Intensify production, transform biomass to energy and novel goods, and protect soils in Europe

Arne Sæbø, Peter Schröder, Elena Maestri, Michel Mench, Rocio Milan, Wieslav Szulc, Nele Witters

INTENSE

FACCE SURPLUS
SUSTAINABLE AND RESILIENT AGRICULTURE FOR FOOD AND NON-FOOD SYSTEMS

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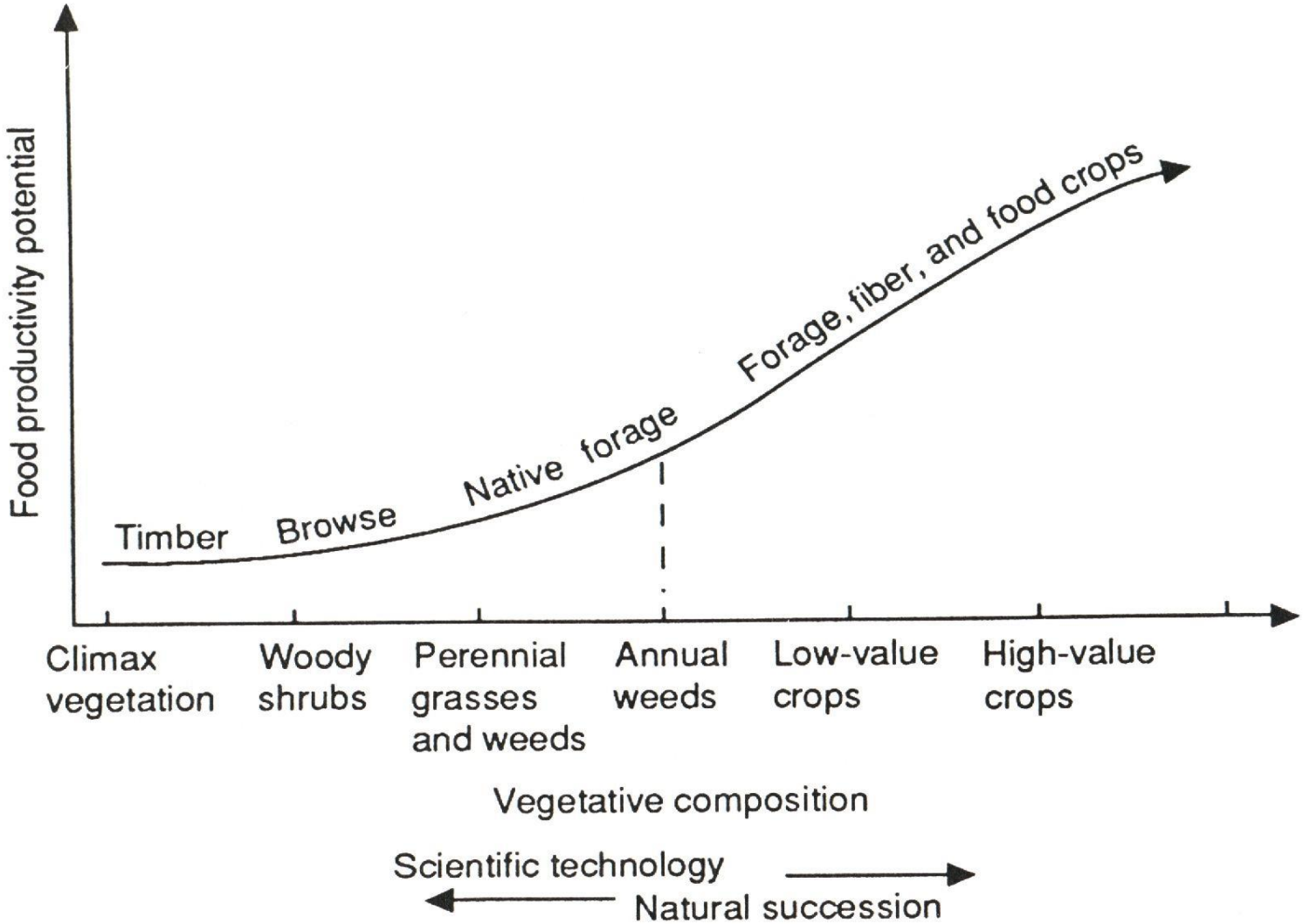

FIGURE 1.1 A graphic display of the food productivity potential of vegetation (17).

FORSCHUNGSVERBUND AGRARÖKOSYSTEME MÜNCHEN

Development in agriculture
weeding yesterday ?

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FAO Hunger Map 2013

PROPORTION OF Total Population Undernourished

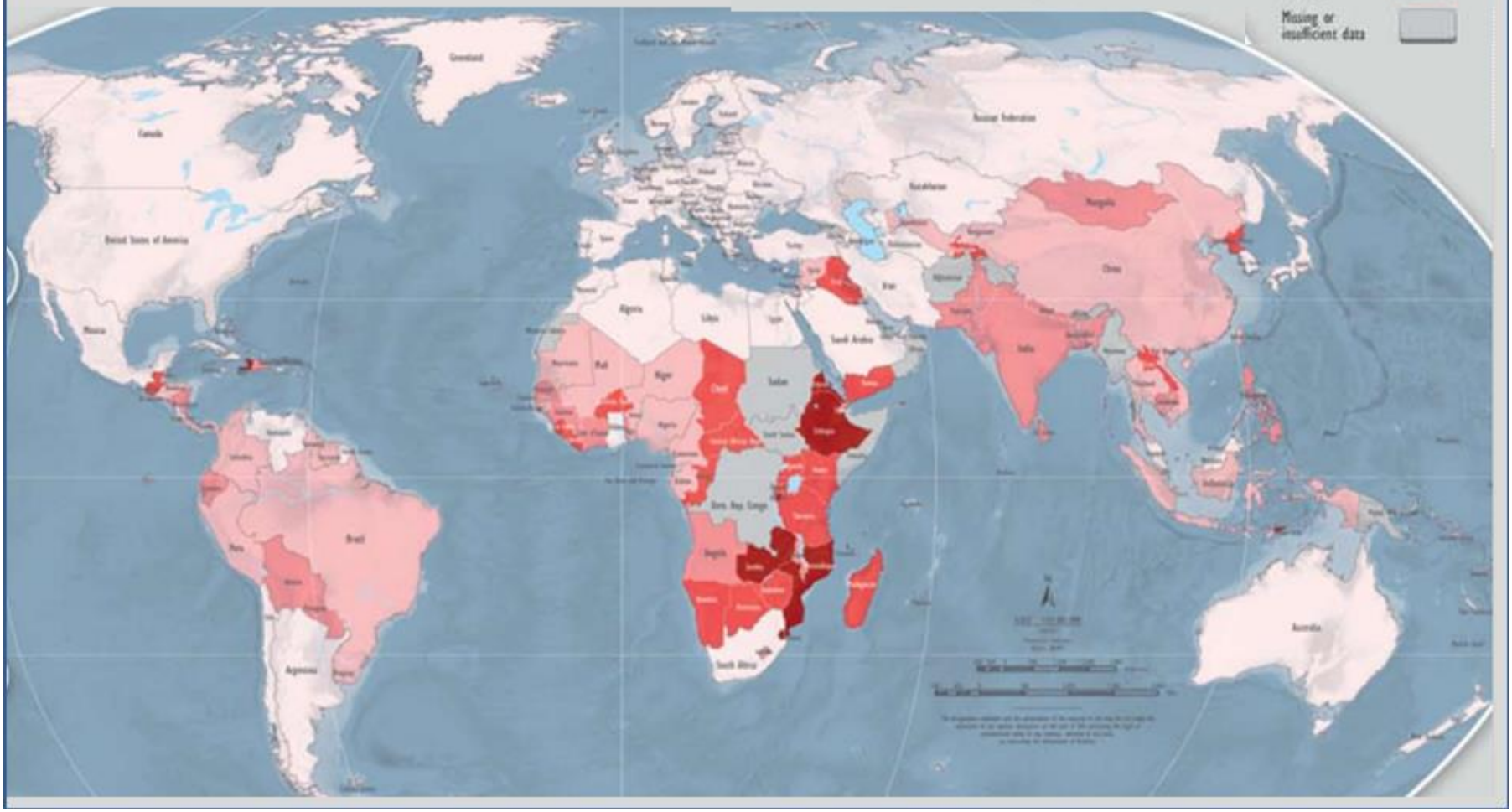
IN 2011 - 2013

Progress in reducing hunger is assessed against two key targets: the 1996 World Food Summit (WFS) target aims at halving the **number** of undernourished by 2015, while the first Millennium Development Goal (MDG) aims at halving the **proportion** of hungry people by 2015.

- In 2011–13 a total of 827 million people were hungry in developing regions. This number has fallen by 169 million, or 17 percent, since 1990–92.
- More than 60 countries have reached or are expected to reach the MDG hunger target. Significant reductions have occurred in most countries of Eastern and South-Eastern Asia, and in Latin America.
- The World Food Summit target is out of reach, at least at the global level. Yet approximately 20 countries have met the target or are estimated to do so by 2015.
- In 16 countries, undernourishment estimates for 2011–13 either point to a lack of progress or a deterioration of food security conditions since 1990–92. Nine of these countries are in sub-Saharan Africa, the region with the highest prevalence of undernourishment and where only modest progress has been made in recent years.

Legend

- < 5% Very low
- 5 → 14.9% Moderately low
- 15 → 24.9% Moderately high
- 25 → 34.9% High
- 35% and over Very high
- Missing or insufficient data



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Typical problems

of an agriculturally intensive used area

- erosion
- soil compaction
- contamination of soil & groundwater
- impoverishment of flora and fauna
- marginal lands set aside without concept
- only few hedges and fallow stripes
- decoupling of energy and matter fluxes
- decreasing quality of life

Klimaschutz-Index 2017 • Gesamtergebnis

KSI 2017 Klimaschutz Index

Rang		Land	Punkte**
1*			
2			
3			
4	▲	Frankreich	66,17
5	▲	Schweden	66,15
6	▼	Großbritannien	66,10
7	▲	Zypern	64,28
8	▲	Marokko	63,28
9	▲	Luxemburg	62,86
10	▲	Malta	62,51
11	▲	Portugal	62,47
12	▼	Belgien	62,08
13	▼	Dänemark	61,87
14	▲	Schweiz	61,66
15	▼	Lettland	61,20
16	▲	Italien	60,72
17	▲	Kroatien	60,66
18	▼	Rumänien	60,33
19	▲	Litauen	59,75
20	▲	Indien	59,08
21	▼	Irland	59,02
22	▼	Indonesien	58,86
23	▼	Ägypten	58,75
24	▲	Tschechische Rep.	58,52
25	▲	Griechenland	58,29
26	▼	Slowakei	57,69
27	▲	Niederlande	57,10
28	▼	Mexiko	57,02
29	▼	Deutschland	56,58
30	▲	Slowenien	56,55
31	▼	Finnland	56,28

Veränderung zum Vorjahr

© Germanwatch 2016

Rang		Land	Punkte**
32	▲	Südafrika	56,17
33	▼	Spanien	56,14
34	▼	Ungarn	55,05
35	▼	Polen	53,68
36	▲	Argentinien	53,15
37	▲	Bulgarien	53,06
38	▼	Norwegen	52,90
39	▼	Island	52,55
40	▲	Brasilien	52,46
41	▲	Österreich	52,00
42	▲	Thailand	51,91
43	▼	USA	51,04
44	▼	Malaysia	50,96
45	▲	Ukraine	50,88
46	▼	Neuseeland	50,48
47	▼	Algerien	48,46
48	–	China	47,49
49	▼	Weißrussland	46,86
50	–	Estland	46,04
51	–	Türkei	45,54
52	–	Taiwan	44,76
53	–	Russland	44,30
54	–	Singapur	43,97
55	▲	Kanada	43,06
56	▼	Iran	43,05
57	–	Australien	40,66
58	▲	Südkorea	38,11
59	▲	Kasachstan	36,87
60	▼	Japan	35,93
61	–	Saudi-Arabien	25,45

Veränderung zum Vorjahr

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Sektoren

- **Emissionsniveau** (30 % Gewichtung)
- **Entwicklung der Emissionen** (30 % Gewichtung)
- **Erneuerbare Energien** (10 % Gewichtung)
- **Effizienz** (10 % Gewichtung)
- **Klimapolitik** (20 % Gewichtung)

Bewertung

- Sehr gut
- Gut
- Mäßig
- Schlecht
- Sehr schlecht

* Kein Land erreicht den ersten bis dritten Platz, da kein Land genug unternimmt, um einen gefährlichen Klimawandel zu vermeiden.
** gerundet

INDEX of Climate Change actions in different countries – cumulative result

FACCEJPI

FACCE-JPI joint research actions relate to the bio-economy and involve international partners

Core Theme 1
Food security under climate change

Knowledge Hub on modelling the impacts climate change on food security **(MACSUR)** - partnerhsip with AgMip (€15M, 300 researchers)

International call (Collaborative Research Action) on food security and land use change with the Belmont Forum (Australia, Brazil, India, Japan, South Africa, USA) (€5.3M)

ERA-NET Cofund on Sustainable food production and consumption **(SUSFOOD2)**

Core Theme 2
Sustainable intensification of agriculture

Knowledge Network on sustainable intensification

FACCE ERA-NET Cofund on Sustainable agriculture for food and non-food systems **(SURPLUS)** with New Zealand (€15M)

Thematic Annual Programming Network on agricultural soil quality and soil C sequestration

ERA-NET Sustainable Animal Production **(SusAn)**

Core Theme 3
Biodiversity & ecosystem services

Joint call with the BiodivERsA ERA-NET (€10M)

+ Exploratory workshops on food and nutrition security, ICT, biorefinery, etc.

Core Theme 4
Adaptation to climate change

FACCE ERA-NET + on Climate Smart Agriculture (€19M)

ERA-NET Cofund with Water JPI on sustainable water management in agriculture **(WATERWORKS 2015)** with Canada, Brazil, USA, China, Vietnam, India, Taiwan, Tunisia, Egypt, South Africa (€26M)

Core Theme 5
GHG mitigation in agriculture

Multipartner call on agricultural GHG mitigation with the GRA (USA, Canada, New Zealand) (€5.5M)

FACCE ERA-NET Cofund on monitoring and mitigation of agricultural GHG **(ERA-GAS)** with New Zealand (€14M)

FACCE-JPI adopts a new European and International Strategy to address the global challenges of sustainable agriculture and food security in the face of climate change in a more effective way.

Members of the Joint Programming Initiative on Agriculture, Food Security And Climate Change (FACCE-JPI) have adopted a new European/ International Strategy (2016-2020) in December 2015.
It aims to:

- Promote greater complementarity and structuring of research at European and international levels to address global challenges in a more effective way;
- Improve the international visibility and enhance the impact of aligned European research on European policymaking and innovation;

and

- Facilitate the exchange of information and mutual learning with similar research initiatives in other regions of the world.

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Figure 1. The 5 Core Themes and the 3 Trans-thematic clusters

INTENSE

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NORSK INSTITUTT FOR BIOØKONOMI

MARTLHOF AM TEGERNSEE

INRA SCIENCE & IMPACT

SZKOŁA GŁÓWNA GOSPODARSTWA WIEJSKIEGO W WARSZAWIE

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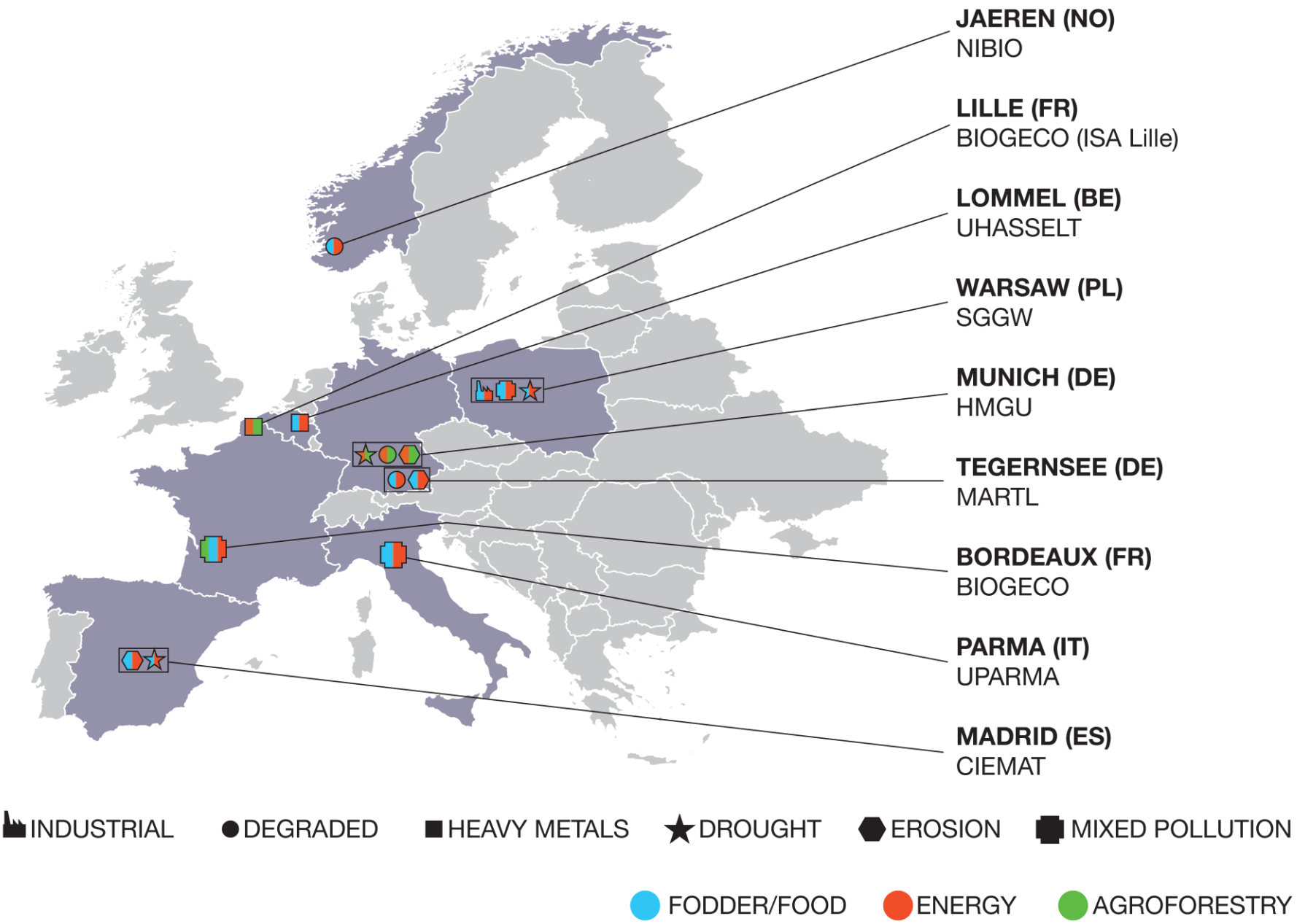
Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas


JAEREN (NO)
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UHASSELT
WARSAW (PL)
SGGW
MUNICH (DE)
HMGU
TEGERNSEE (DE)
MARTL
BORDEAUX (FR)
BIOGECO
PARMA (IT)
UPARMA
MADRID (ES)
CIEMAT
INDUSTRIAL
DEGRADED
HEAVY METALS
DROUGHT
EROSION
MIXED POLLUTION
FODDER/FOOD
ENERGY
AGROFORESTRY

When is Agriculture sustainable?

Indicators

for sustainable land use

- High crop quality / high yield / low residues
- Low nitrogen losses / high groundwater quality
- Low erosion / high soil fertility
- High biodiversity: hedges, buffer strips
- Farming by soils
- Circular bioeconomy
- Good quality of life

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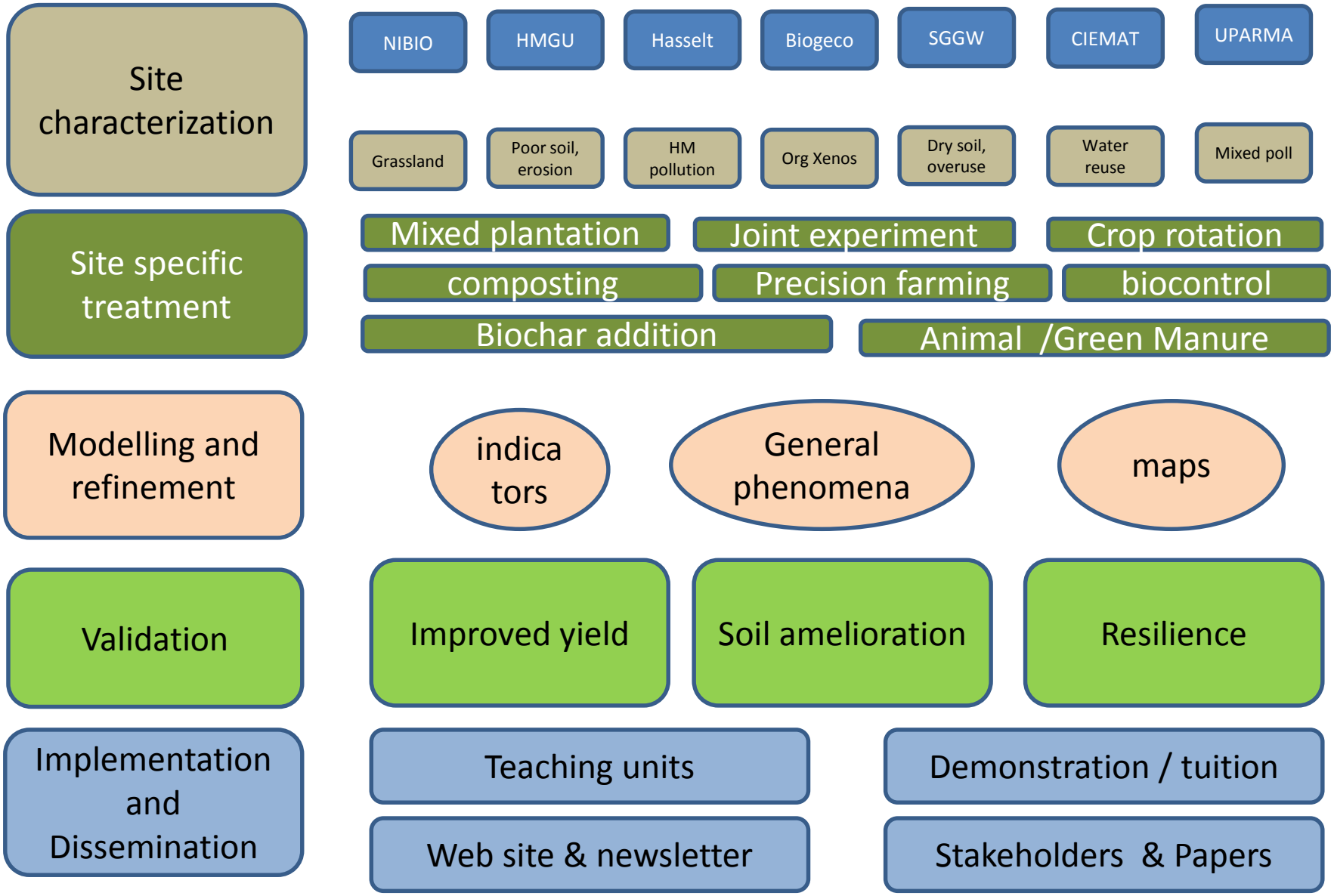
- **INTENSE contributes to 3 of the "Great Challenges" for the 21st century:**
  - Food security, use of renewable raw materials and production of energy from biomass.
  - Increased food production; novel products; sustainable perspectives for EU rural areas.
  - Efficient production for improved economic, environmental & social outcomes.
- **A higher quality status is needed on 30 % (at least) of the agricultural (and idle) soils in the EU:**
  - Reconvert poor, idle and polluted soils; grassland, set aside & marginal land across Europe.
  - Innovative systems-based tools to develop / implement integrated food and non-food products serving for intensified land management of these land areas.
- **A wide range of novel products and services across farming communities in the EU is possible:**
  - Models to characterize fluxes of matter and productivity
  - Recovery of soils from abiotic stress
  - *identify crucial soil processes;*
  - *identify/assess plant species producing high biomass on marginal and contaminated soils*;
  - assess optimum composition for composting and biogas production;
  - demonstrate the potential of selected species to degrade, absorb or contain pollutants


Site characterization
NIBIO
HMGU
Hasselt
Biogeco
SGGW
CIEMAT
UPARMA
Grassland
Poor soil, erosion
HM pollution
Org Xenos
Dry soil, overuse
Water reuse
Mixed poll
Site specific treatment
Mixed plantation
Joint experiment
Crop rotation
composting
Precision farming
biocontrol
Biochar addition
Animal /Green Manure
Modelling and refinement
indica tors
General phenomena
maps
Validation
Improved yield
Soil amelioration
Resilience
Implementation and Dissemination
Teaching units
Demonstration / tuition
Web site & newsletter
Stakeholders & Papers

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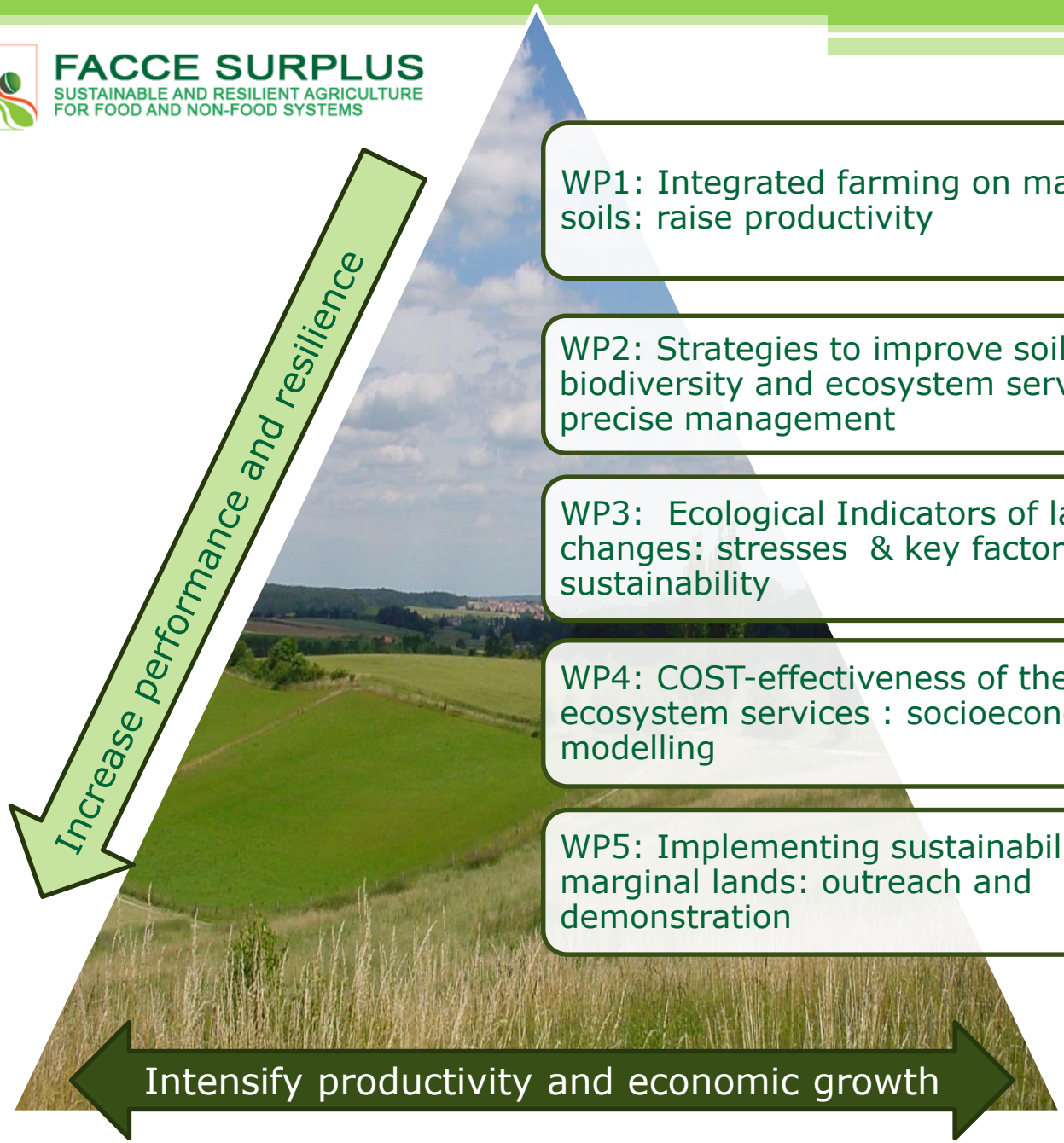

WP1: Integrated farming on marginal soils: raise productivity

WP2: Strategies to improve soil biodiversity and ecosystem services: precise management

WP3: Ecological Indicators of land use changes: stresses & key factors of sustainability

WP4: COST-effectiveness of the delivery of ecosystem services : socioeconomic modelling

WP5: Implementing sustainability of marginal lands: outreach and demonstration

WP6: Project management and dissemination

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please fill up the green marked boxes as complete as possible.

The aim is to collect as many parameters of the status quo of the sites and soils. The scheme is based on the GREENLAND project.

Partner	**INRA (Biogeco)**	**Soil classification (WRB)**	**Fluvisol – Eutric Gleysol**
Location	St Médard d'Eyrans, France	**Type of soil stress**	soil Cu and PAH contamination
Site type	brownfield (former arable	**Origin of soil stress**	wood preservatives
Former land use	wood preservation	**Treatment / Crop type**	aided phytostabilisation + rhizodegradation (m
Current land use	derelicted area (mainly) + s	**Surface area (ha)**	10 ha (site P7: 2 X 150m²)
Final land use	phytomanaged area dotted	**Climate**	mild oceanic climate (but with heat waves)
Specific objectives	long term assessment of phytomanagement options (energy crops, wood) and restoration of ecological		

Horizon Characterisation		mg/kg		g/kg		cmol+/kg
Ap	**Particle <0.02mm**	**total soil Cu**	**pH**	**org C**	**C/N**	**CEC**
(0-35cm)	6.4%	464 - 2600	6.7 - 7.6	10.5	20.7	2.16
B						
(35-55cm)		8.75		58	38	1.07
C						
(55-100cm)		16.8		3.4	10	2.01

Soil characteristics	**Initial values**
pH	6.2 - 7.0
Sand, silt, clay (%)	88.8, 4.8, 6.4
Soil moisture (%)	WHC max: 10%
CEC (meq/100 g)	3.5
TOC (%)	1.05 - 1.51
TON (%)	0.05
Intensity of stress	medium - high
Fertilization amendment	compost, dolomitic limesto

St Médard d'Eyrans, France brownfield (former arable land)

Additional Information	
Composts	pine bark chips/poultry manure (1st dressing) 5%
alkaline materials	dolomitic limestone 0.2%
iron grit	wheelabrator GH120 2%

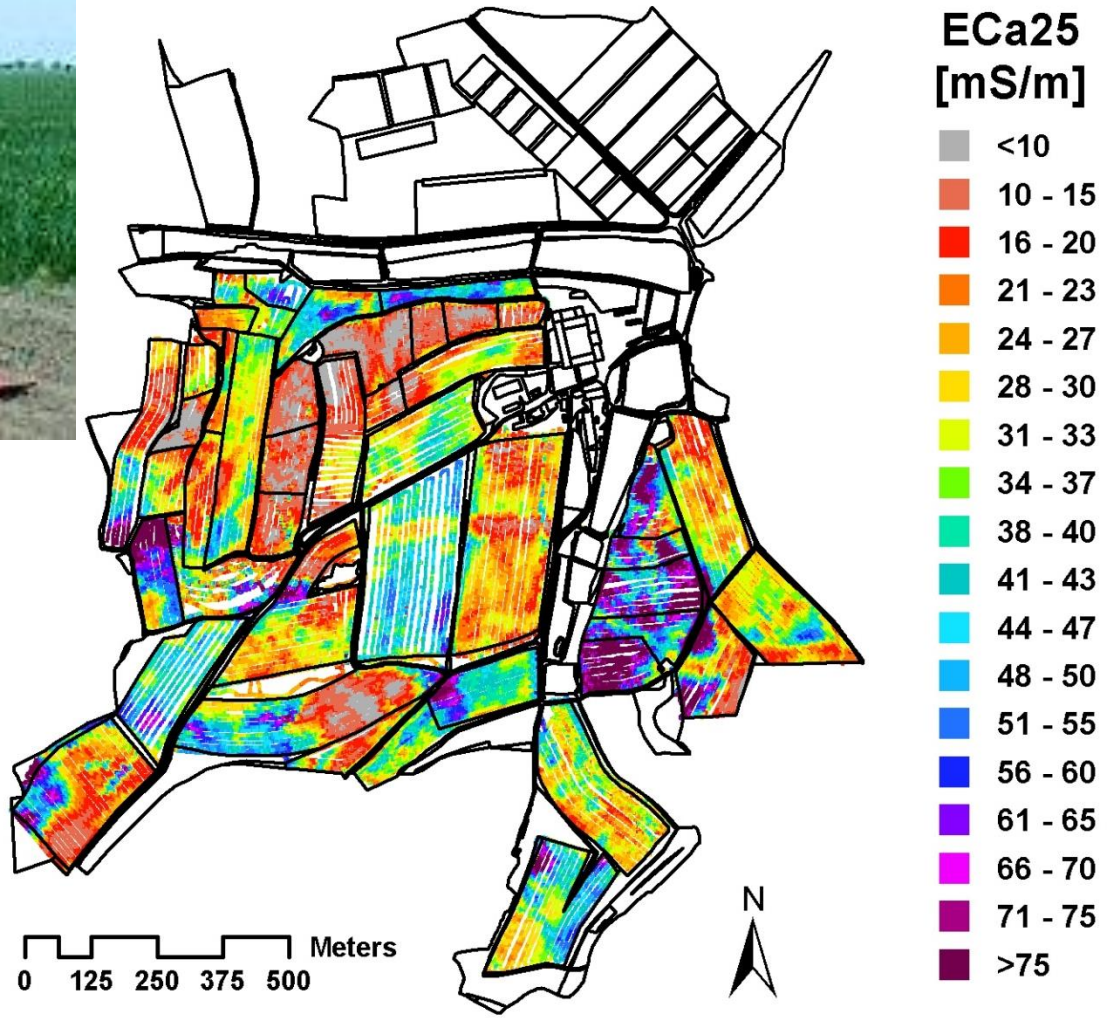
Core stakeholder	**Function**	**Remark**	**Main site operators**
ADEME (French Environment	National authority		biogeco INRA SCIENCE & IMPACT
Lyonnet SA	owner		
DREAL	local authority		

Core competences	restoration ecology, plant biology, ecotoxicology
Main interests	intensify non-food crops (for the Bioeconomy), restore soil functions and associated ecosystem services
Main meassurements	soil pore water, soil parameters, plant biomass, plant ionome

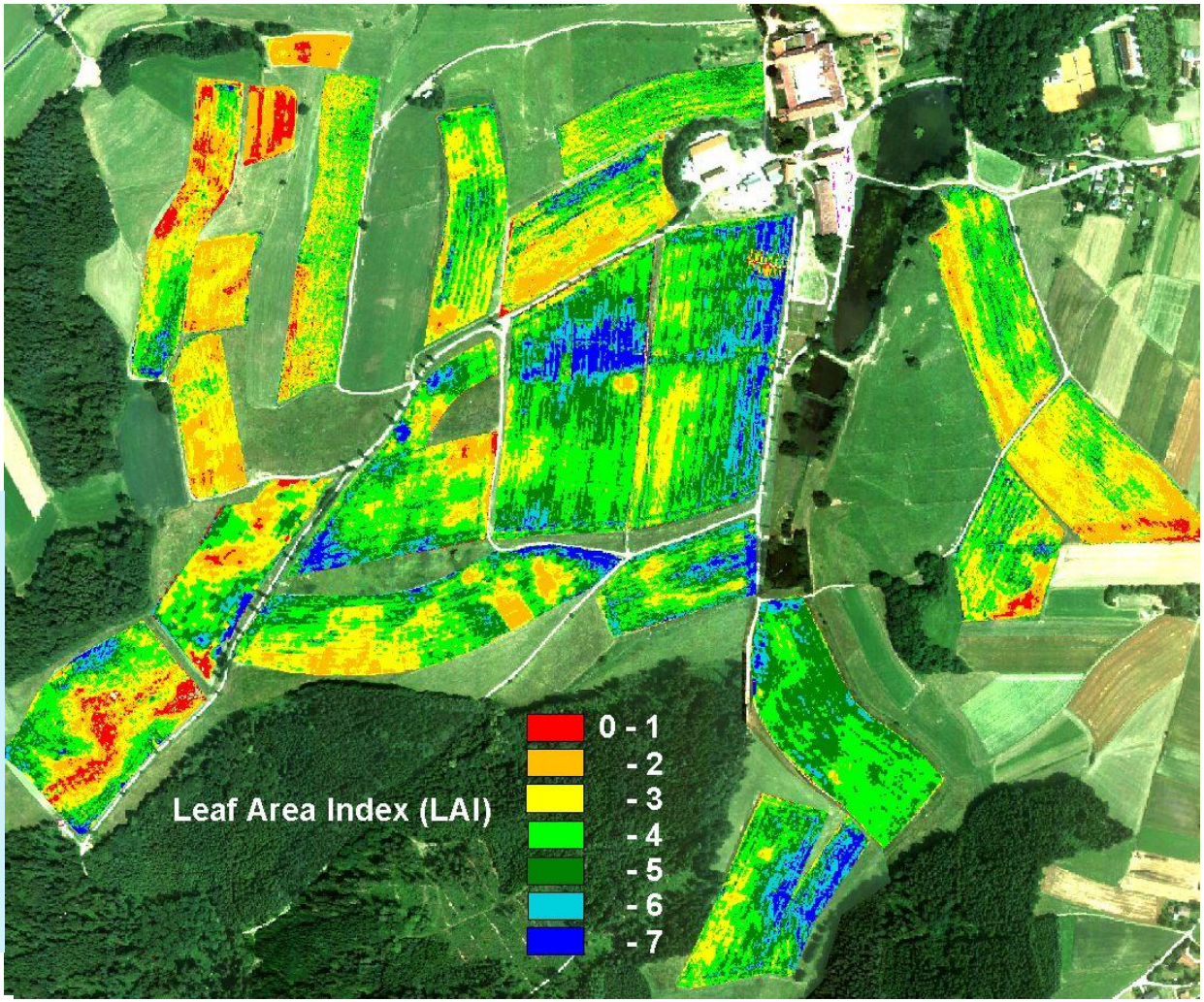
Partners with more than one site, please fill up the formular for each site.

EM38 – a geophysical methodology

- Device is mounted on a sledge and pulled across the terrain
- Apparent electrical conductivity of the soil is determined
- **facilitates assessment of the clay content (and water retetion) of soils**



Remote sensing



- Optical scanner in drone
- Determining leaf area index,measure of plant dry weight
- Incredible special variability
- Hypothesis: „Plant status mirrors soil condition“

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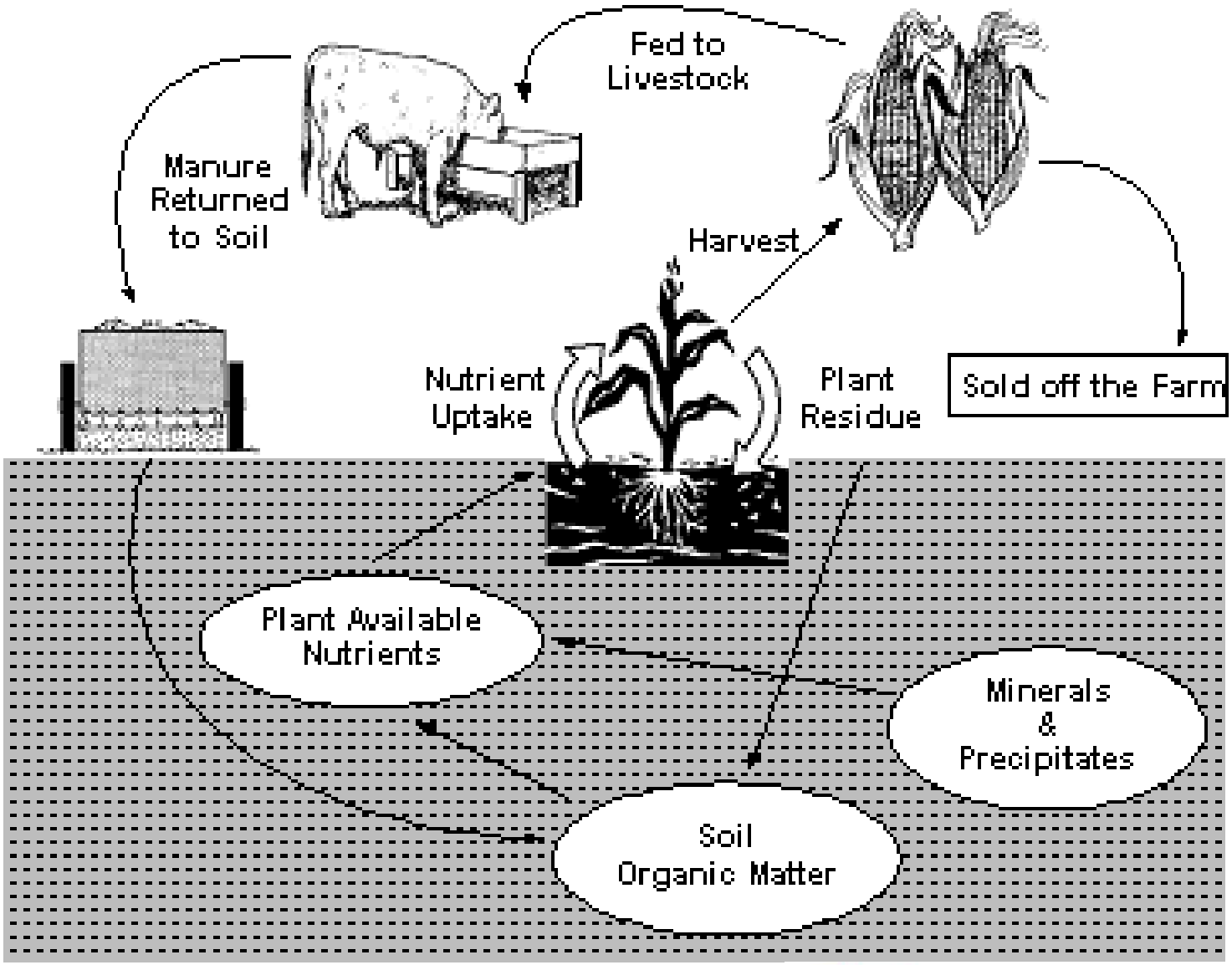
HOW CAN THE INDUSTRY BENEFIT and how can the results be used by the industry?

Impact on farms:

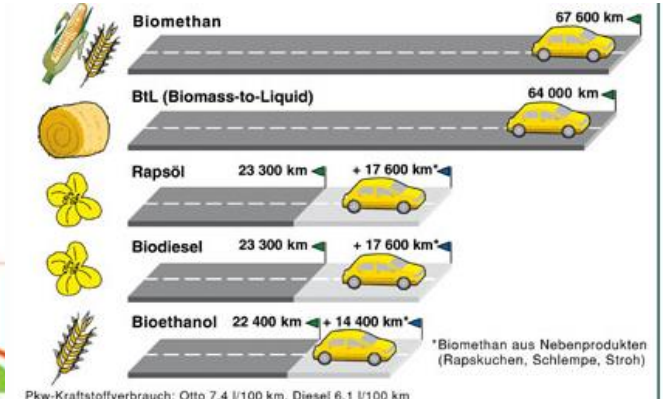
- Deliver tools to farmers to change agricultural practices to increase high quality food and biomass production in a holistic approach;
- Help to generate a sustainable income and increase productivity on the farm level, provide novel crop rotation schemes for nutrient cycling, and sustainable biomass production for biorefineries.

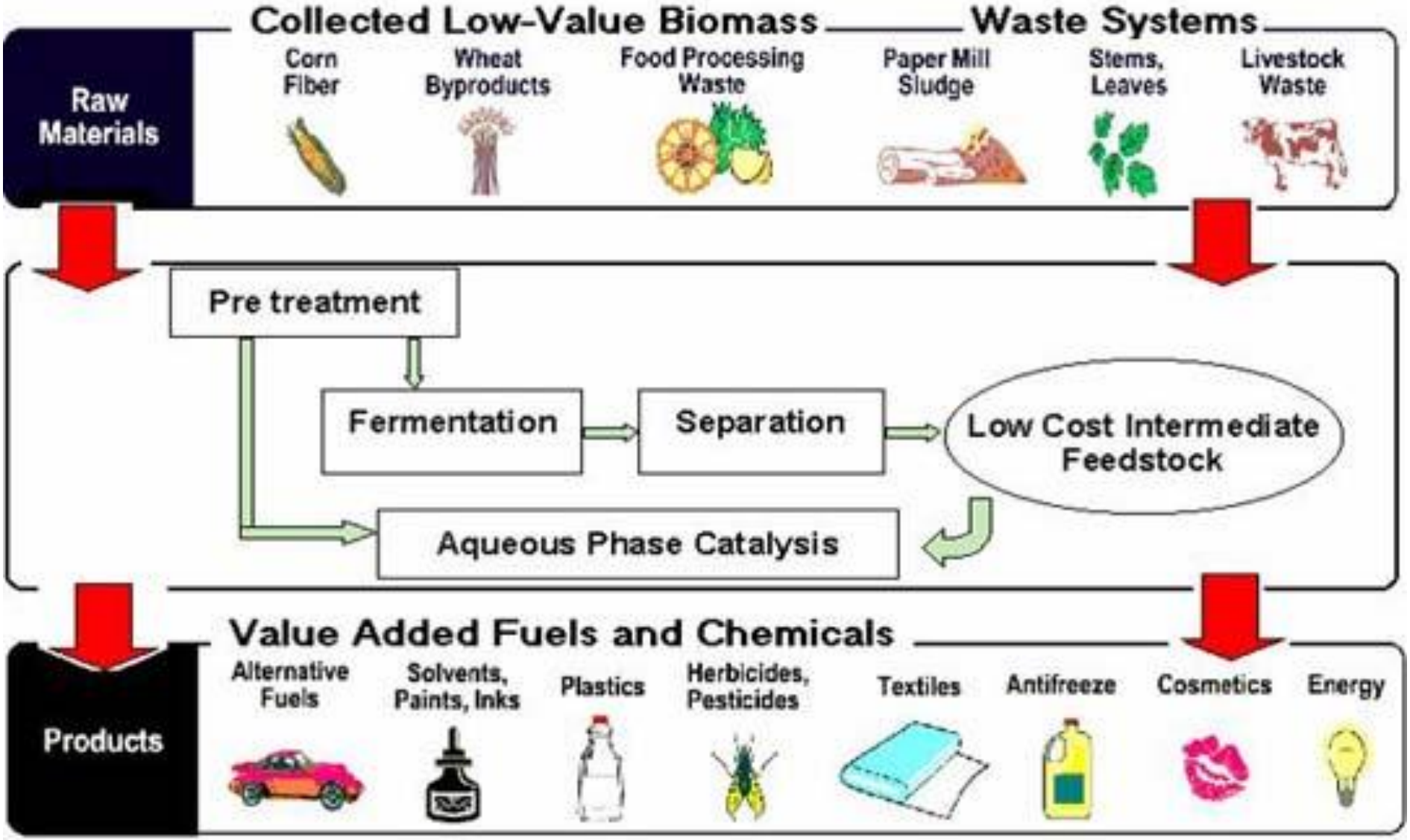
Marketing agriculture in based on citizens' concerns:

- Marketing food quality and environmental safety; sustainable uses of marginal land, including polluted soils, and safe green remediation strategies at various time scales.
- Develop practical, user friendly, open access tools for the farmers, local authorities, extension services, farmers and the public.


Fed to
Livestock
Manure
Returned
to Soil
Harvest
Nutrient
Uptake
Plant
Residue
Sold off the Farm
Plant Available
Nutrients
Minerals
&
Precipitates
Soil
Organic Matter

- Numerous rural communities in Germany switch to independent energy supply
- 50 % of the agricultural production and all waste used to produce bioenergy
- Demand for high quality biomass is increasing: intensive agriculture needed
- Only few farmers search for alternative crops or weeds





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Preparation of Martlhof

Preparation of the test site at Martlhof

08.07.2016

Figure 19: Grassland (many different species)

Pigs and sheep are fertilizing

23.08.2016

Figure 20: Ploughing and sowing *Vicia faba*

04.11.2016

Figure 21: Agricultural land (intercrop *Vicia faba)*

- From grassland to agricultural land

Experimental setup 2017

Different strains to compare the influence of amendments on microbial diversity

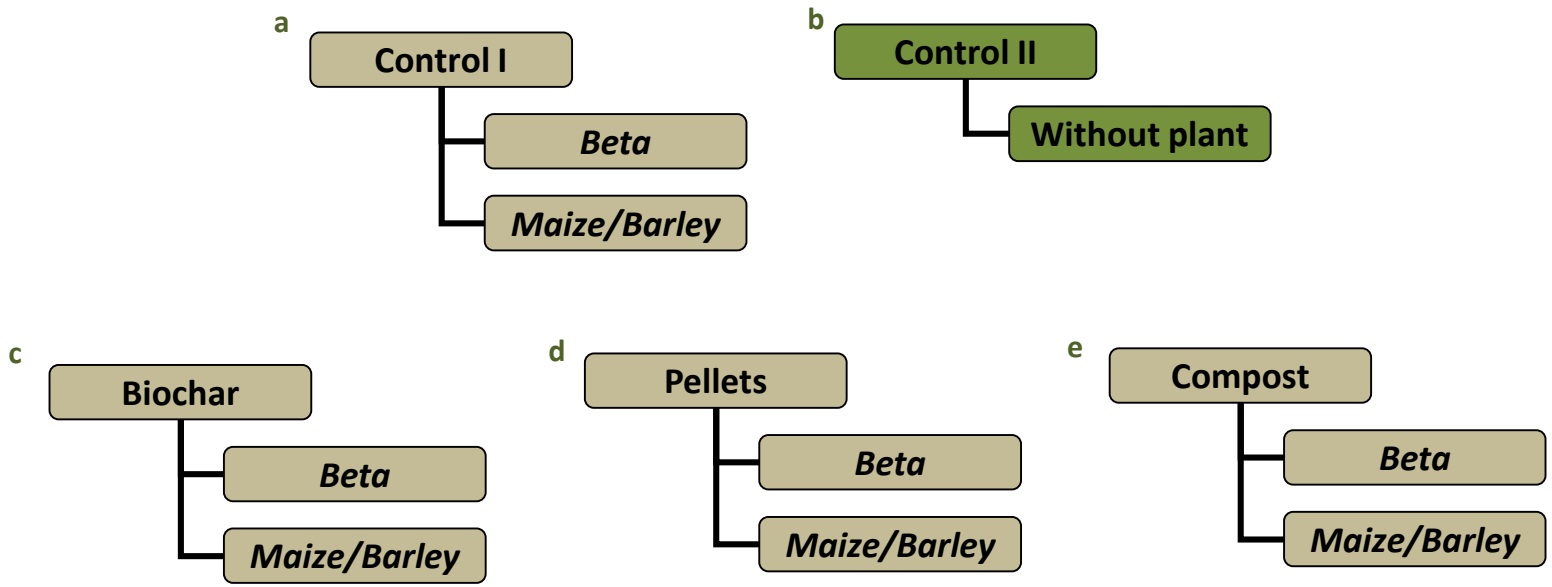

Figure 32 a, b, c, d, e: Different strains for comparative analysis of microbial diversity and biometrics

Control I: without amendments
Control II: grassland

Economic cycling at Martlhof

Pyrolysis at Martlhof

thermochemical decomposition of organic material*

Chestnut (*Aesculus* L.)

Chestnut wood chips

Rocket stove
(Top Lit Up Draft – batch reactor)

Biochar

20 – 50 kg per day

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INTENSE wants to be a forum to recognize and solve lans use conflicts

… and provide a role for ecosystem services

TARGET GROUP(S) / WHO WILL BENEFIT?

Impact on policy and EU scale:

- Fundamental processes affecting food production in Europe: plant-soil-microbe interactions.
- EU policy makers gain novel solutions for marginal land management and increased food production, in safe ways.

Impact on regional scale:

- INTENSE aids planners to address novel uses for marginal land.
- Toolboxes will propose measures to increase biomass production, **ecosystem services**, water availability; soil quality and the use of possible new crops.

Impact on farms:

- Farmers change agricultural management; to produce high quality food and biomass in a holistic approach.
- Help to generate a sustainable income and increase productivity on farm level, provide crop rotation schemes for nutrient cycling, and sustainable biomass production for biorefineries.

Impact on citizens:

- Address citizens concern for food quality and environmental safety; sustainably use marginal land, including polluted soils, and safe green remediation strategies.
- INTENSE will develop practical, user friendly, open access tools for the farmers, local authorities, extension services, farmers and the public.

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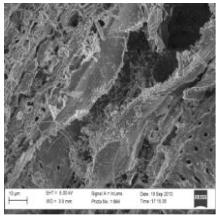


Research and Potential

- Provide reliable tools for decision makers about remediation options vs natural attenuation
- Understand plant-plant and plant-microbe interactions on the stand level
- Deliver key factors for carbon sequestration and phosphorus cycling
- Unravel plant stresses in marginal environments
- Perform LCA of biorefineries and novel products
- Improve whole chain economic and environmental sustainability via the cascading of agricultural products and green biomass

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Status of our project

- ✓ WP plans are coordinated
- ✓ Common protocols are implemented
- ✓ Field trials are under establishment

Please follow us;

- http://www.nibio.no/prosjekter/intense
- https://www.researchgate.net/project/INTENSE

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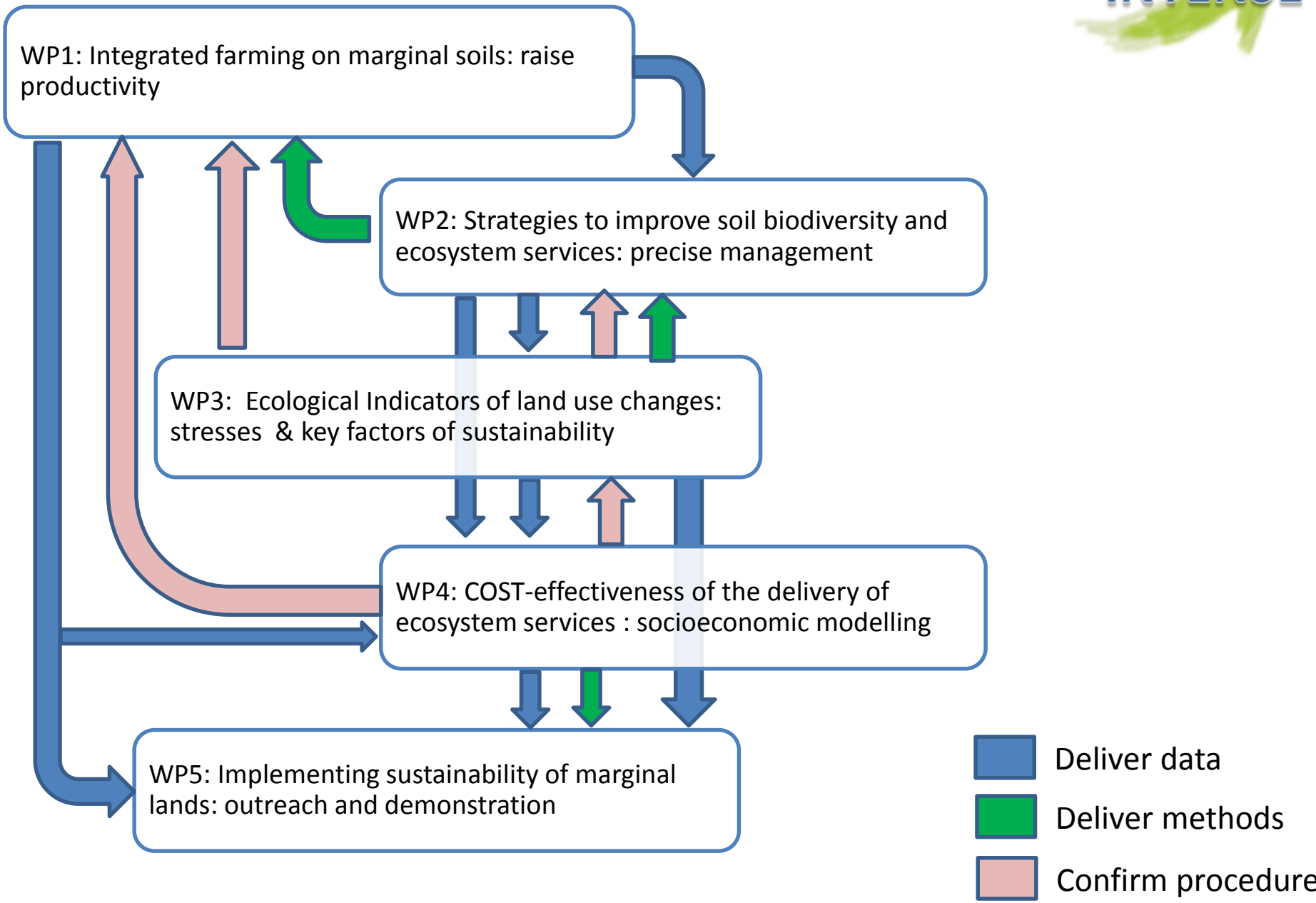
Complementarity of Workpackages



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INTENSE RESULTS OF INTEREST TO THE INDUSTRY:

- **Increase food/fodder/biomass production** in Europe, applying sustainable methods, nutrient cycling, and better use of ecosystem services.
- **Strengthen the agricultural sector**, conservation and propagation of agricultural biodiversity and ecosystem services.
- **Issue guidelines** to include polluted sites (under remediation), set aside land and degraded ecosystems in the production chain for agricultural goods and ecosystem services and deliver novel services and products based on non-food products and agricultural residues.
- **Apply and adapt** remote sensing and ecotoxicological **test procedures** to assess land use changes.
- **Supply the EU with a toolbox** to reduce the environmental impact of agricultural intensification; controlling nutrient and energy fluxes.
- **Disseminate knowledge;** training scientists for capacity building and launch networks of farmers and of stakeholders, helping to establish the resilient and adaptable European landscape needed for sustainable Bioeconomy;
  - Clean air, soil and water, no erosion, and a pollination friendly environment.
  - Economically and environmentally sound integrated food and biomass production under different agro-ecological conditions.

INTENSE results:

- **Increase food/fodder/biomass production** in Europe, applying sustainable methods, nutrient cycling, and better use of ecosystem services.
- **Strengthen the agricultural sector**, conservation and propagation of agricultural biodiversity and ecosystem services.
- **Issue guidelines** to include polluted sites (under remediation), set aside land and degraded ecosystems in the production chain for agricultural goods and ecosystem services and deliver novel services and products based on non-food products and agricultural residues.
- **Apply and adapt** remote sensing and ecotoxicological **test procedures** to assess land use changes.
- **Supply the EU with a toolbox** to reduce the environmental impact of agricultural intensification; controlling nutrient and energy fluxes.
- **Dissemination of knowledge;** training scientists for capacity building and launch networks of farmers and of stakeholders, helping to establish the resilient and adaptable European landscape needed for sustainable bioeconomy;
    - Clean air, soil and water, no erosion, and a pollination friendly environment.
    - Economically and environmentally sound integrated food and biomass production under different agro-ecological conditions.

Table 2. Complementarity of the consortium: roles, responsibilities and specific contributions of each partner

Partner	System in focus	Responsibility/Role	Specific contribution	Strategies developed
NIBIO Coordinator	Grassland pasture and bio-rest as fertilizer, northern climate	WP6. Management, nutrient cycling, grass yields, dissemination, crop model	Diversity, biomass, soil biology	Biomass, nutrient use from organic sources, climate adaptation
HMGU	Set aside land, Agroforestry, small plots	WP 3. Indicators, plant stress, maps, models (EXPERT-N, PLATHO)	Proteomics, N,P,C, yield model, water relations, indicators	Biomass, pellets, agroforest, precision farming
SGGW	Arable land, poor soils, set aside land	WP1. Agronomy, biofuels, energy budgets, GHG, teaching	Farming, yield . model, GHG emissions, nutrient availability,	Biomass, fibers, new varieties
UMR-BIOGECO	Brownfields, restoration sites, tailings	WP5. Industrial sites, pollutant uptake, phytoremediation	Soil restoration, organic pollutants, remediation	Biofuel, gentle remediation, mixed plantation
UHASSELT	Abandoned / arable land, plots	WP4. Heavy metals, socio-economy model	Models, Plant-microbe interaction, genomics	Agroforest, microbial inoculates
CIEMAT	Dryland, Innovative Greenhouses	Water reuse, biomass, socio-economy	Water use efficiency, soil biology, CO_2 cycling	Biomass, water reuse
MARTL	Small farm, erosion, pasture (SME)	Small scale productivity, dissemination, contact to local stakeholders	Marketable crops and fruits, biogas biomass, economy budgets	Biogas, alternative products, vegetables, alternative heating
UPAMA	Greenhouse, arable land, restoration sites	WP2. Heavy metal analysis, biofuel, biochar, teaching	Genomics, proteomics, life cycle analysis, fate of heavy metals	Biochar, LCA, ecotoxicology, teaching