Norway - Country report

Ministry of Agriculture and Food: Evaluation 2015- February 2016:
Climate change and challenges for Agriculture- Knowledge status - need of new knowledge. Adaptation. Evaluate Norwegian climate policy related to new IPCC 5 report.


For agriculture different scenarios evaluated include:

- Reduced meat production, change diet from red meat to white meat, Change diet to more fish and vegetables
- Reduced food waste. Reduced peat cultivation
- Management practices also evaluated, Manure - biogas

Development of GHG emission calculator (April 2015) – emissions depending on food consumption, diet, need of agricultural land for production, national emission factors.

Calculator used in consultancy for the Climate and Environment Directorate
Reduced GHG emissions Norway. Calculations – Low emission society 2050

<table>
<thead>
<tr>
<th></th>
<th>1000 tonn CO2-ekv</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without CO2</td>
</tr>
<tr>
<td>Todays emissions</td>
<td>4 835</td>
</tr>
<tr>
<td>Emissions 2050 (6.7 mill inhabitants)</td>
<td></td>
</tr>
<tr>
<td>Todays practice and efficiency</td>
<td>5 990</td>
</tr>
<tr>
<td>10 % increase in cereal and forage yields</td>
<td>5 864</td>
</tr>
<tr>
<td>Increased milk production /cow</td>
<td>5 497</td>
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<tr>
<td>Reference scenario 2015</td>
<td>5 083</td>
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<tr>
<td>Red to white meat</td>
<td>4 580</td>
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<tr>
<td>Stop in cultivation of peatsoil</td>
<td>5 051</td>
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<tr>
<td>Less food waste</td>
<td>4 984</td>
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<tr>
<td>Biogass from manure</td>
<td>4 922</td>
</tr>
<tr>
<td>From meat to vegetables</td>
<td>4 427</td>
</tr>
<tr>
<td>Low emission scenario</td>
<td>4 182</td>
</tr>
</tbody>
</table>
Need of agricultural area for the different measures mill daa (1 daa = 0.1 ha)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Cereals</th>
<th>Other food crops</th>
<th>Harvested forage</th>
<th>grasland, meadow</th>
<th>Other agricultural area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Todays area</td>
<td>9,9</td>
<td>3,0</td>
<td>0,2</td>
<td>4,7</td>
<td>1,5</td>
<td>0,5</td>
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<tr>
<td>Emissions 2050 (6,7 mill inhabitants)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Todays practice and efficiency</td>
<td>12,8</td>
<td>4,0</td>
<td>0,3</td>
<td>6,1</td>
<td>2,0</td>
<td>0,5</td>
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<tr>
<td>10% increase in cereal and forage yields</td>
<td>11,7</td>
<td>3,6</td>
<td>0,3</td>
<td>5,6</td>
<td>1,8</td>
<td>0,5</td>
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<td>0,5</td>
</tr>
<tr>
<td>References scenario 2015</td>
<td>10,5</td>
<td>3,7</td>
<td>0,3</td>
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<td>1,5</td>
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<td>10,2</td>
<td>3,6</td>
<td>0,3</td>
<td>4,4</td>
<td>1,4</td>
<td>0,5</td>
</tr>
<tr>
<td>Biogas from manure</td>
<td>10,5</td>
<td>3,7</td>
<td>0,3</td>
<td>4,5</td>
<td>1,5</td>
<td>0,5</td>
</tr>
<tr>
<td>From meat to vegetables</td>
<td>9,4</td>
<td>3,3</td>
<td>0,3</td>
<td>4,0</td>
<td>1,3</td>
<td>0,5</td>
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<tr>
<td>Low emission scenario</td>
<td>9,1</td>
<td>3,2</td>
<td>0,3</td>
<td>3,9</td>
<td>1,3</td>
<td>0,5</td>
</tr>
</tbody>
</table>
Climate change – agricultural challenges: Effects of climate change. Adaptation to climate change. Reduction of GHG emissions.

Longer growing season (1-3 months) - New possibilities: Higher yields, increased number of harvests, new varieties, new crops, crops for other purposes like energy, better quality.
Change in agricultural management recommendations like fertilisation, plant health (weed, diseases, fungi), soil tillage, increased need of environmental measures.
Challenges – wetter climate

- Adaptation to wetter climate:

- Harvesting:
Wetter conditions - plant production

Robust plant material adapted to wet soil conditions and compacted soils

Unstable winter conditions. Reduced winter survival.
Svanhovd, Pasvik valley. 7 km from Nickel, Russia
The Meadow warm experiment
Contact. Hanna Silvennoinen@nibio.no

- Installation of an experimental system to test; Increased temperature flux and show what the effects might be on food production for populations in the high north and measure changes in greenhouse gas emissions.
- Plots of meadow are heated up by three degrees Celsius and monitored by a complex system of sensors and imaging devices in the field, remote satellite imagery from above and laboratory tests of soil samples. Test of biochar stability under northern heated conditions - effect of biochar – ability to hold heavy metal in polluted soils.
- A collaboration of a dozen scientists across Norway will keep track of plant production, soil moisture, nutrients, microbial communities, heavy metal concentrations and greenhouse gas emissions in the soil and in the air above the heated sites.
- Will heated plots be a carbon sink or a carbon source?
- Effect on plant production? higher production higher emissions - microbiology activity in soil
- Effect of biochar - warmer northern conditions
Meadow warm

Experimental set up
Biochar research
Climate and Environment Directorate: Biochar is calculated as one of the most efficient measures to store carbon and reduce GHG-emissions from agriculture. Biochar is not available for farmers. Effect on agricultural soils?

- Biochar and effect on C-storage and GHG emission in Norwegian soil. Contact: Adam O. Toole. Bioforsk
- Surface Properties and chemical composition of corncob and miscanthus biochars: effects of production temperature and method. Contact Alice Budai. Bioforsk
- Stability of Biochar Series in Soils and Induced Priming Effects. Contact: Daniel Rasse, Alice Budai, Bioforsk. daniel.rasse@nibio.no Adam.o.toole@nibio.no alice.budai@nibio.no
Field trial in Norway – 2010-14


- Crops – 2011 Oats
  2012 Barley
  2013 Oats
  2014 Oats

- Fertilizer: 150 kg N ha$^{-1}$

Ås (University of Life Sciences, field station)
Measurements 2011 - 2014

- **CO₂-flux measurement**: Closed static chambers, Infrared gas analyzer (IRGA)
- **CO₂ from biochar**: repeated δ¹³C measurements with Piccaro G1101-i, and keeling plot method.
- **N₂O fluxes**: Larger closed chambers, measured via GC
Results - Soil respiration

Pyreng miscanthus biochar at 8 and 25 t per ha does not significantly increase soil CO\textsubscript{2} efflux.
Cumulative C losses - 2012

Growing season 2012 (initial fall and spring periods not captured)

<table>
<thead>
<tr>
<th></th>
<th>C4 plant-C loss</th>
<th>Contribution to CO₂</th>
<th>C loss from straw and biochar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO₂-C loss</td>
<td>g m⁻²</td>
<td>g m⁻²</td>
</tr>
<tr>
<td>Control</td>
<td>279</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Straw 8 t C ha⁻¹</td>
<td>303</td>
<td>63.4</td>
<td>7.9%</td>
</tr>
<tr>
<td>Biochar 8 t C ha⁻¹</td>
<td>262</td>
<td>2.2</td>
<td>0.7%</td>
</tr>
<tr>
<td>Biochar 25 t C daa⁻¹</td>
<td>307</td>
<td>2.4</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

In the field, Pyreg miscanthus biochar appeared to decompose at about 0.5% per growing season (June – October).
N$_2$O flux 2012

- fertilization
- harvest

- No statistically difference between treatments.
- Large variations.
- Peak after fertilization
- High peak in September after harvest and no plant growth.

O'Toole et al. in prep
Soil N$_2$O flux 2014

μg N2O-N m$^{-2}$ hr$^{-1}$

- **Fertilization** (110 kg N ha$^{-1}$)
- **Harvest**
- **Fertilization** (30 kg N ha$^{-1}$)

*Control*  *BC aged*  *BC new*
## Modeling approach

**Christophe Moni, GRA: cross-cutting C-N modelling**

### Weather data from 2011 to 2014
- Air temperature
- Soil temperature at 6 depth
- Air humidity and pressure
- Wind speed and direction
- Solar radiation
- PAR
- Precipitation

### Soil and plant properties
- Agricultural management
- Plant parameters
- Soil bulk density
- Soil hydraulic properties
- Soil texture
- Soil OC content

### Parameterization

### Calibration

### Validation

### Weather data from 2011 to 2014

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Recorded</th>
<th>Year</th>
<th>From</th>
<th>To</th>
<th>Frequency</th>
<th>Treatments</th>
<th>(number of replicates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil moisture</td>
<td>2011</td>
<td>June</td>
<td>October</td>
<td></td>
<td>24 h</td>
<td>4</td>
<td>4</td>
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<tr>
<td>NO$_3^-$/NH$_4^+$</td>
<td>2012</td>
<td>April</td>
<td>September</td>
<td></td>
<td>x7</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Heat fluxes</td>
<td>2012</td>
<td>April</td>
<td>June</td>
<td></td>
<td>30 min</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>2012</td>
<td>June</td>
<td>September</td>
<td>4 h</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>2012</td>
<td>September</td>
<td>October</td>
<td>1 h</td>
<td>3-10</td>
<td>1-5</td>
<td>2-5</td>
</tr>
<tr>
<td>Temperature</td>
<td>2012</td>
<td>September</td>
<td>October</td>
<td>1 h</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>N$_2$O fluxes</td>
<td>2012</td>
<td>April</td>
<td>September</td>
<td>x10</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil moisture</td>
<td>2014</td>
<td>June</td>
<td>November</td>
<td>15 min</td>
<td>3-4</td>
<td>3-4</td>
<td>2-3</td>
</tr>
<tr>
<td>Temperature</td>
<td>2014</td>
<td>June</td>
<td>November</td>
<td>15 min</td>
<td>3-4</td>
<td>3-4</td>
<td>2-4</td>
</tr>
<tr>
<td>CO$_2$ fluxes</td>
<td>2014</td>
<td>June</td>
<td>October</td>
<td>x5</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>$\delta^{13}$C CO$_2$ fluxes</td>
<td>2014</td>
<td>June</td>
<td>October</td>
<td>x5</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>N$_2$O fluxes</td>
<td>2012</td>
<td>May</td>
<td>October</td>
<td>x15</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Restoration of cultivated peatlands

• Measurements over the last 3 years.
• Examined the effect of drain blocking on GHG fluxes.
• Measured:
  • Ecosystem Respiration with dark chambers
  • Water table
  • Plant species composition

• Blocked the drains at the start of year 3.
• Measured the response of ecosystem respiration to drain blocking.
• Post drain blocking in year 3.
• Single campaign with high frequency measurements to compare currently cultivated with the abandoned plots.
• Contact: Simon Weldon.nibio.no, Arne Grønlund, Nibio
In Cultivation

Old abandoned
>60 år

Recently abandoned
<10 år

Measurement sites
High emissions of CO2-years after abandoned

Low losses of N20 (no fertilization).

Rewetting 1 year. No effect/reduction on CO2 losses or increase in CH4- emissions.

Dry year- need longer measurement period.
Nitrous oxide emissions from clover rich leys during the long northern winter

Ievina Sturite¹, Synnøve Rivedal¹, Peter Dörsch²

¹NIBIO, ²NMBU

ievina.sturite@nibio.no   peter.doerch@nmbu.no
Materials and methods

- Clover:
  - 0%
  - 30%
  - 100%

- 110 kg N ha⁻¹ cattle slurry

- Undisturbed Removed
Conclusions

Clover in grasslands promotes off-season N$_2$O emissions under northern winter conditions.

Removal of foliage did not reduce gaseous losses under the conditions encountered at our sites.
More than 70% of N2O was lost during winter.
N content in clover leaves reduced by 82%.
Increased N-content in straw and roots.
Highest emission during thawing soil.

Contact; ievina.sturite@nibio.no; peter.doerch@nmbu.no
Cropping systems - environmental effects - (emissions og GHG and nutrient loss to surface and drainage water.
Contact - Peter Dörsch, Audun Korsæth

* Measurement of N2O in long term field trials (NMBU and NIBIO, Apelsvoll). 20 years of measurements of cropping systems, crops, fertilizer, soil tillage. Yield, runoff losses, surface and drainage water.
* Development of equipment for automatic measurements of N2O in field.

Project DRAINIMP: Effect of drainage status on N2O emissions. Peter Dörsch
Project: Mitigation of Greenhouse gas emission from cropped soils by mafic Mineral applications (MIGMIN).

- **Purpose**: Innovative strategies for pH regulation in acid soils – field research– increased yield with less GHG emissions.
- **Dolomite, Olivine a.o for regulating pH.**
- **Peter Dörsch, Lars Bakken (NMBU Nitrogen Group), Nina Simon (Ife) and Pål Tore Mørkved (UiB)**

Automatic N₂O emission measurements in cooperation with EU prosjekt (NORA – N₂O Research Alliance, Marie Curie ITN, 2013-2016) lead by NMBU Nitrogen group.

Contact Lars Bakken (lars.bakken@nmbu.no)
Peter Dörch (peter.doerch@nmbu.no)

NMBU = Norwegian University of Life Sciences
GRA- Cropland- Norway Country update

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