LUONNONVARAKESKUS

Modelling of soil carbon changes in agricultural soils – Hiilimaito project

Karoliina Rimhanen

Biogenic carbon working group meeting,

Teams 26.1.2023 14.00

Modelling of soil carbon changes in agricultural soils – Hiilimaito project

Content of the presentation

- Aims of the project
- Steps in the Methodoly
    - Assessment of above and below ground C inputs
    - AWEN fractions
    - Modelling changes in the SOC stock using Yasso soil model
    - Assessing annual carbon sequestration rate

Aim of the project

- Maidontuotannon hiilijalanjäljen pienentäminen, muutokset maatilan pellonkäyttöstrategiaan (HiiliMaito) Reducing the carbon footprint of milk production, changes to the field use strategy at the farms
- Coordinator Auvo Sairanen, Luke Maaninka
- Aim is to change the field use at the dairy farm towards more grass-dominated and reduce the need for total field area required for for milk production. This is a way to develop dairy cattle feeding strategy aiming to lower the emissions from the LULUCF sector.
- Second goal is to calculate the impact of these changes on the farm´s economy and estimate costs for emission reduction.

WP3 Field use strategy and climate impact

- Compare alternative feeding strategies and estimate how the change in the land use influence soil C stock
- Alternative proportion of concentrated feed 45 % (baseline scenario) and 35 % (improved practice),
- Scenario calculations for real farms and fictional farms,
- Yasso07 soil model is used, describes the decomposition of organic matter for mineral agricultural soils based on information on **climate** and **C input quality** (Tuomi et al 2008, Tuomi et al. 2011). The simulated estimates represented soil layers down to a depth of 1 m (Palosuo et al. 2015)
- The Yasso07 model is widely applied to assess carbon balances of both forest and agricultural soils. It is used in the greenhouse gas inventory of Finland to assess changes in soil C stocks (UNFCCC 2020).

Methodology

- The estimation of the changes of SOC stock include:
  - Assessment of above and below ground **C inputs** from crop and manure in the baseline scenario (CF 45%) and in the improved, grass dominated scenario (CF 35%)
  - Assessment of the **additionality** in SOC stock when grass dominated scenario is implemented

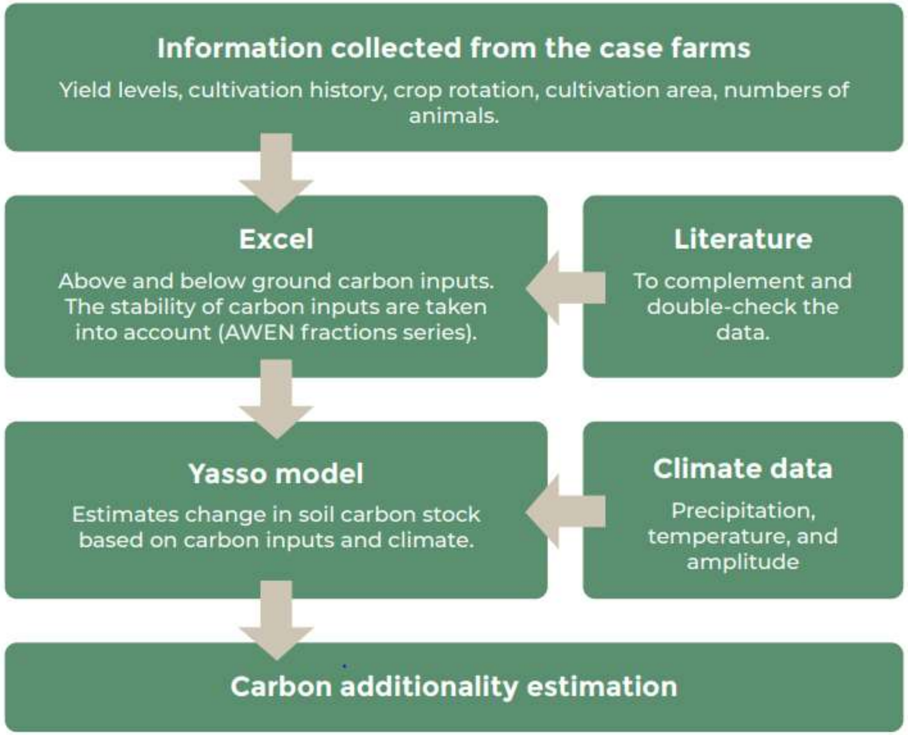


Figure 1. Description of the carbon calculation process from data acquisition to the carbon additionality estimation results.

(Rimhanen et al. 2022)

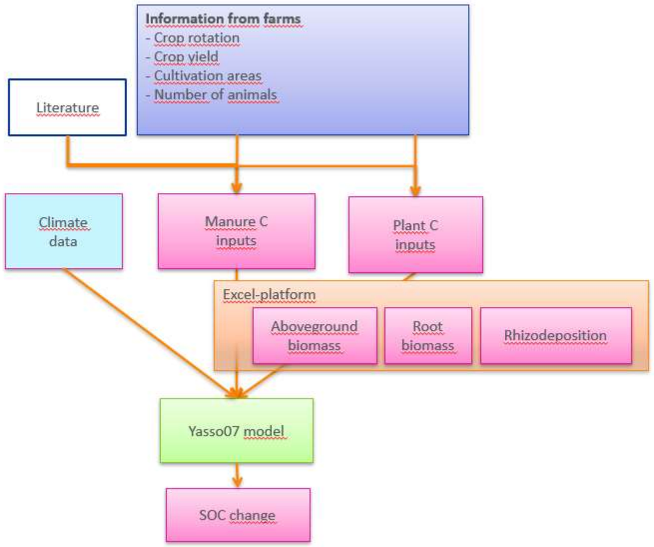
Methodology: above and below ground C inputs from crops and manure

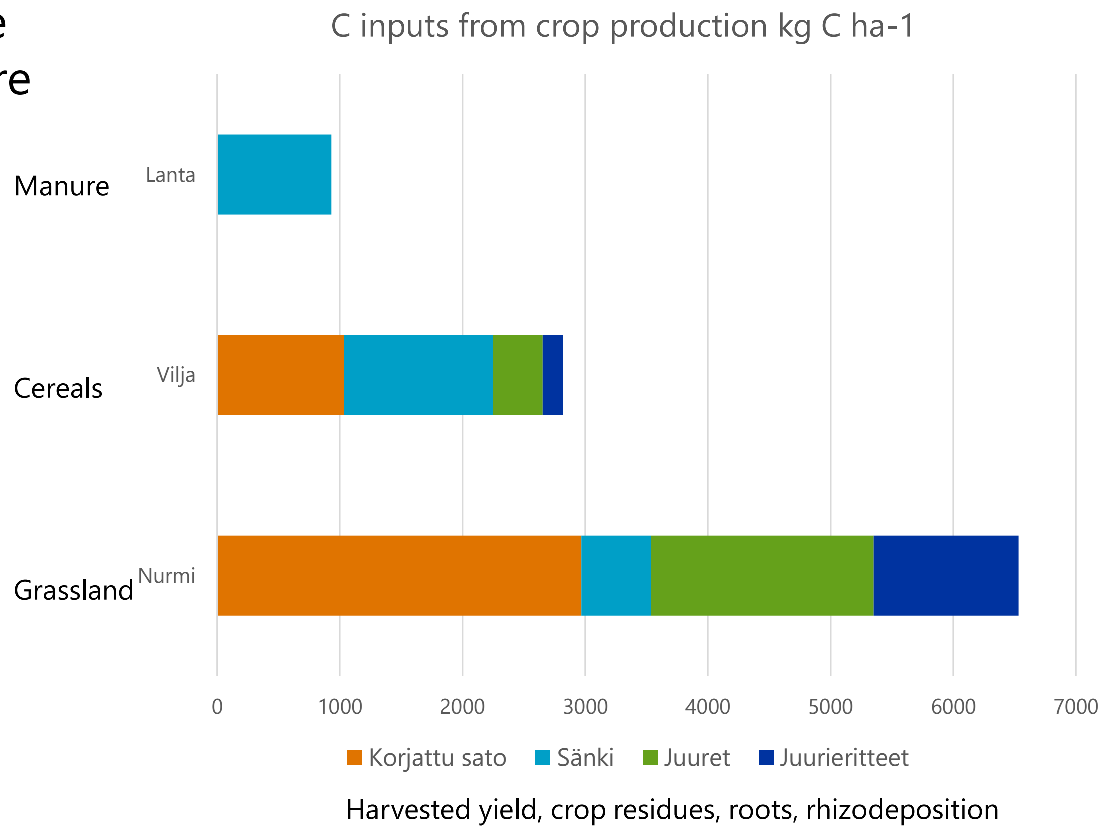
- C inputs involve all organic matter allocated to the soil, including aboveground and belowground crop residues, manure, and organic soil amendments
- C inputs from crops: information from farms regarding crop rotation, crop yields, and cultivation area.
- The C input from the crop residues
  - C inputs from above-ground biomass: C inputs from straw, leaves, and stubble
  - C inputs from below-ground biomass: C inputs from roots, and rhizodeposition.
- Based on the number of head of livestock and literature estimations of the amount of manure produced the C inputs from the manure is calculated
- Several mathematical formulas are utilised from the literature to estimate above and below ground C inputs (Palosuo et al. 2015, Rimhanen et. al. 2022)

	A	B	
	Baseline, CF 45	CF 35	
Cows	145	145	pcs
Heifers > 1 yr	63	63	pcs
Calves < 1yr	60	60	pcs
Grass area	138	161	ha
Cereal area	89	46	ha
Other field, green fallow	13	33	ha
Total area	240	240	
Grass yield	6600	6600	kgka/ha
Cereal yield	2300	2300	kgka/ha

Average C inputs from cereal crops, grasses and manure currently produced at case farms (kg C ha-1).

- The basis for calculations of C inputs are yields estimated by farmers and literature values





Methodology: C inputs in AWEN fractions

- Yasso07 requires information on the C input quality in AWENs fractions
    - Model consists of these four litter compartments
    - Organic litter is broken down into these compartments based on its chemical quality
    - Each compartment has a specific decomposition rate, affected by temperature and precipitation
- Describe the chemical composition of decomposing materials as acid (A), water (W) and ethanol (E) soluble, non-soluble (Ns) fractions. Represent roughly the content of cellulose (A), sugars (W), waxes (E) and lignin (N) in the residues.

Crop residue	A	W	E	Ns	Ref.
Cereals (barley, oats, maize, and wheat)	0.71	0.08	0.03	0.18	Karhu et al. 2012
Grasses, alfa-alfa	0.46	0.32	0.04	0.18	Jensen et al. 2005, Liski et al. 2013
Manure	0.65	0.12	0.07	0.16	Karhu et al. 2012
Oilseed,	0.87	IPCC 2000	0.50	5.0	IPCC 2000
rapeseed	0.40	0.34	0.04	0.22	Jensen et al. 2005, Liski et al. 2013
Pea, beans, and other vegetables	0.63	0.14	0.02	0.21	Jensen et al. 2005, Liski et al. 2013
Sugar beet	0.26	0.54	0.04	0.16	Jensen et al. 2005, Liski et al. 2013
Sugar beet	0.21	Pahkala 2009	0.66	5.0	IPCC 2000
Wheat	0.86	MTT 2013	0.42	5.6	Hansson et al. 1987, Ilola et al. 1988, Paustian et al. 1990, Johansson, G. 1992, Kätterer et al. 1993, Maljanen et al. 2001, Rajala and Peltonen-Sainio 2001, Pietola and Alakukku 2005.

Palosuo et al 2015

Methodology: from inputs to Yasso

Based on the information concerning production areas of different crops and C inputs (kg per ha) from cropping and livestock, we calculated hectare based total C inputs = input for Yasso07 model.

Assessment of the additionality in SOC

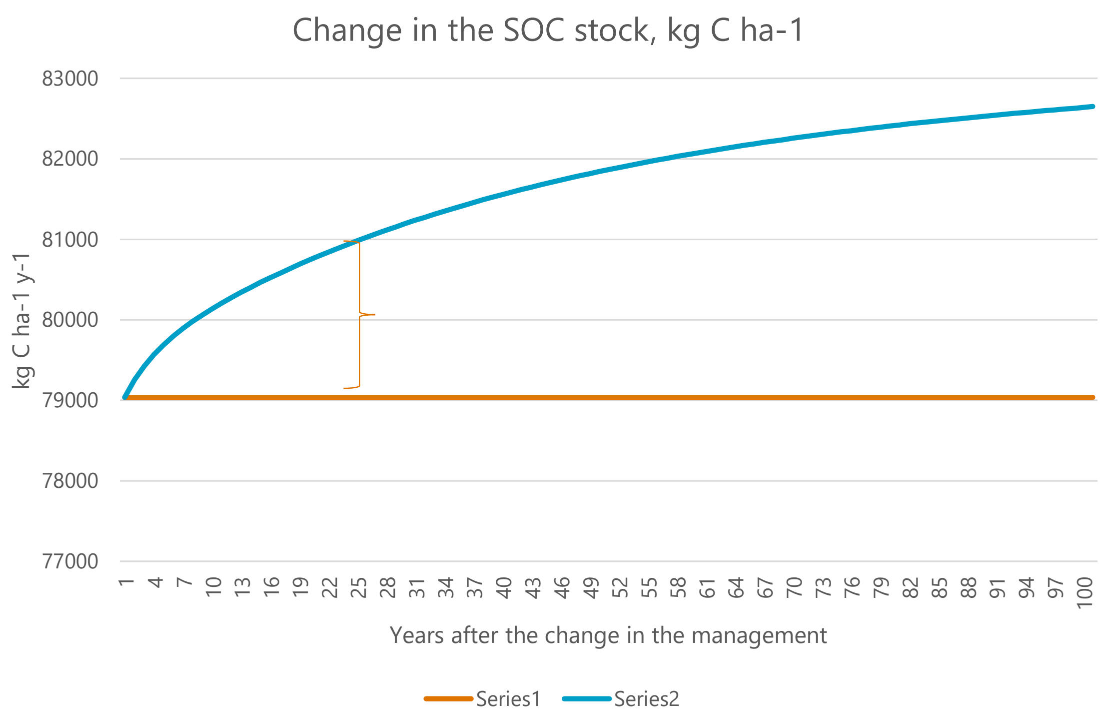
The theoretical baseline for the calculation is the current state of the soil C stock, being a result of current farming practices

The calculation is based on a comparison of the modeled impact of current practices (baseline) and "improved" practices on soil C stock.

1. We ran the Yasso07 model to an equilibrium state with the information of the C inputs allocated to soil based on current farming practices and simulated their effect on soil C stock change, corresponding to a zero effect.

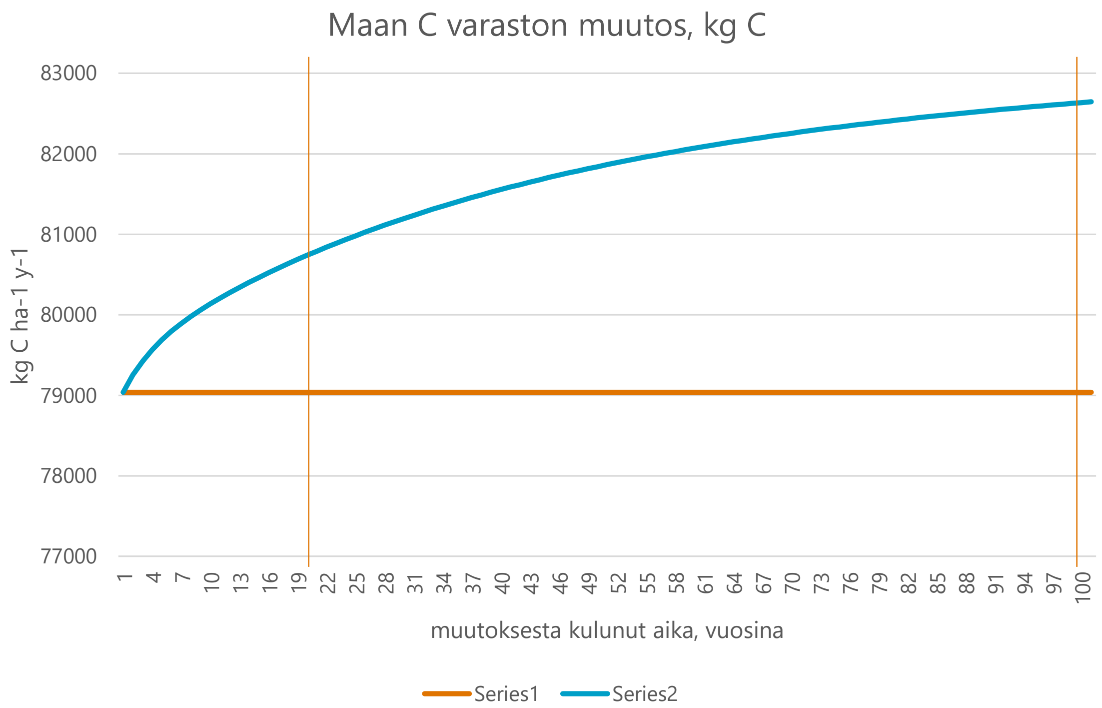
2. We simulated the change in soil C stock as a result of implementing proposed "improved" practices.

3. We calculated the difference between the SOC stocks of current and "improved" practices. This represented the additionality in the SOC stocks.



Assessing annual carbon sequestration rate

	Average difference in SOC, kg C ha-1	Annual difference in SOC stock, kg C ha-1 y-1	C to CO2-e	C sequestration CO2-e ha-1y-1
100 yrs	-2584	-26	3,67	-95
20 yrs	-1136	-57	3,67	-208



Literature

Rimhanen, K. Harjama, N. and Ilvesniemi, H. 2022. Carbon farming Scheme. LIFE Preparatory Project. Action A1, Science-based mechanisms for farmers and foresters to capture carbon from the atmosphere. https://content.st1.fi/sites/default/files/2022-03/LIFE-Luke-A1_report_02-2022_0.pdf

Palosuo T., Heikkinen J., and Regina K. 2015. Method for estimating soil carbon stock changes in Finnish mineral cropland and grassland soils, Carbon Management, 6:5-6, 207-220, DOI: 10.1080/17583004.2015.1131383

Tuomi, M., Vanhala, P., Karhu, K., Fritze, H., Liski, J., 2008. Heterotrophic soil respira-tion - Comparison of different models describing its temperature dependence.Ecological Modelling 211, 182–190. Tuomi M, Rasinmäki J, Repo A, Vanhala P, and Liski J. 2011. Soil carbon model Yasso07 graphical user interface. Environ. Model. Softw. 26(11), 1358–1362.

Kiitos!

Löydä meidät verkosta

› luke.fi

Tilaa uutiskirjeemme ja pysy jyvällä!
luke.fi/uutiskirje

Luonnonvarakeskus (Luke)

Latokartanonkaari 9, 00790 Helsinki