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
FIGURE 1.1 A graphic display of the food productivity potential of vegetation (17).
Development in agriculture
weeding yesterday?
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 30 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.
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
INDEX of Climate Change actions in different countries – cumulative result

<table>
<thead>
<tr>
<th>Rang</th>
<th>Land</th>
<th>Punkte**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>Südafrika</td>
<td>56,17</td>
</tr>
<tr>
<td>2</td>
<td>Spanien</td>
<td>56,14</td>
</tr>
<tr>
<td>3</td>
<td>Ungarn</td>
<td>55,05</td>
</tr>
<tr>
<td>4</td>
<td>Polen</td>
<td>53,68</td>
</tr>
<tr>
<td>5</td>
<td>Argentinien</td>
<td>53,15</td>
</tr>
<tr>
<td>6</td>
<td>Bulgarien</td>
<td>53,06</td>
</tr>
<tr>
<td>7</td>
<td>Norwegen</td>
<td>52,90</td>
</tr>
<tr>
<td>8</td>
<td>Island</td>
<td>52,55</td>
</tr>
<tr>
<td>9</td>
<td>Brasilien</td>
<td>52,46</td>
</tr>
<tr>
<td>10</td>
<td>Österreich</td>
<td>52,00</td>
</tr>
<tr>
<td>11</td>
<td>Thailand</td>
<td>51,91</td>
</tr>
<tr>
<td>12</td>
<td>USA</td>
<td>51,04</td>
</tr>
<tr>
<td>13</td>
<td>Malaysia</td>
<td>50,96</td>
</tr>
<tr>
<td>14</td>
<td>Ukraine</td>
<td>50,88</td>
</tr>
<tr>
<td>15</td>
<td>Neuseeland</td>
<td>50,48</td>
</tr>
<tr>
<td>16</td>
<td>Algerien</td>
<td>48,46</td>
</tr>
<tr>
<td>17</td>
<td>China</td>
<td>47,49</td>
</tr>
<tr>
<td>18</td>
<td>Weißrussland</td>
<td>46,86</td>
</tr>
<tr>
<td>19</td>
<td>Estland</td>
<td>46,04</td>
</tr>
<tr>
<td>20</td>
<td>Türkei</td>
<td>45,54</td>
</tr>
<tr>
<td>21</td>
<td>Taiwan</td>
<td>44,76</td>
</tr>
<tr>
<td>22</td>
<td>Russland</td>
<td>44,30</td>
</tr>
<tr>
<td>23</td>
<td>Singapur</td>
<td>43,97</td>
</tr>
<tr>
<td>24</td>
<td>Kanada</td>
<td>43,06</td>
</tr>
<tr>
<td>25</td>
<td>Iran</td>
<td>43,05</td>
</tr>
<tr>
<td>26</td>
<td>Australien</td>
<td>40,66</td>
</tr>
<tr>
<td>27</td>
<td>Südkorea</td>
<td>38,11</td>
</tr>
<tr>
<td>28</td>
<td>Kasachstan</td>
<td>36,87</td>
</tr>
<tr>
<td>29</td>
<td>Japan</td>
<td>35,93</td>
</tr>
<tr>
<td>30</td>
<td>Saudi-Arabien</td>
<td>25,45</td>
</tr>
</tbody>
</table>

* Veränderung zum Vorjahr
** Gewichte:
- Emissionsniveau: 30 %
- Entwicklung der Emissionen: 30 %
- Erneuerbare Energie: 10 %
- Effizienz: 10 %
- Klimapolitik: 20 %
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 of climate change on food security (MACSUR) - partnership 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 (SUSF-0002)

Core Theme 2: Sustainable intensification of agriculture

Knowledge Network on sustainable intensification

FAFACE 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)

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

Core Theme 3: Biodiversity & ecosystem services

Core Theme 4: Adaptation to climate change

Core Theme 5: GHG mitigation in agriculture

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

FACCE ERA-NET Cofund 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 (£20M)

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

FAFACE ERA-NET Cofund on monitoring and mitigation of agricultural GHG (ERA-GAS) with New Zealand (£14M)

HelmholtzZentrum münchen
German Research Center for Environmental Health
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.
Figure 1. The 5 Core Themes and the 3 Trans-thematic clusters

1. Sustainable food security under climate change
2. Environmentally sustainable intensification of agricultural systems
3. Developing synergies and reducing trade-offs: food supply, biodiversity & ecosystem services

Cluster 3. Increasing resilience of food value chains under climate change

4. Adaptation to climate change
5. Mitigation of climate change

Cluster 1. Land and water management (including soil systems) for climate adaptation and mitigation

Cluster 2. Climate change challenges to farming systems (efficiency and ecosystem services)
When is Agriculture sustainable?

- 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
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
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

Intensify productivity and economic growth

Increase performance and resilience
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.

<table>
<thead>
<tr>
<th>Partner</th>
<th>INRA (Biogeco)</th>
<th>Soil classification (WRB)</th>
<th>Fluvisol – Eutric Gleysol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>St Méard d’Eyran, France</td>
<td>Type of soil stress</td>
<td>soil Cu and PAH contamination</td>
</tr>
<tr>
<td>Site type</td>
<td>brownfield (former arable)</td>
<td>Origin of soil stress</td>
<td>wood preservatives</td>
</tr>
<tr>
<td>Former land use</td>
<td>wood preservation</td>
<td>Treatment / Crop type</td>
<td>aided phytostabilisation + rhizodegradation (m)</td>
</tr>
<tr>
<td>Current land use</td>
<td>derelicted area (mainly) + Surface area (ha)</td>
<td>10 ha (site P7: 2 x 150m²)</td>
<td></td>
</tr>
<tr>
<td>Final land use</td>
<td>phytomanaged area dotted</td>
<td>Climate</td>
<td>mild oceanic climate (but with heat waves)</td>
</tr>
<tr>
<td>Specific objectives</td>
<td>long term assessment of phytomangement options (energy crops, wood) and restoration of ecologica</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Horizon Characterisation</th>
<th>mg/kg</th>
<th>g/kg</th>
<th>cmol+/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ap (0-35cm) Particle &lt;0.02mm</td>
<td>6.4%</td>
<td>total soil Cu 464 - 2000</td>
<td>6.7 - 7.6</td>
</tr>
<tr>
<td>B (35-55cm)</td>
<td>8.75</td>
<td>58</td>
<td>38</td>
</tr>
<tr>
<td>C (55-100cm)</td>
<td>16.8</td>
<td>3.4</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil characteristics</th>
<th>Initial values</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.2 - 7.0</td>
</tr>
<tr>
<td>Sand, silt, clay (%)</td>
<td>88.8, 4.8, 6.4</td>
</tr>
<tr>
<td>Soil moisture (%)</td>
<td>WHC max: 10%</td>
</tr>
<tr>
<td>CEC (meq/100 g)</td>
<td>3.5</td>
</tr>
<tr>
<td>TOC (%)</td>
<td>1.05 - 1.51</td>
</tr>
<tr>
<td>TON (%)</td>
<td>0.05</td>
</tr>
<tr>
<td>Intensity of stress</td>
<td>medium - high</td>
</tr>
</tbody>
</table>

| Fertilization amendment | compost, dolomitic limest | St Méard d’Eyran, France | brownfield (former arable land) |

<table>
<thead>
<tr>
<th>Core stakeholder</th>
<th>Function</th>
<th>Remark</th>
<th>Main site operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADEME (French Environment)</td>
<td>National authority</td>
<td></td>
<td>biogeco</td>
</tr>
<tr>
<td>Lyonnet SA</td>
<td>owner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DREAL</td>
<td>local authority</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Core competences</th>
<th>restoration ecology, plant biology, ecotoxicology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main interests</td>
<td>Intensify non-food crops (for the Bioeconomy), restore soil functions and associated ecosystem services</td>
</tr>
<tr>
<td>Main measurements</td>
<td>soil pore water, soil parameters, plant biomass, plant ionome</td>
</tr>
</tbody>
</table>

Partners with more than one site, please fill up the formular for each site.
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 retention) 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“
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.
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.
Preparation of the test site at Martlhof

- From grassland to agricultural land

Figure 19: Grassland (many different species)

08.07.2016

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*)
Different strains to compare the influence of amendments on microbial diversity

Control I: without amendments
Control II: grassland

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

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

... but I was first

... 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.
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
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
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

Complementarity of Workpackages
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>
<thead>
<tr>
<th>Partner</th>
<th>System in focus</th>
<th>Responsibility/Role</th>
<th>Specific contribution</th>
<th>Strategies developed</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIBIO Coordinator</td>
<td>Grassland pasture and bio-ner as fertilizer, northern climate</td>
<td>WP6. Management, nutrient cycling, grass yields, dissemination, crop model</td>
<td>Diversity, biomass, soil biology</td>
<td>Biomass, nutrient use from organic sources, climate adaptation</td>
</tr>
<tr>
<td>SGGW</td>
<td>Arable land, poor soils, set aside land</td>
<td>WP1. Agronomy, biofuels, energy budgets, GHG, teaching</td>
<td>Farming, yield model, GHG emissions, nutrient availability</td>
<td>Biomass, fibers, new varieties</td>
</tr>
<tr>
<td>UMR-BIOGECO</td>
<td>Brownfields, restoration sites, tailings</td>
<td>WP5. Industrial sites, pollutant uptake, phytoremediation</td>
<td>Soil restoration, organic pollutants, remediation</td>
<td>Biofuel, gentle remediation, mixed plantation</td>
</tr>
<tr>
<td>UHASSELT</td>
<td>Abandoned / arable land, plots</td>
<td>WP4. Heavy metals, socio-economy model</td>
<td>Models, Plant-microbe interaction, genomics</td>
<td>Agroforest, microbial inoculates</td>
</tr>
<tr>
<td>CIEMAT</td>
<td>Dryland, Innovative Greenhouses</td>
<td>Water reuse, biomass, socio-economy</td>
<td>Water use efficiency, soil biology, CO₂ cycling</td>
<td>Biomass, water reuse</td>
</tr>
<tr>
<td>MARTL</td>
<td>Small farm, erosion, pasture (SME)</td>
<td>Small scale productivity, dissemination, contact to local stakeholders</td>
<td>Marketable crops and fruits, biogas biomass, economy budgets</td>
<td>Biogas, alternative products, vegetables, alternative heating</td>
</tr>
<tr>
<td>UPAMA</td>
<td>Greenhouse, arable land, restoration sites</td>
<td>WP2. Heavy metal analysis, biofuel, biochar, teaching</td>
<td>Genomics, proteomics, life cycle analysis, fate of heavy metals</td>
<td>Biochar, LCA, ecotoxicology, teaching</td>
</tr>
</tbody>
</table>