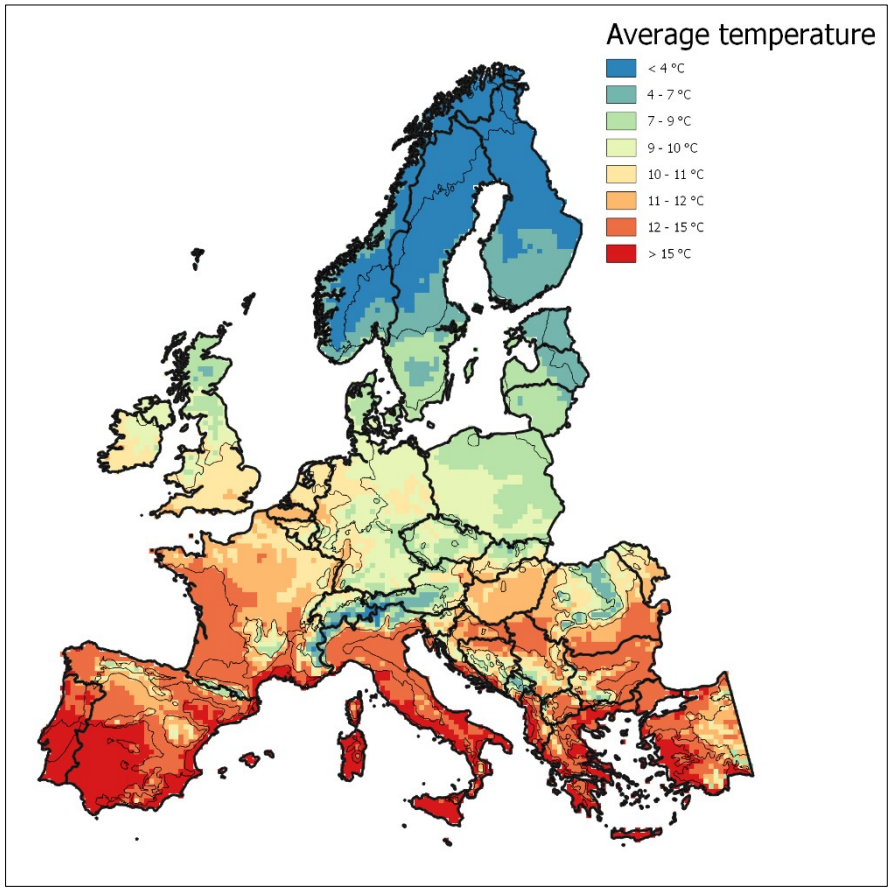
Land-use data (Source)

- CLC 2018
- Minimum mapping unit: 25 ha

Land-use data (used)

- 5 Agricultural land-use classes
  - 12 sub-classes

AEZ of i-SoMPE: Characterization - Climate

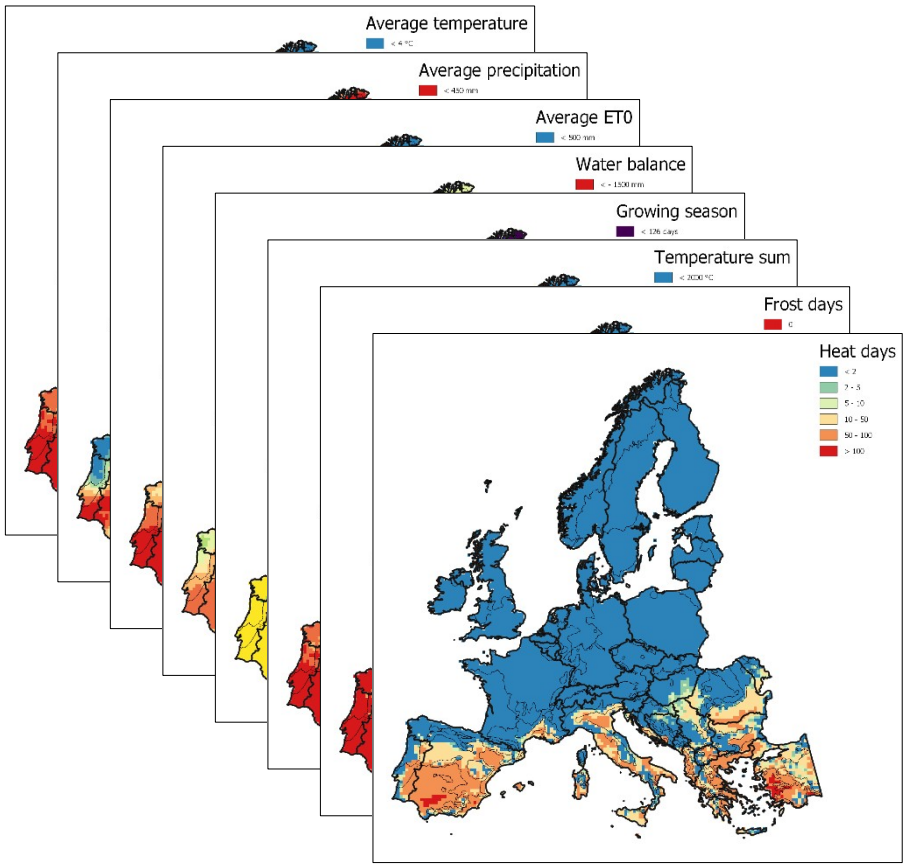


Climate data (Source)

- Agri4Cast long term averages (1991 – 2020)
- 25 x 25 km grid
- Daily values for:
  - Temperature (min, max, average)
  - Precipitation
  - Evapotranspiration (ET0)

JOINT RESEARCH CENTRE
AGRI4CAST RESOURCES PORTAL

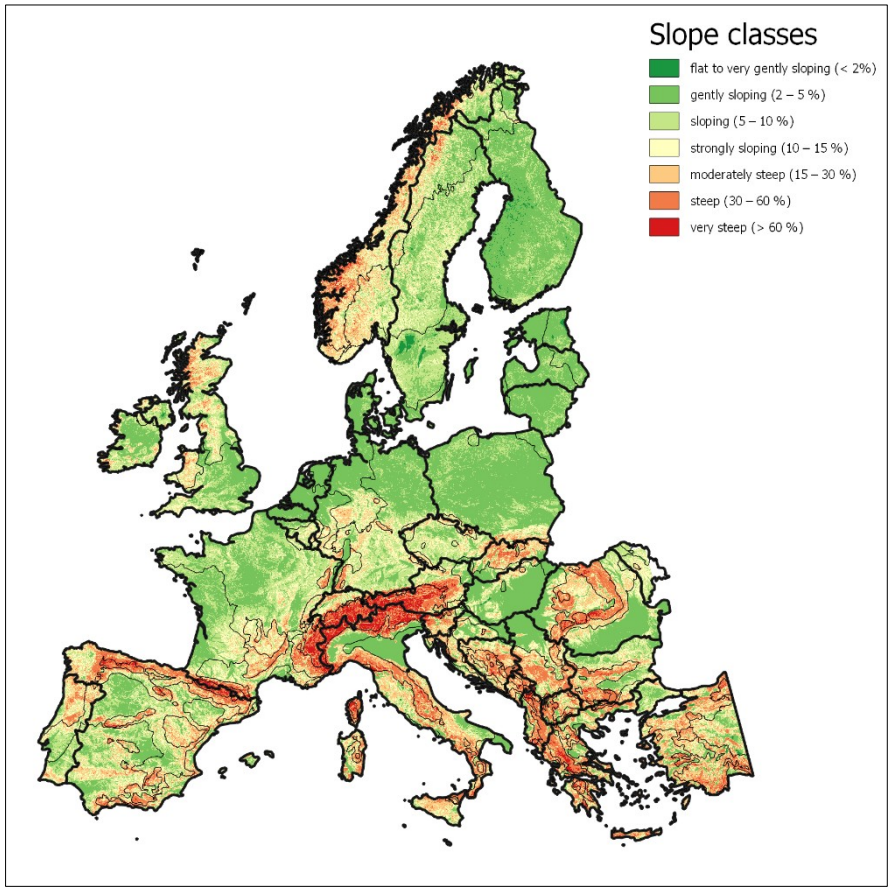
AEZ of i-SoMPE: Characterization - Climate



Climate data (Derivatives)

- Average temperature
- Average precipitation
- Average ET0
- Annual water balance
- Length of the growing season
- Temperature sum
- Number of days with frost
- Number of hot days
- …

AEZ of i-SoMPE: Characterization - Topography

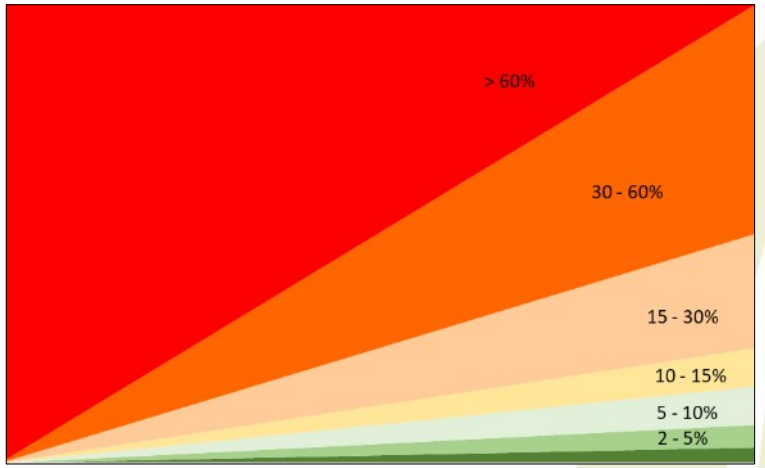


Topography data (Source)

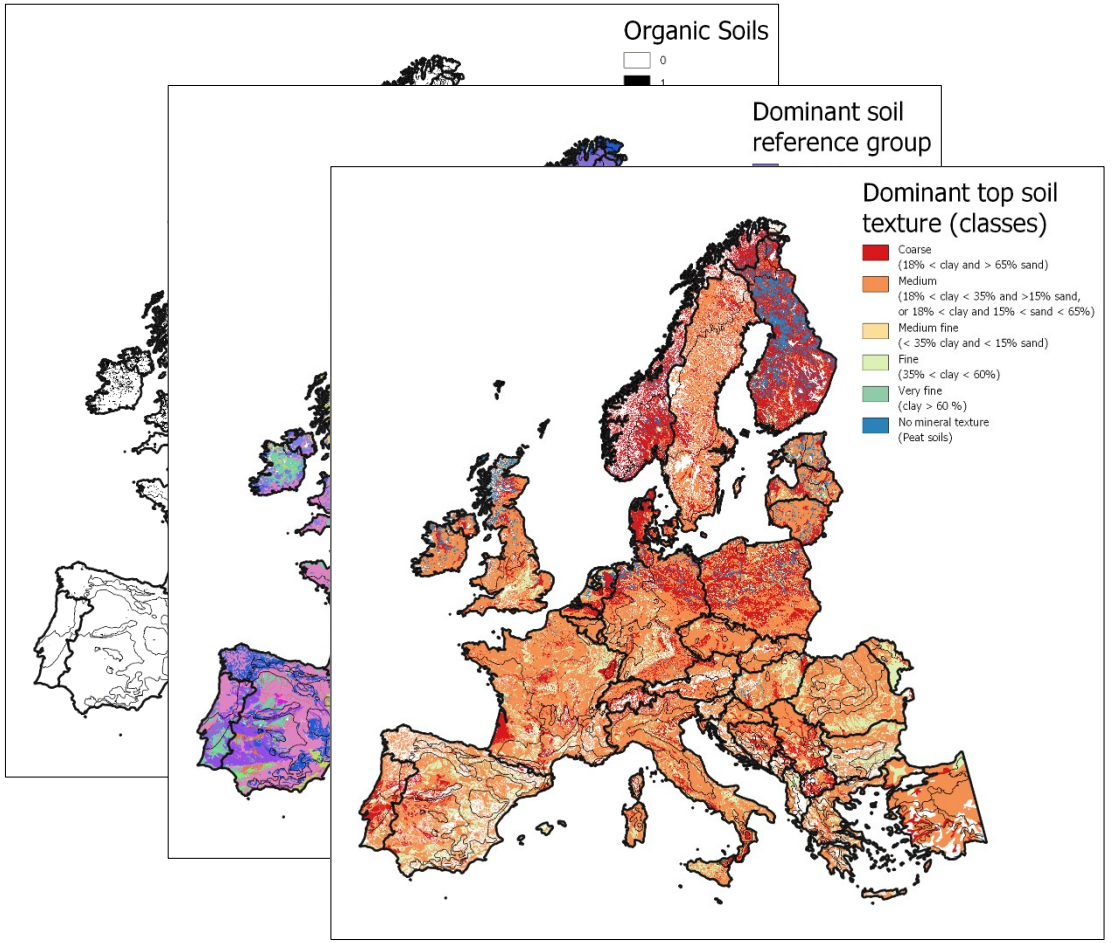
- EU-DEM v1.0
- 25 x 25 m grid

Topography data (Derivatives)

- Slope in %
- 7 slope classes



AEZ of i-SoMPE: Characterization - Soil



Organic soils (Source)

- Peatland map of Europe (Tanneberger et al., 2017)
- 1 x 1 km grid

Other soil data (Source)

- European soil database derived
- 2001 / 2006 / 2013
- 1 x 1 km grid / 1:1’000’000
- Data on:
  - Dominant WRB reference group
  - Dominant texture
  - Dominant rooting depth
  - Dominant gravel content
  - Dominant water regime
  - …

AEZ of i-SoMPE: Characterization

EnZ	Country	CLC_Code	Area_km2	Peat_km2	SoilType_k	SoilType_k	SoilType_k
ALS	CH	211	116	0	0	0	39
ALS	CH	221	62	0	0	0	35
ALS	CH	222	38	0	0	0	18
ALS	CH	231	1336	26	0	0	17
ALS	CH	242	47	2	0	0	6
ALS	CH	243	249	5	0	0	14
ALS	CH	321	3757	83	0	0	6
ATC	CH	211	172	1	0	0	1
ATC	CH	221	13	0	0	0	0
ATC	CH	222	7	0	0	0	1
ATC	CH	231	6	0	0	0	0
ATC	CH	242	24	0	0	0	0
ATC	CH	243	8	0	0	0	0
CON	CH	211	5640	306	114	0	10
CON	CH	221	68	0	1	0	0

Example of L4 data

4 Levels of AEZ description

- **L1**: EnZ (13 zones)
- **L2**: AEZ (146 zones)
- **L3**: AEZ (agri. only, 146 zones)
- **L4**: AEZ x land-use (1006 zones)

Variables of AEZ description

- Area
- Land-use information
- Climate data (mean, SD)
- Soil information
  - Area of organic soils
  - Area of WRB reference group
- Area per slope classes
- Max. 70 variables

AEZ of i-SoMPE: Characterization (Example)

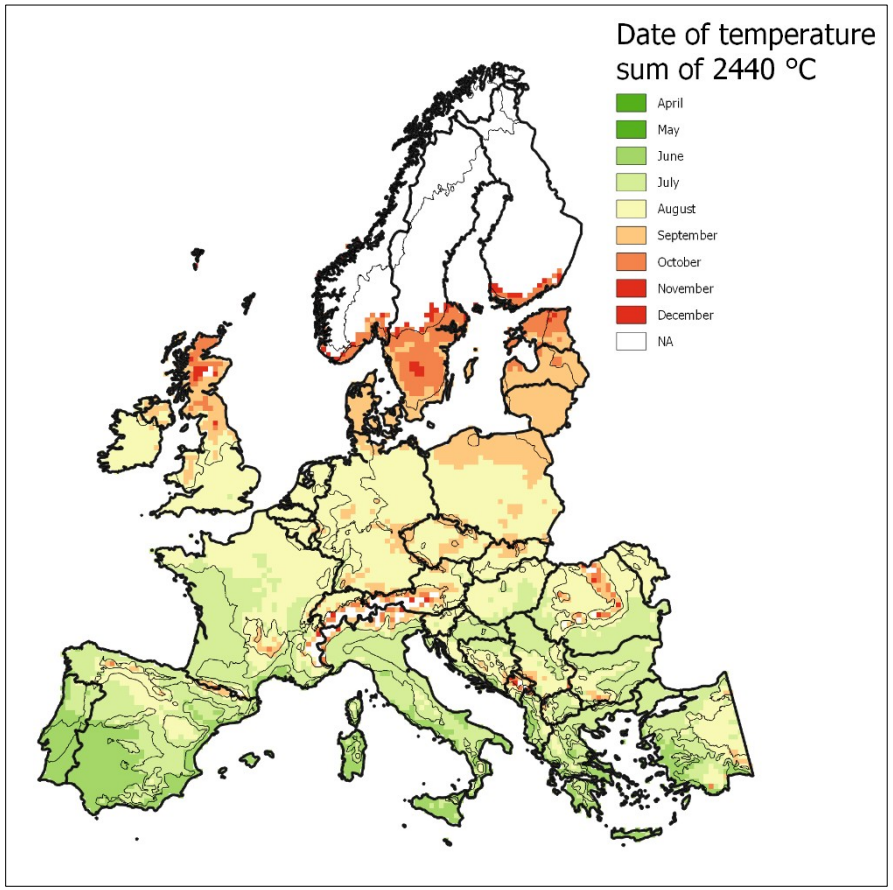
EnZ	Area [km2]	Agri. [km2]	Share
ALN	324'564	7'669	2%
ALS	286'579	80'969	28%
ANA	43'298	27'232	63%
ATC	512'055	354'552	69%
ATN	294'911	161'095	55%
BOR	646'110	54'353	8%
CON	974'733	518'081	53%
LUS	194'565	100'319	52%
MDM	338'477	119'534	35%
MDN	527'125	309'172	59%
MDS	380'739	242'044	64%
NEM	266'781	95'982	36%
PAN	380'488	252'704	66%

Country	Agri. [km2]
AL	505
AT	15'338
BA	10'917
BE3	4'827
BG	11'214
CH	9'324
CZ	38'527
DE	130'032
DK	10'909
FR	8'353
HR	8'581
HU	3'875
LI	35
LT	976
LU	536
LV	772
MD	25
ME	1'197
MK	1'391
NL	482
NO	506
PL	172'531
RO	45'862
RS	18'052
SE	8'906
SI	414
SK	13'994

CLC_Code	CLC	Area [km2]	Peat [km2]	Cambisol [km2]	GrowSeason_M	SD
211	Non-irrigated arable land	5'640	306	4'297	253	3
221	Vineyards	68		46	252	11
222	Fruit trees and berry plantations	14	1	9	253	6
231	Pastures	1'885	59	934	250	7
242	Complex cultivation paterns	864	27	633	248	12
243	Land principaly occupied…	474	7	272	228	
321	Natural grasslands	379	24	6	248	

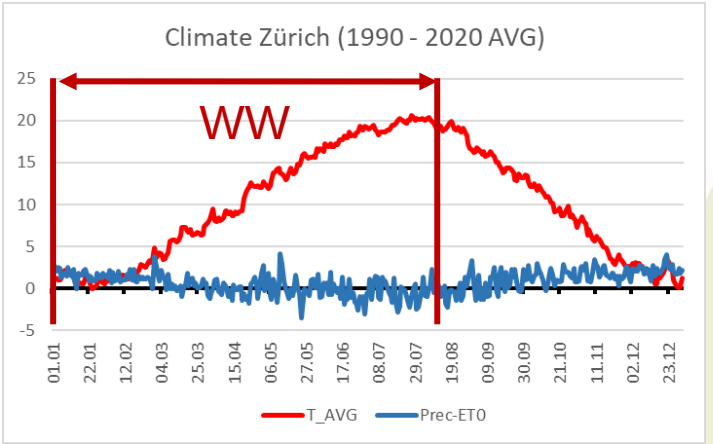
CLC_Code	CLC	Area [km2]	< 2%	2-5%	5-10%	10-15%	15-30%	30-60%	>60%
211	Non-irrigated arable land	126'483	62%	28%	8%	2%	1%	0%	0%
222	Fruit trees and berry plantations	1'732	64%	26%	7%	2%	1%	0%	0%
231	Pastures	25'823	66%	23%	7%	2%	1%	0%	0%
242	Complex cultivation paterns	7'692	47%	31%	13%	5%	4%	0%	0%
243	Land principaly occupied…	10'600	39%	34%	15%	6%	5%	0%	0%
321	Natural grasslands	201	64%	25%	6%	1%	2%	1%	0%

Application of the framework: cover crops

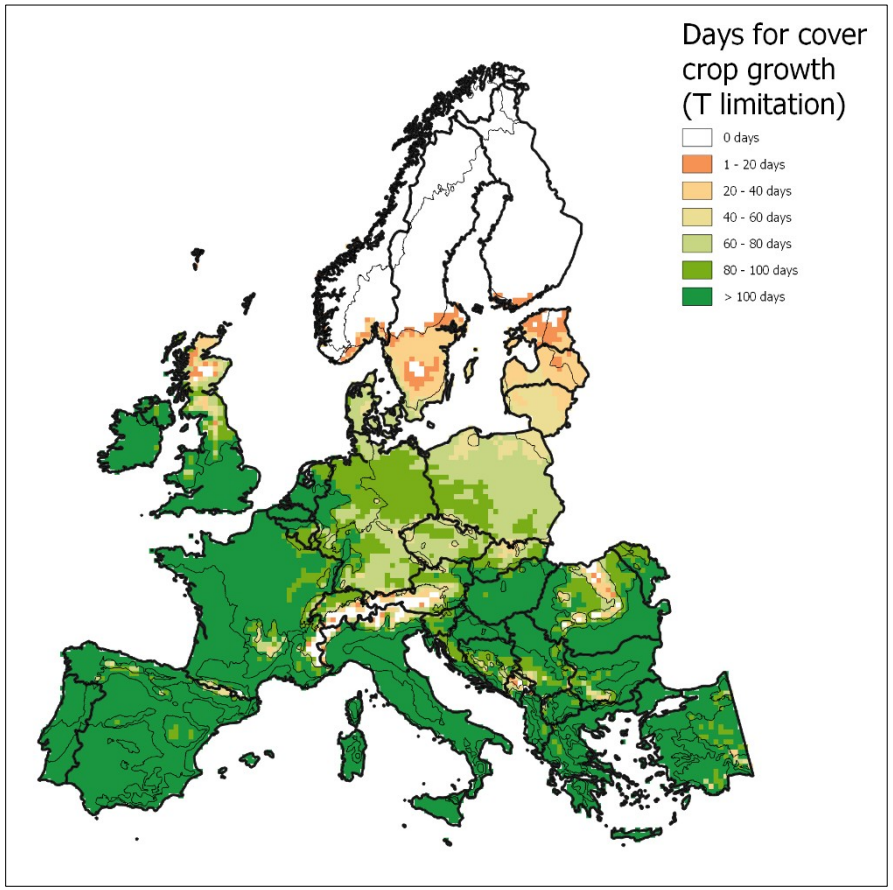


Assumptions

- Cover crop after winter wheat
- WW needs a T_{sum} of 2440°C to maturity

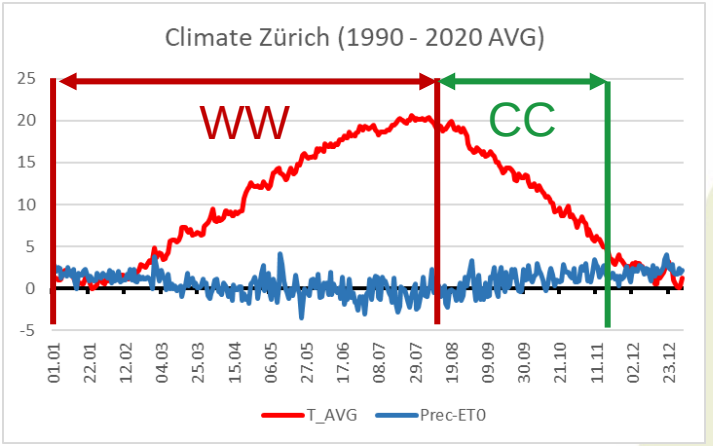


Application of the framework: cover crops

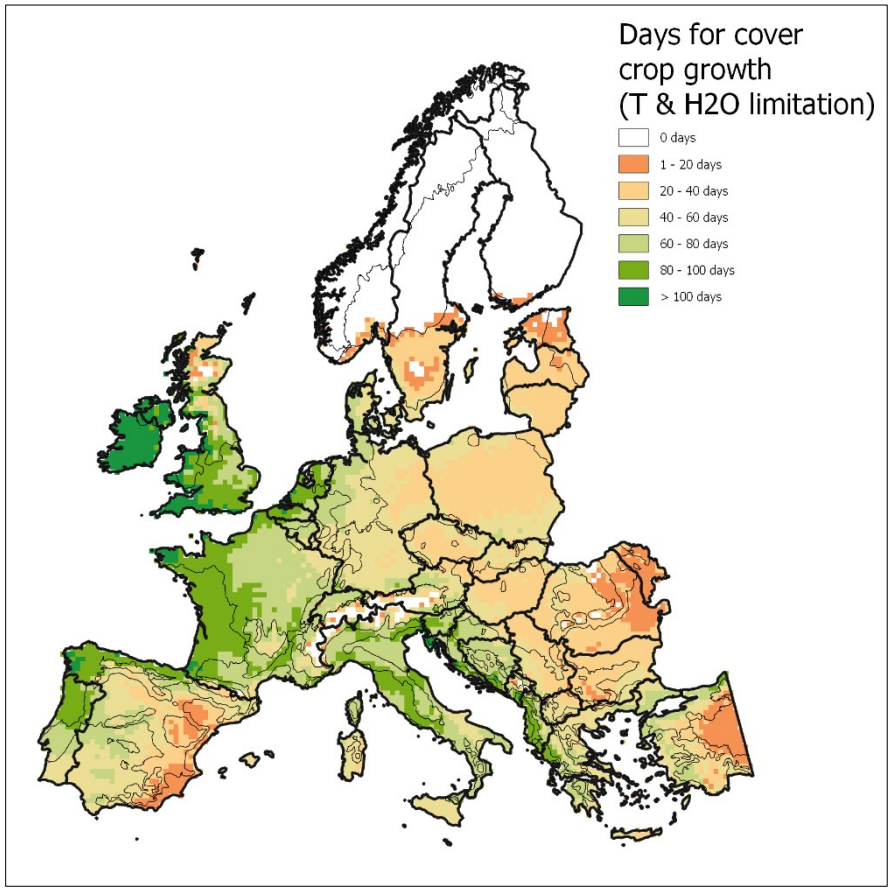


Assumptions

- Cover crop after winter wheat
- WW needs a T_{sum} of 2440°C to maturity -> calculate harvest date
- Cover crops need:
  - T_{AVG} > 5°C

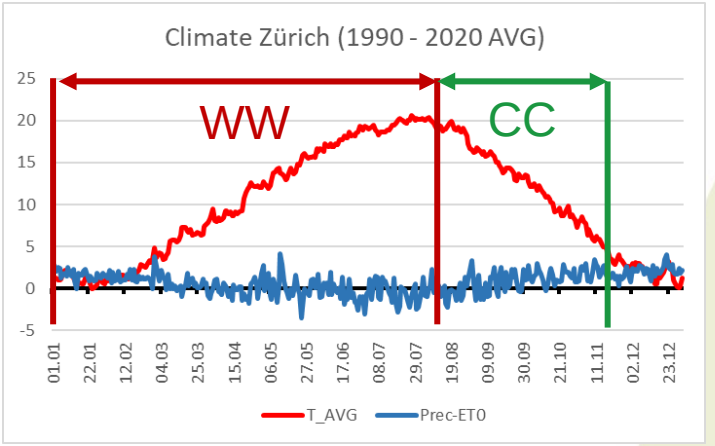


Application of the framework: cover crops

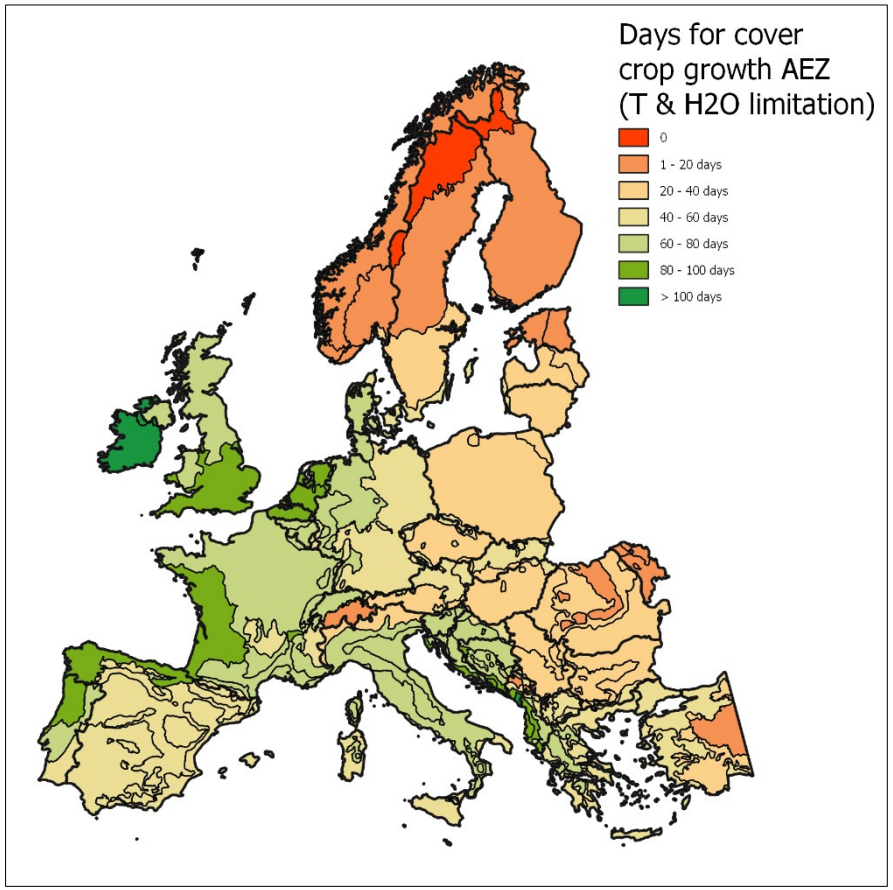


Assumptions

- Cover crop after winter wheat
- WW needs a T_{sum} of 2440°C to maturity
- Cover crops need:
  - T_{AVG} > 5°C
  - Prec > ET0



Application of the framework: cover crops



Assumptions

- Cover crop after winter wheat
- WW needs a T_{sum} of 2440°C to maturity
- Cover crops need:
  - T_{AVG} > 5°C
  - Prec > ET0
- min. of 40 to 60 days for cover crop growth
- Arable land use
- slope < 30%

Application of the framework: cover crops

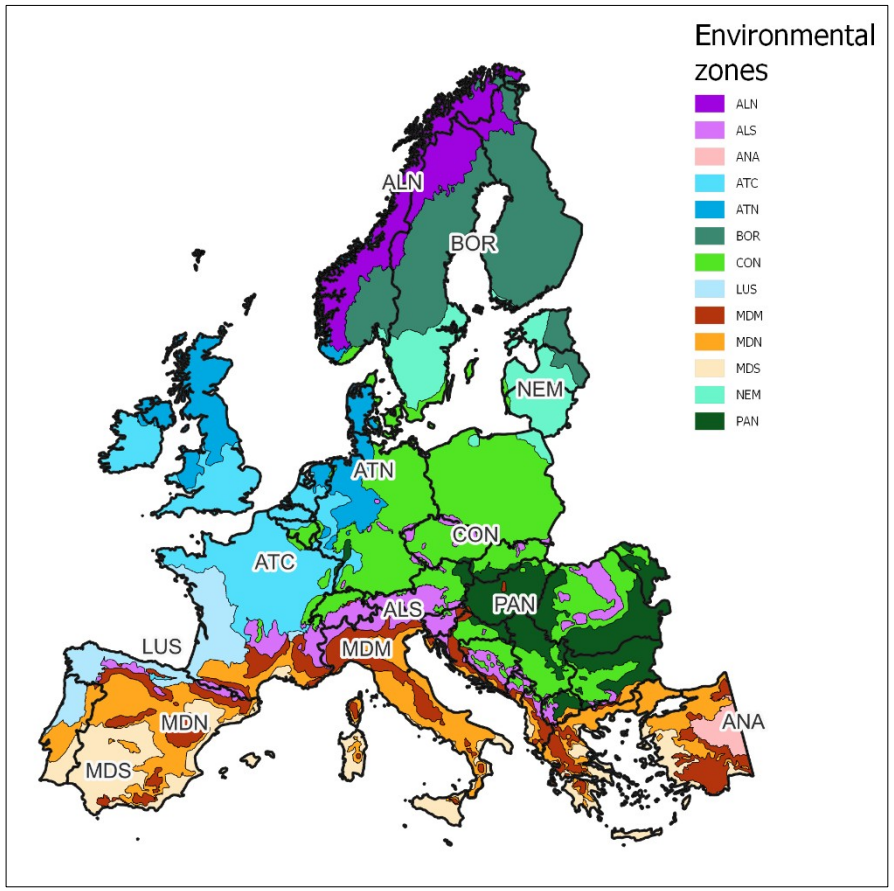
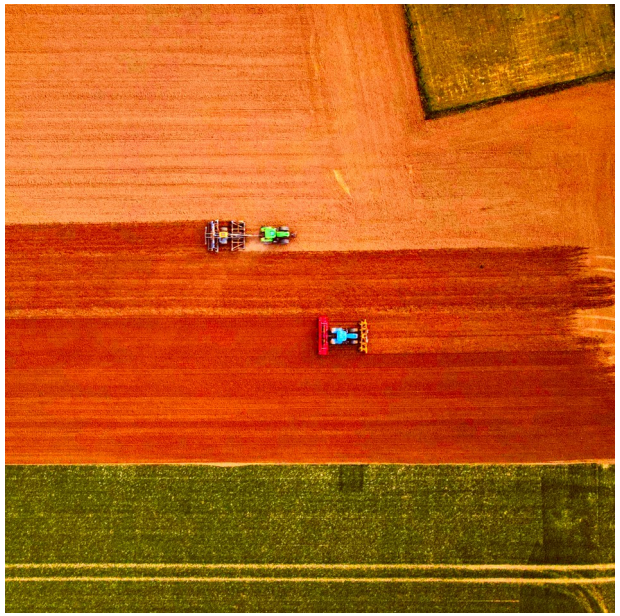


Table 5.1: Agricultural land suited for the growth of cover crops. LU: land use, S: slope, T: temperature, M: moisture. All areas in km^2.

EnZ	Area	Suitable LU	S limited	S+T limited	S+T+M limited
ALN	324'564	1'220	2.7%	100%	100%
BOR	646'110	29'847	1.0%	100%	100%
NEM	266'781	59'275	0.1%	53% - 100%	100%
ATN	294'911	69'415	0.1%	1%	1% - 1%
ATC	512'055	182'468	0.1%	0%	0% - 0%
CON	974'733	312'877	0.1%	0% - 3%	57% - 97%
ALS	286'579	6'718	0.1%	19% - 63%	39% - 90%
PAN	380'488	185'095	0.3%	0% - 0%	93% - 100%
LUS	194'565	36'507	0.8%	0%	0%
MDM	338'477	36'964	0.4%	1%	20% - 54%
MDN	527'125	161'951	0.5%	0%	0% - 59%
MDS	380'739	86'473	0.0%	0%	0% - 98%
ANA	43'298	16'534	0.0%	0%	100%
Europe	5'170'425	1'185'344	0.2%	6% - 9%	40% - 68%

i-SoMPE explored four main axes around soil management practices

2 – Current adoption



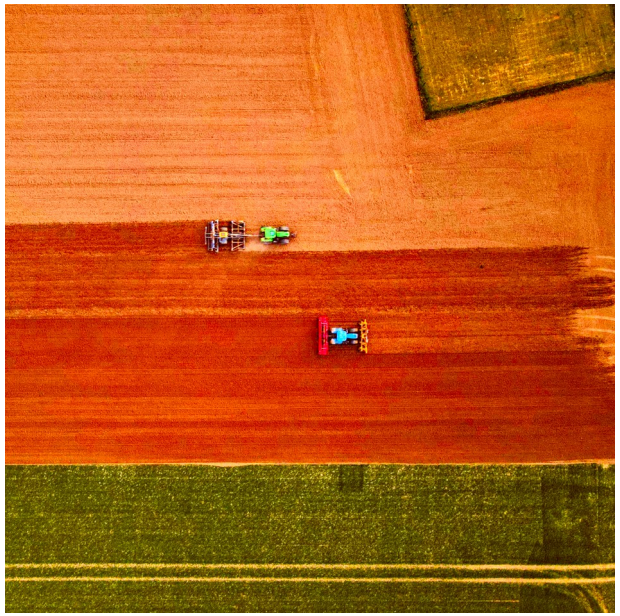
1 – Inventory

3 – Bio-physical limitations

4 – Barriers & opportunities

i-SoMPE explored four main axes around soil management practices

2 – Current adoption



1 – Inventory

3 – Bio-physical limitations

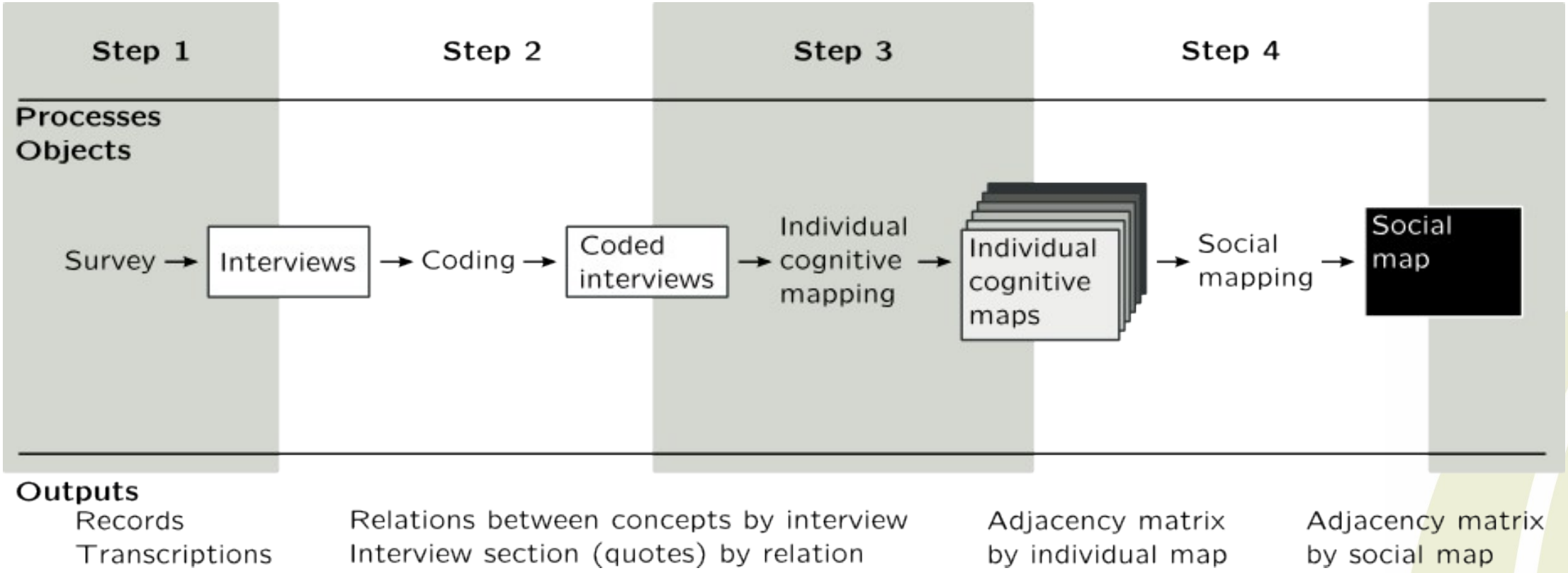
4 – Barriers & opportunities

4 – Barriers and opportunities

EJP SOIL
European Joint Programme

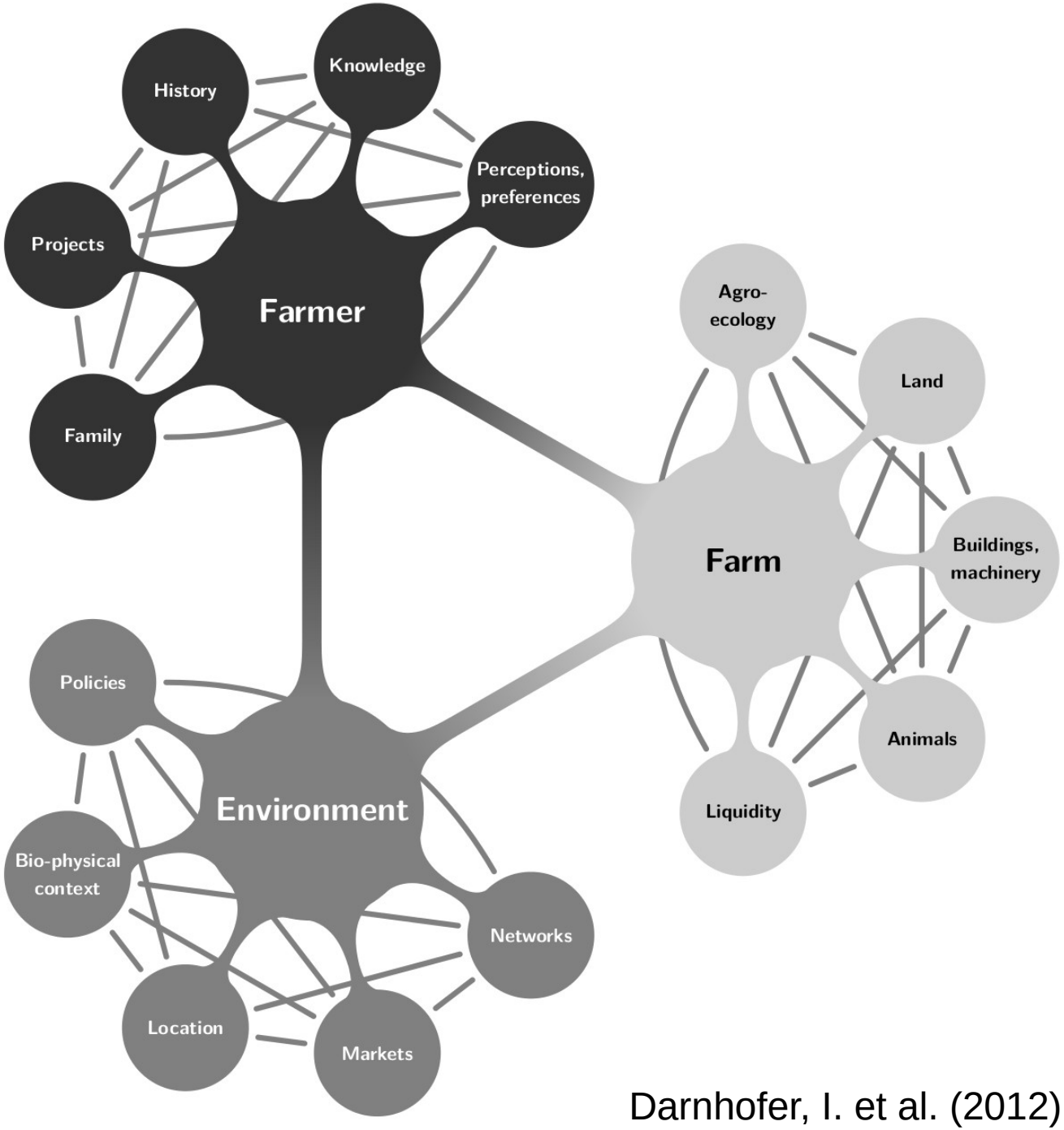
EJP SOIL has received funding from the European Union's Horizon 2020 research and innovation programme: Grant agreement No 862695

4 – Barriers and opportunities analyses



Vanwindekens, F. et al. (2013)

4 – Barriers and opportunities analyses



Darnhofer, I. et al. (2012)

EJP SOIL European Joint Programme

i-SoMPE

4 – Barriers and opportunities analyses

- Qualitative interviews done by partners
  - 20 on **Conservation agriculture**
  - 3 on Low emission **slurry spreading**
  - 4 on **Cover crop incorporation** without herbicide application
  - 3 on **Drip irrigation**
  - 7 on **Conservation tillage**

4 – Barriers and opportunities analyses

Conservation agriculture, a system of practices whose practitioners promote:

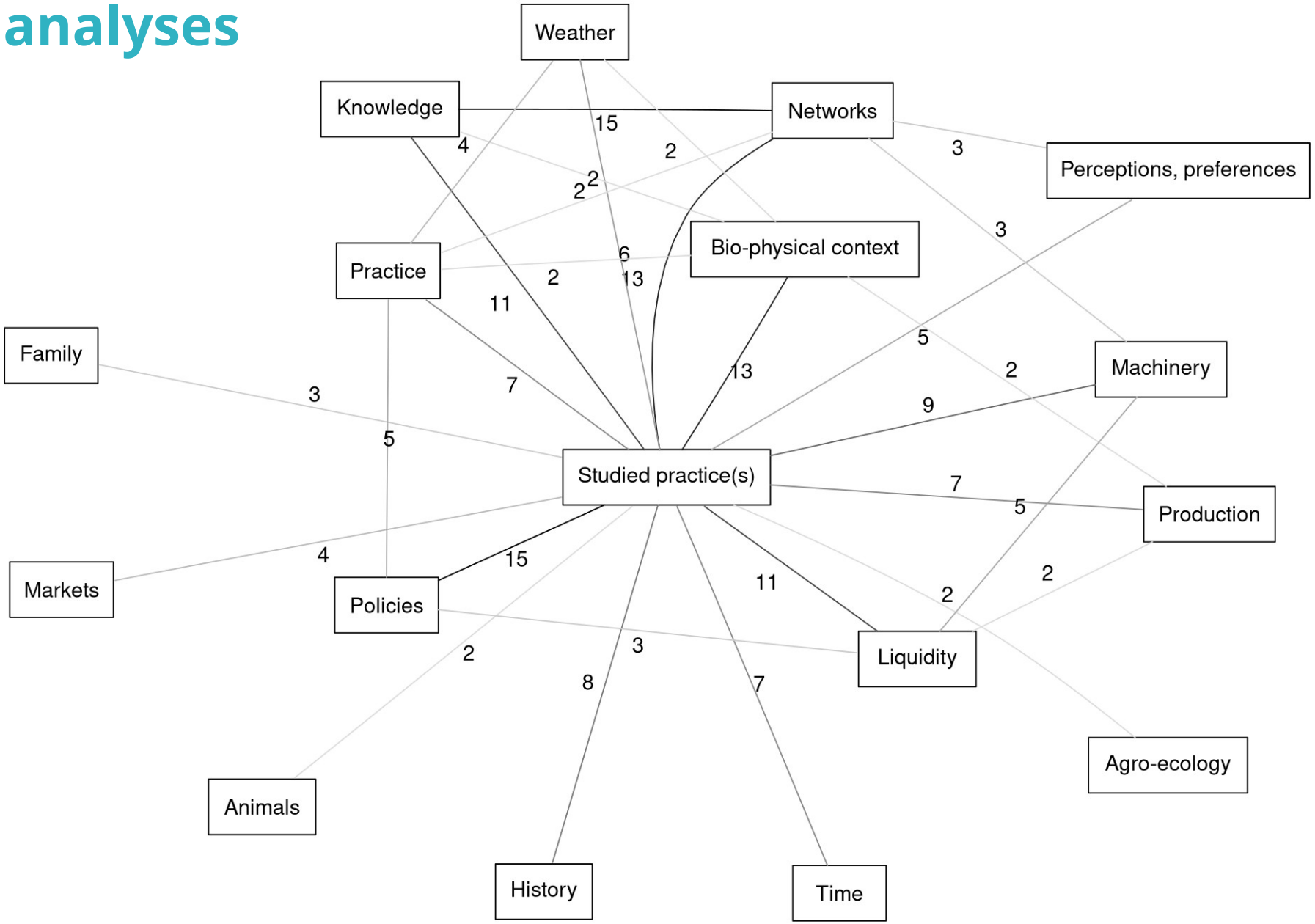
- minimum **soil** disturbance (i.e. no tillage, conservation tillage, ...),
- maximisation of the **soil cover** (in space, in time)
- and **diversification** of plant species (including longer rotations with new crops, inter-cropping, multiple cropping)

CA enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production.

4 – Barriers and opportunities analyses

Conservation agriculture

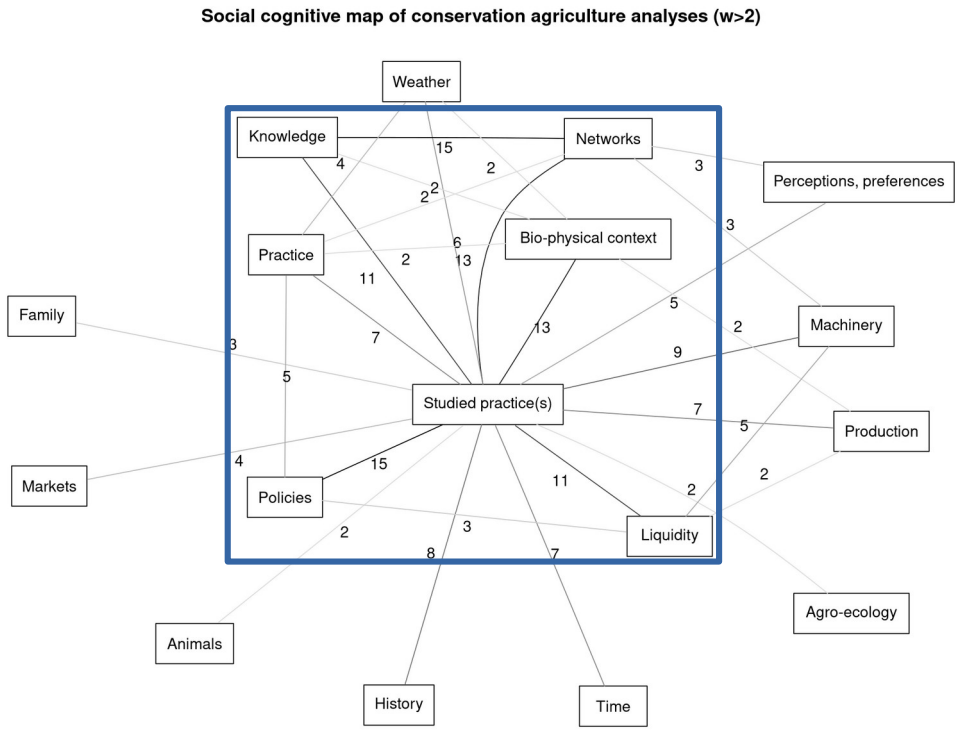
Social cognitive map of conservation agriculture analyses (w>2)



EJP SOIL
European Joint Programme

4 – Barriers and opportunities analyses

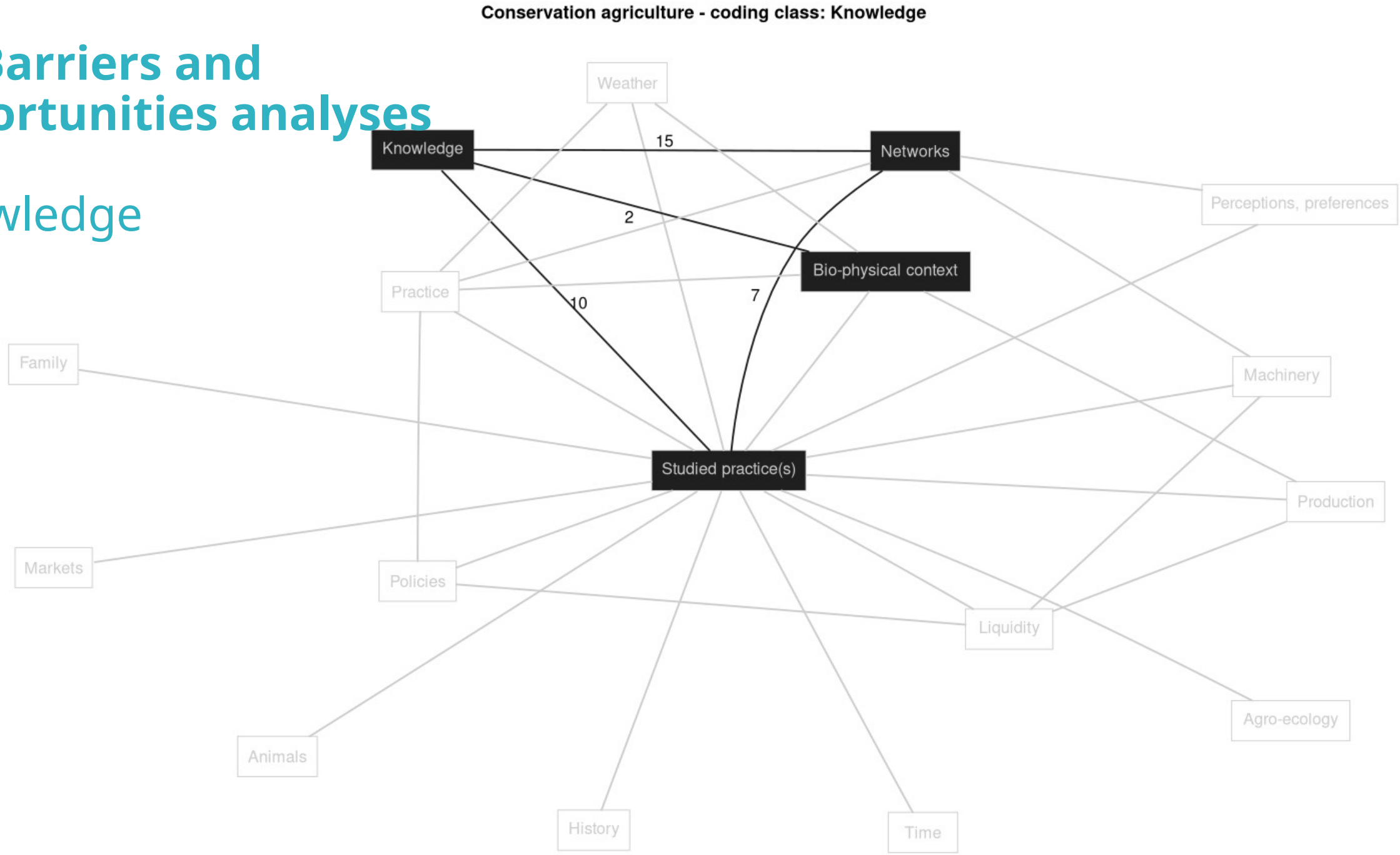
Centrality of concepts



Concept	Centrality
Studied practice(s)	124
Networks	38
Knowledge	31
Policies	27
Bio-physical context	24
Liquidity	23
Practice	21

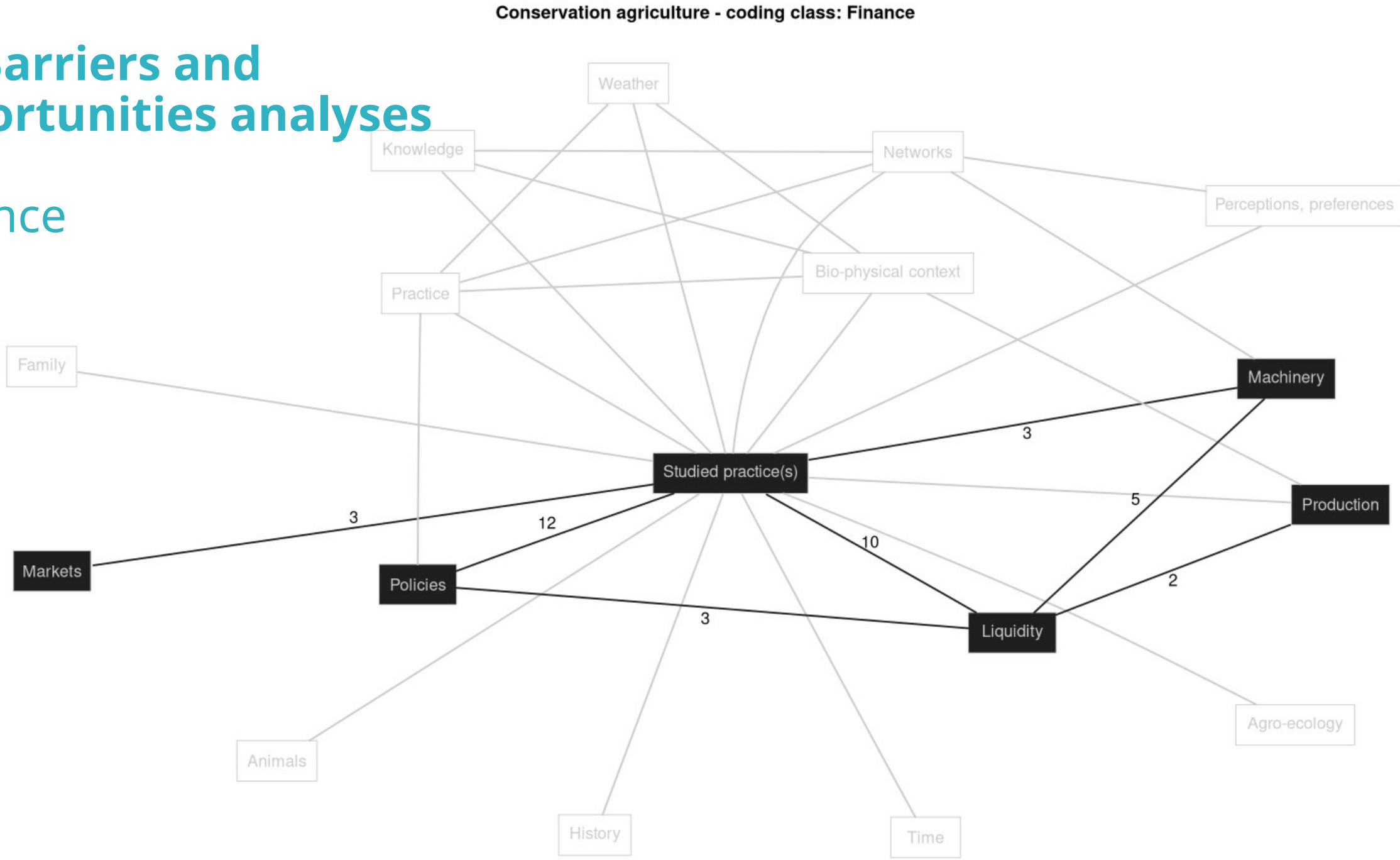
4 – Barriers and opportunities analyses

Knowledge



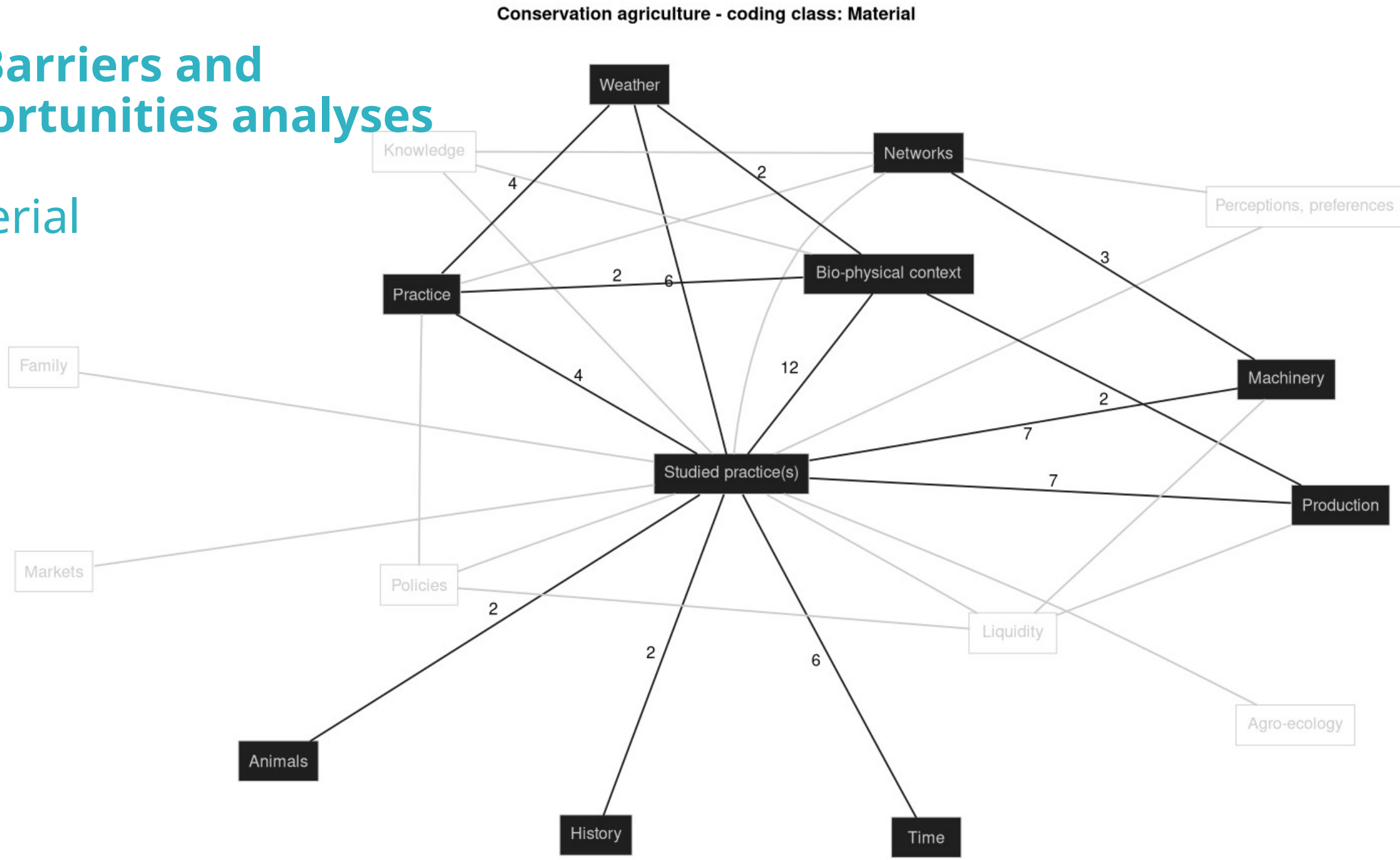
4 – Barriers and opportunities analyses

Finance



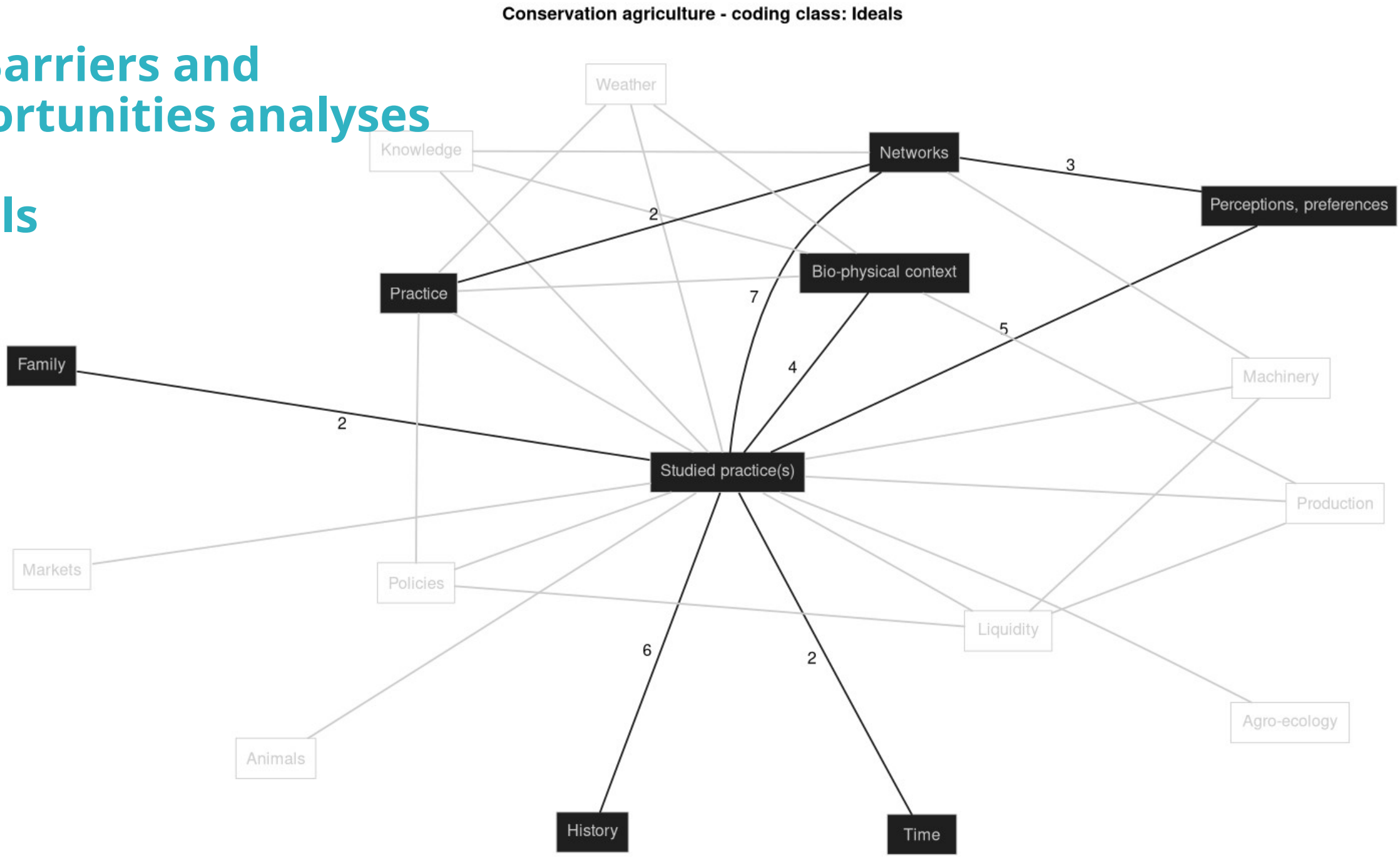
4 – Barriers and opportunities analyses

Material



4 – Barriers and opportunities analyses

Ideals



4 – Barriers and opportunities analyses

Knowledge

- Conservation agriculture linked to skills, risks, fine understanding of processes (soil, environment, ...)
- Importance of networks around the farmers : advisers, other farmers, for sharing knowledge, experiences, through trainings or farm visits
- Classical research and academic institutions are “left behind”

Policies, Liquidity and legislation can help farmers to adopt new practices

- Conservation agriculture requires equipment with prohibitive cost, at least for small-scale farms
- Importance of networks (again) : share / rent
- Subsidies can help, but size of the farms matter (?) ...
- Uncertainties around the glyphosate usage

4 – Barriers and opportunities analyses

Ideals

- Traditions and structure of the farms (ex. solid manure)
- The gaze of neighbours and citizen expectation: risk of failure, but … positive effects
- Working time

Available tools and outputs

EJP SOIL
European Joint Programme

EJP SOIL has received funding from the European Union's Horizon 2020 research and innovation programme: Grant agreement No 862695

Available tools and outputs in the near future

- Results
  - Inventory : printable version, gitbook, shiny application
- Open data on Zenodo
  - Surveys (factor data)
  - Geodata (weather, soil,...)
- Scripts and programs on Gitlab
  - Framework for bio-physical limitations based on geodata
  - ‘inventr’ for inventory building based on surveys data

More info, links,... soon via newsletter and project page on EJP SOIL website

Thanks

EJP SOIL
European Joint Programme

EJP SOIL has received funding from the European Union's Horizon 2020 research and innovation programme: Grant agreement No 862695