DERIVING INDICATORS FOR SOIL ORGANIC MATTER MANAGEMENT FROM FLINT DATA

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12 December 2016

Public

D5.2N

agriXchange is funded by the European Commission's 7th

ABOUT THE FLINT PROJECT

FLINT will provide an updated data-infrastructure needed by the agro-food sector and policy makers to provide up to date information on farm level indicators on sustainability and other new relevant issues. Better decision making will be facilitated by taking into account the sustainability performance of farms on a wide range of relevant topics, such as (1) market stabilization; (2) income support; (3) environmental sustainability; (4) climate change adaptation and mitigation; (5) innovation; and (6) resource efficiency. The approach will explicitly consider the heterogeneity of the farming sector in the EU and its member states. Together with the farming and agro-food sector the feasibility of these indicators will be determined.

FLINT will take into account the increasing needs for sustainability information by national and international retail and agro-food sectors. The FLINT approach is supported by the Sustainable Agriculture Initiative Platform and the Sustainability Consortium in which the agro-food sector actively participates. FLINT will establish a pilot network of at least 1000 farms (representative of farm diversity at EU level, including the different administrative environments in the different MS) that is well suited for the gathering of these data.

The lessons learned and recommendations from the empirical research conducted in 9 purposefully chosen MS will be used for estimating and discussing effects in all 28 MS. This will be very useful if the European Commission should decide to upgrade the pilot network to an operational EU-wide system.

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LIST OF ACRONYMS

EU	European Union
FADN	Farm Accountancy Data Network
SOM	Soil Organic Matter
TF	Type of Farming (FADN)
UAA	Utilised Agricultural Area

EXECUTIVE SUMMARY

Maintaining adequate soil organic matter (SOM) levels is an important indication for good soil management. For cost and methodological reasons, soil sampling results often include no information on SOM contents. Thus empirical information on SOM levels is usually not available, explaining the interest to derive indicators for SOM management from other farm data. The FLINT (Farm Level Indicators for New Topics) project helps filling this gap by collecting additional data to Farm Accountancy Data Network (FADN) data for a sample of farms in the European Union.

This report compares three indicators for farm-level SOM management using FLINT data (CountPractices: count SOM relevant practices on farm), FLINT and FADN data (SOM index: sum of area with SOM-relevant farming practices divided by total farm area) as well as FLINT and FADN data + cofficients from standard data tables (SOM balance: SOM return to field – SOM removal through harvest).

The three indicators were compared at different levels (by Type of Farming, Production Systems and FLINT Partner Country). The SOM index appeared to be the most suitable of the three indicators, taking into account the necessary calculation effort, the current data situation and the level of uncertainty. The SOM balance is useful for a normative sustainability assessment for the soil topic as it shows the direction of the impact (positive/negative balance). However, due to time constraints current results are only of illustrative value. Small changes in the FLINT farm return as well as adaptations in the SOM standard coefficients to different pedo-climatic zones are likely to improve the SOM balance results.

1 INTRODUCTION

Soil Organic Matter (SOM) management is an important factor to maintain SOM contents over time, ensure long-term soil fertility and adequate soil structure as well as water holding capacity (Bot and Benites, 2005).

An important obstacle to analysing SOM management has up to now been the lack of data. In the FLINT project, variables from the Farm Accountancy Data Network (FADN) and other variables collected with the FLINT farm return can be linked to SOM. The FLINT data are farm-level data for a sample of 1,099 farmers of the FADN in several European Union (EU) countries (The Netherlands, Hungary, Finland, Poland, Spain, Ireland, Greece, France and Germany). The data include accountancy data from FADN (here after: 'FADN data'), as well as additional data on economic, environmental and social sustainability of farms. These additional data, the 'FLINT data', were collected via face-to-face survey or merging of existing data, depending on the country. The FADN and FLINT data relate to accountancy year 2015, except for France and Germany for which it is 2014.

The objective of this report is to illustrate what indicators of SOM management can be derived from FLINT data, and to identify which additional information would be desirable to improve the indicators.

2 METHODOLOGY AND DATA

Three comparatively simple indicators for SOM management were calculated and compared (

Table 1). As the objective of FLINT was to use primarily indicators for which data could be collected with reasonable effort from a large number of farms, complex dynamic humus models (e.g. Hülsbergen, 1997; Six and Jastrow, 2002) were not considered because of their data demands.

Table 1: SOM indicators and how they were calculated

SOM indicator	Method	Data	Indicator Type
CountPractices (Max = 7) The higher, the better	Counting the number of soil relevant practices occurring per farm (unit: ares[1]) based on the seven variables in FLINT relating to soil organic matter (variables beginning with Z5_SO…, n=7). Z5_SO_5020_A_1 Ploughing in of straw Z5_SO_5020_A_2 Application of farmyard manures or compost Z5_SO_5020_A_3 Application of organic fertilizer Z5_SO_5020_A_4 Use of cover crops Z5_SO_5020_A_5 Crop rotation Z5_SO_5020_A_6 Long term reduced till options Z5_SO_5020_A_7 Use of a grass based crop as part of the arable system/crop rotation	FLINT	Simple
SOM index The higher, the better	Summing up the area for the single SOM practices listed above and dividing by the total utilised agricultural area (UAA). The higher the index the better is the SOM management on the farm. Because different categories can occur on the same field, the total area with SOM practices can exceed total UAA (resulting in an index > 1).	FLINT + FADN	Simple
SOM balance (kg Humus C/ ha) Sustainable: …-75 to +300 kg C per ha	Deduct SOM removal through harvest from SOM return through SOM practices, divided by UAA	FLINT + FADN + coefficents from standard data tables	Complex

Source: the author based on FLINT

Description of SOM balance calculation

A simplified SOM balance is often calculated in SOM decision support tools for farmers, developed, for example, by agricultural authorities and farm advisors[2]. SOM balances compare SOM removal through harvest and SOM return through manure, compost, straw and other by-products as well as catch and cover crops (Breitschuh, 2008; Körschens et al., 2004). Usually the result of this calculation is divided by the total agricultural area to have a comparable measure among farms.

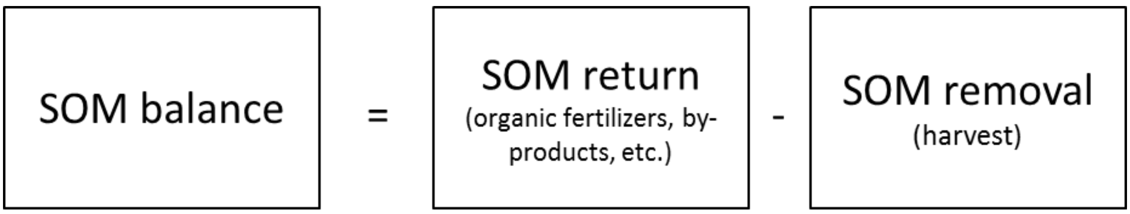

Figure 1: Illustration of Soil Organic Matter balance calculation (Source: Körschens et al., 2004, translated)

SOM balance results between 0 to +100 kg Humus C per ha are considered optimal, while -75 to +300 kg C per ha is the tolerable range for sustainability (Breitschuh, 2008). Higher negative values, particularly if

[1] 1 ar = 0.01 ha
[2] https://www.llh.hessen.de/downloads/landwirtschaft/pflanzenproduktion/humus/xls/Humusbilanz.xls

they occur over several years, indicate SOM degradation, while persisting high positive values may be a hint for over-fertilisation. Farms with a high share of row crops and that apply only non-organic fertilizers often have a negative balance, while organic and mixed farms usually show balanced or positive results.

Data used for the SOM balance

The following variables from the FADN and FLINT farm return were used for the SOM balance calculation (see

Table 2).

Table 2: FADN and FLINT variables used for the SOM balance calculation (accounting year 2014 or 2015)

Source	Table	Variables	Description	Original Unit
FADN	I	I_PR_..XX.._Q I_A_..XX.._TA	Production: Quantity Area: Total Area	quintals[3] ares
FLINT	Z5	Z5_SO_5020_A_1	Ploughing in of straw	ares
		Z5_SO_5020_A_2	Application of farmyard manures or compost	ares
		Z5_SO_5020_A_3	Application of organic fertilizer	ares
		Z5_SO_5020_A_4	Use of cover crops	ares
		Z5_SO_5020_A_5	Crop rotation	ares
		Z5_SO_5020_A_6	Long term reduced till options	ares
		Z5_SO_5020_A_7	Use of a grass based crop as part of the arable system/crop rotation	ares

Source: the author based on FLINT

In addition, coefficients from Standard Tables[2] were used (see Appendix), that indicate the extent and direction of the impact of each component considered in the SOM balance. The coefficients used for this study originate from one region in Germany. For other pedo-climatic zones, all coefficients might need adjustment, but this could not be achieved during the project life time of FLINT. The following analysis is rather to illustrate the principle use of a SOM balance, while its results cannot be considered final at this stage.

3 RESULTS

Tables 3-5 show the results of the indicator calculations grouped by Type of Farming (TF) (

[3] 1 quintal = 100 kilogrammes

Table 3), Production System (Table 4) and FLINT partner country (Table 5).

Table 3: SOM indicators grouped by FADN Type of Farming

Type of farming (TF) - General	n	Average UAA ha	CountPractices (Max = 7)	Average SOM index[4]	SOM balance kg Humus C/ ha
Specialist field crops	230	167.67	2.83	1.46	-120.01
Specialist horticulture	9	80.34	3.00	1.34	**102.13**
Specialist permanent crops	45	41.41	2.02	0.79	563.01
Specialist grazing livestock	265	84.16	3.42	1.31	581.87
Specialist granivores	51	217.53	3.14	1.71	**288.44**
Mixed cropping	18	241.48	2.89	1.52	**113.61**
Mixed livestock	14	71.04	4.64	1.72	1716.37
Mixed crops-livestock	109	213.06	3.68	1.54	338.29
Total sample (for SOM)	741	139.15	3.18	1.40	311.07

Source: the author based on FLINT; bold figures are within the tolerable range for sustainability defined by Breitschuh (2008): -75 to +300 kg C per ha

It can be expected that all SOM indicators are higher in livestock-keeping farms (due to the presence of organic fertiliser), while specialist field crops should have lower values. All three indicators confirm this expectation. For example, the highest values of all three indicators occur in the TF “Mixed livestock”, while the TFs “Specialist field crops”, “Specialist horticulture” and “Specialist permanent crops” all have lower values than their livestock-keeping counterparts (

[4] Because different categories can occur on the same field, the total area with SOM practices can exceed total UAA (resulting in an index > 1).

Table 3).

The negative SOM balance in "Specialist field crops" is in line with results from the literature, however some farm types have extraordinarily high values (e.g. 1716.37 kg Humus C per ha in "Mixed livestock" farms), which is a hint that the SOM balance calculation requires improvement and should be checked again particularly for these systems.

Table 4: SOM indicators grouped by FADN Production System

Production system	n	Average UAA ha	CountPractices (Max = 7)	Average SOM index[4]	SOM balance kg Humus C/ ha
Conventional	669	142.2	3.20	1.40	**286.03**
Organic	39	91.4	3.21	1.56	516.65

Source: the author based on FLINT; bold figures are within the tolerable range for sustainability defined by Breitschuh (2008): -75 to +300 kg C per ha

Organic farms have on average a higher SOM index and a higher positive SOM balance (Table 4) which is in line with expectations, while the counting of SOM relevant practices (CountPractices) shows only small differences and therefore seems to be less suitable to characterise organic farms.

Finally, a comparison of the FLINT countries is shown (Table 5) although it has no real analytical value due to the different sample structure in each country. The Finish farms in FLINT have on average the highest SOM index and SOM balance, while Ireland has the lowest, due to the low share of arable land in the systems covered by the FLINT sample in these countries (mainly livestock). Thus many of the SOM practices asked for in FLINT are not actually relevant for these farms, although due to the high share of grassland SOM levels in Ireland are particularly high.

Thus all three SOM indicators can be misleading when different countries are compared, and when farms have only little arable land. For between-farms comparisons the indicators are useful.

Table 5: SOM indicators grouped by FLINT partner country

FLINT Country	n	Average UAA ha	CountPractices (Max = 7)	Average SOM index[4]	SOM balance kg Humus C/ ha
Finland	49	97.18	4.08	2.00	725.49
Ireland	27	53.52	1.37	0.58	**188.15**
France	231	120.69	3.65	1.48	517.78
Germany	38	231.08	3.45	1.13	**215.21**
Poland	125	39.29	3.66	1.64	304.63
Netherlands	75	75.15	2.75	1.34	-152.33
Hungary	89	468.76	2.80	1.49	**225.68**
Greece	50	28.61	2.24	0.76	439.43
Spain	57	114.88	2.07	1.06	-116.16
Total sample (for SOM)	741	139.15	3.18	1.40	311.07

Source: the author based on FLINT; bold figures are within the tolerable range for sustainability defined by Breitschuh (2008): -75 to +300 kg C per ha

4 CONCLUSION

4.1 Conclusions on the analysis

The SOM index is the most suitable of the three indicators that were compared taking into account calculation effort, current data availability and the level of uncertainty. The correlation with CountPractices is medium high (spearman correlation coefficient: 0.627, p=0.01). Thus both indicators will in many cases come to similar conclusions, however due to its lower performance for organic farms, CountPractices is less suitable, particularly given the relatively similar calculation effort.

The SOM balance has potential but requires further checking of the assumptions that were made and adjustments of the coefficients for different pedo-climatic zones. Its advantage is that it shows the direction of the SOM impact, while SOM index and CountPractices have only positive values, which makes it difficult to assess sustainability normatively. Only a “the more-the better” assessment is possible with these two indicators, while the SOM balance allows for a “sustainable/non-sustainable” assessment. Thus investing further efforts into this indicator in the future is desirable to support farm sustainability assessment for soil topics.

4.2 Conclusions on the data

Recommendation for FLINT Farm Return

The FLINT variables come from personal assessments of the farmers during the farm interview that was done in FLINT, which is a potential source of error. Farmers answered with relatively round values, which is a hint for rather broad over-the thumb estimations, whereas areas and production quantities in FADN often have decimal places, indicating a possible mismatch. However, straw returns are usually not that well recorded, on the other hand, in some cases, the straw return area exceeded the total UAA, which is an obvious error. If possible, the figures given should thus be cross-checked with FADN areas already during the interview.

Another problem is related to the formulation of the categories themselves.

The term “ploughing in of straw” is too specific and may have caused misunderstandings. It implies that straw return to field is only relevant in combination with a plough, although straw return in combination with other tillage options, e.g. howing and direct seeding, would be equally important.

Thus, the description of this category should be changed to “straw return to field”.

In contrast, the other two categories, “Application of farmyard manures or compost” and “Application of organic fertilizer” are not clear enough, particularly if both categories are looked at together. The first could lead to a false assignment of manure not from the farmyard to this category. The second category is very broad and covers a variety of different organic fertilizers, e.g. slurry, manure, biogas substrates, sludge etc., which makes it difficult to assign coefficients for SOM impacts which are quite different for the different types of fertilizers. It cannot be ruled out that “farm manure” (not farmyard manure) quantities are filled in each of the two categories (double counting), or that manure is assigned to the first, and slurry to the second.

To avoid confusion and ensure more clarity, each organic fertilizer should thus form a separate category, and the total quantities applied (in tons) should be enquired in addition to have a measure of the per ha application quantity. To allow for cross-checking, it is also desirable to have some additional general information regarding the livestock housing system, e.g. bedding material, flooring system etc. and the existence of of or farm cooperation with a biogas plant.

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6 APPENDIX

Table 6: SOM impact of FADN crops

FADN_code	FADN_name	kg Humus C per ha
10110	Common wheat and spelt	-280
10120	Durum wheat	-280
10130	Rye	-280
10140	Barley	-280
10150	Oats	-280
10160	Grain maize	-560
10170	Rice	-280
10190	Other cereals for the production of grain	-280
10210	Peas, field beans and sweet lupines	160
10220	Lentils, chickpeas and vetches	160
10290	Other protein crops	160
10300	Potatoes (including early potatoes and seed potatoes)	-760
10310	Potatoes for starch	-760
10390	Other potatoes	-760
10400	Sugar beet (excluding seed)	-760
10500	Fodder roots and brassicas (excluding seed)	-760
10601	Tobacco	-280
10602	Hops	-280
10604	Rape and turnip rape	-280
10605	Sunflower	-280
10606	Soya	160
10607	Linseed (oil flax)	-280
10608	Other oil seed crops	-280
10910	Temporary grass	400
10921	Green maize	-560
10922	Leguminous plants	160
10923	Other plants harvested green but not mentioned elsewhere	-560
11100	Other arable land crops	-280
11210	Fallow land without any subsidies	180
11220	Fallow land subject to the payment of subsidies, with no economic use	180
30100	Pasture and meadow, excluding rough grazings	600
30200	Rough grazings	600
30300	Permanent grassland no longer used for production purposes and eligible for the payment of subsidies	600
50100	Unutilised agricultural land	180
90310	Straw	100

Coefficients from
https://www.llh.hessen.de/downloads/landwirtschaft/pflanzenproduktion/humus/xls/Humusbilanz.xls

Table 7: SOM coefficients of crop by-products

Crop	Grain:Straw or Root:Leaf Ratio	kg Humus C per ha
Fodder beets	0.4	8
Oats	1.1	100
Grain Maize	1	100
Linseed	1.5	100
Spring barley	0.8	100
Sommerraps	1.7	100
Sunflower	2	100
Winter barley	0.7	100
Winter rapeseed (Canola)	1.7	100
Winter rye	0.9	100
Winter triticale	0.9	100
Winter wheat	0.8	100
Sugarbeets	0.7	8

Coefficients from
https://www.llh.hessen.de/downloads/landwirtschaft/pflanzenproduktion/humus/xls/Humusbilanz.xls

Table 8: SOM coefficients of organic fertilisers, average

Crop	Avg kg Humus C per ton	Min kg Humus C per ton	Max kg Humus C per ton
Green manure	12	8	16
Slurry	7.8	4	12
Manure	53.7	28	96
Straw	100	100	100

Coefficients from
https://www.llh.hessen.de/downloads/landwirtschaft/pflanzenproduktion/humus/xls/Humusbilanz.xls

Original coefficients distinguish between the type of organic fertiliser and its dry matter content. As this information was not available in FLINT, three calculations were run, with minimum, maximum and average values across categories.