SOLID | Sustainable Organic and Low Input Dairying

Participatory research in the UK:
Soil health and grassland productivity

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Research question

How to improve productivity?

SOLID workshop of UK dairy farmers identified soil related problems with productivity:

- Difficulties understanding key elements of soil health and fertility (how to measure it?)
- Lack of knowledge on how to improve soil health and fertility

Compaction and organic matter
as key factors of grassland fertility

What methods are out there to measure it?
(scientific knowledge / farmers' knowledge)

Which ones are actually used and useful?

What determines the decision to use them (or not)?

Steps of the project

Literature review on available methods

Online survey of UK farmers

In-depth interviews with selected farmers

Case studies on 3 farms to compare methods

Workshop: demonstration and feedback

Literature review: Indicators of intact and impaired soil structure

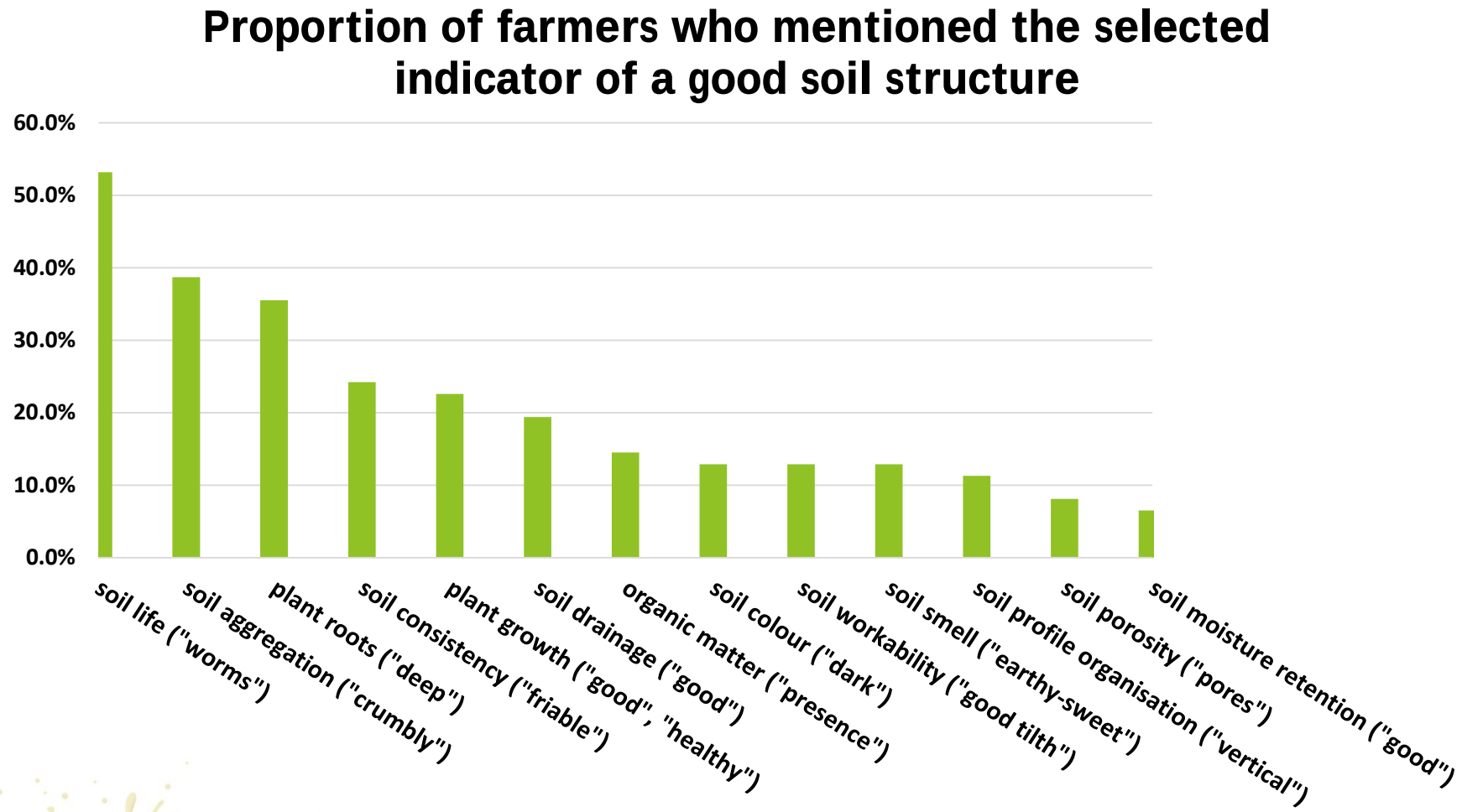
(easily identifiable (e.g. visual) for a diagnostic directly in the field)

Indicators	Significance	Indicator characteristics in an intact soil structure	Indicator characteristics in an impaired soil structure
Surface appearance	Indication of structural damage below the surface	Unbroken surface (no wheeling or poaching signs); Earthworm casts	Wheeling, poaching signs by livestock, weeds and/or low crop surface cover, water ponding, runoff pathways, surface crusting, restricted crop growth
Aggregate size, shape and porosity	Indication of soil aeration, potential drainage and root development	Small aggregates (0-10 mm); round shape, macro pores in and between the aggregates	Large or very large aggregates (5-10, >10 cm) Angular (blocky, platy) or no shape (massive); Few or no macro-pores
Aggregate consistency (moist soil)	Indication of the root pressure needed to break aggregates and soil workability	Friable (aggregates easily crushed between thumb and index finger)	Firm (noticeable pressure needed to break the aggregates)
Soil colour	Indication of soil oxydo-reduction status related to aeration, drainage and soil organic matter	Dark brown colour near the surface	Pale soil with grey-blue-green colour Presence of rusty coloured mottles, and/or black mottles
Soil smell	Indication of soil aeration and drainage	Sweet earthy smell	Sulphur smell (rotten eggs)
Roots	Indication of the potential effect of soil structure on roots	Smooth, cylindrical shape, even spatial distribution	Stubby, gnarled shape, restricted to the surface or clustered in pores or cracks, absence of root hairs
Earthworms	Indication of the potential effect of soil structure on soil fauna (represented by earthworms; the inference is that if earthworms are present, other less discernible fauna is present).	Presence and number of earthworms, earthworm burrows and cast material on the surface. Diversity of ecological classes (epigeics, endogeics, anecics)	Absence or reduced number of earthworms, earthworm burrows, cast material on the surface Reduced diversity of ecological classes (epigeics, endogeics, anecics)

Literature review: Methods to assess soil structure

	Topsoil observation					
	Visual Evaluation of Soil Structure (VESS)	**Healthy Grassland Soils (HGS)** *inspired of the VESS*	**Trierer Soil Quality Test**	**Visual Soil Assessment (VSA or "drop test")**	**Visual Soil Assessment - fast (VSA-fast)**	**Peerklamp scoring**
References	(BALL et al., 2011)	(EBLEX-DAIRYCO, 2014)	(RUF et EMMERLING, 2014)	(SHEPHERD, 2000)	(McGARRY, 2006)	(INRA, 2005)
Sampling						
Assessment depth	Topsoil (0-25 cm)	Topsoil (0-30 cm)	Topsoil (0-30 cm)	Topsoil (0-20 cm)	Topsoil (0-40 cm)	Topsoil (0-25cm)
Labour input	Low	Low	Low	Low	Low	Low
Time input for caracterisation	Medium	Medium	Low	Medium	Low	Medium
Cost	Low	Low	Low	Low	High (active Organic C field kit)	Low
Knowledge required	No	No	No	Yes (botannical knowledge for the plant indicators)	No	No
Repetitions number	10 in an area of uniform crop or soil color or where there is a problem	No information	1 or 2 if there is a slope (top and bottom)	3 to 4	1 in representative areas, depending on the reason for the investigation	Minimum 10, up to 20 to enable statistical comparisons between land units
Caracteristics						
Textural qualifier	No	No	Yes	Yes	Yes	Yes
Distinguish layers	Yes	Yes	No	No	Yes	Yes
Indicators assessed	**Soil indicators**: - Structure quality / consistence - Size, porosity, strength and shape of aggregates - Number an distribution of roots - Aggregate fragmentation 1,5-2cm (shape, porosity, roots and easily break up) - Anaerobism: Pockets or layers of grey soil, smell of sulphur, ferrous ions, - color,	**Soil indicators**: - Structure quality / consistence - Size and appearance of aggregates - Visible porosity and roots - Anaerobism (red-orange mottling, roots shape, worm channels, sulphur smell, grey color)	**Soil indicators:** - Organic residues (mulch layer) - Erosion, - Penetration rate, - Worm casts, - Root penetration - Humus, - Aggregate stability	**Soil indicators** : - Structure and consistence - Porosity - Colour - Number and colour of soil mottles - Earthworm counts - Surface relief **Plant indicators** - Pasture composition - Pasture growth and regrowth - Pasture utilisation - Area of bare ground Drought stress - Surface ponding - Stock carrying capacity and fertiliser use	**Soil structure indicators** : - Presence/degree of tillage pan - Aggregate size distribution - Earthworms - Diameter and development of roots - *Type, size, consistency of aggregates* - *Soil texture* - *Soil colour* **Soil measurements** : - Slaking and dispersion - Soil pH - Water infiltration - Organic carbon (labile)	**Soil indicators** : - Aggregate size, shape, porosity, stability and strenght - Anaerobic zones

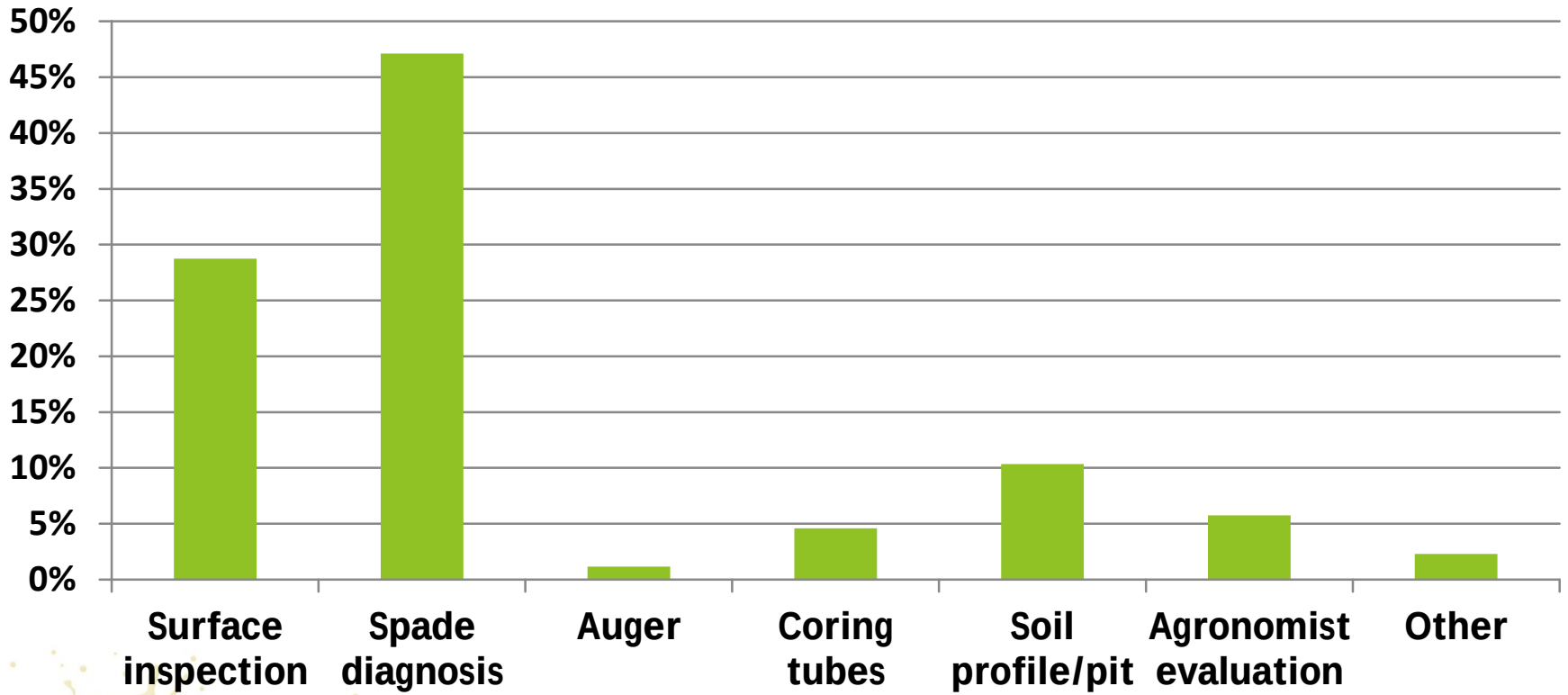
Online survey and interviews



[Capron C., 2015]

Online survey and interviews

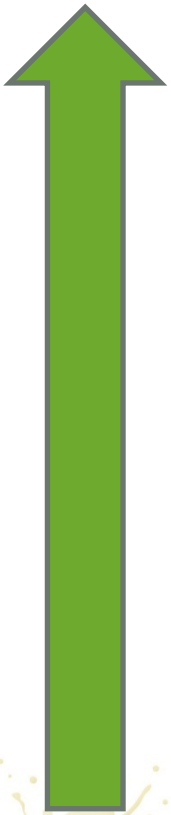
Proportion of answers for the use of certain soil structure assessment methods



[Capron C., 2015]

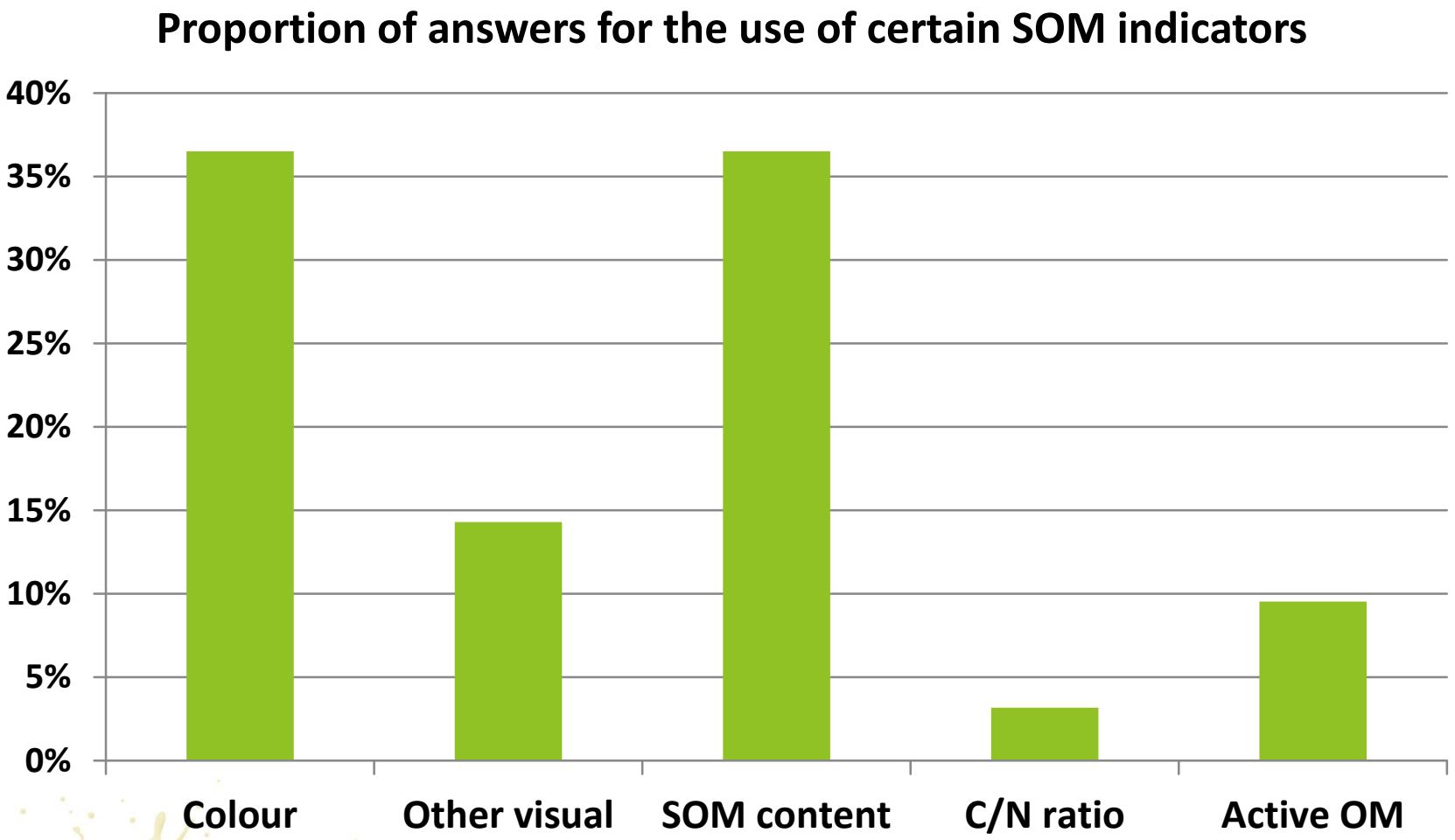
Indicators of SOM

Three fractions of SOM are usually described
(stages of decomposition, breakdown time, function etc.)



- **Labile SOM:**
  - energy and nutrients for soil micro-organisms
  - release of nutrients for plant use
  - most sensitive to changes.
- **Stable SOM:**
  - less decomposable
  - cation exchange capacity
- **Inert SOM:**
  - least reactive OM fraction
  - products of humification most resistant to min.
  - affecting the physical properties of the soil

Online survey and interviews



[Capron C., 2015]

Online survey and interviews

- Farmers' indicators of soil structure **generally match** scientific indicators
- Farmers' experience and monitoring of **their own land** is a complementary source of information
- The **spade diagnosis** (cheap, quick, reliable) is commonly used
- However 17.7% of farmers **never assess** SS, 50% of farmers use <3 indicators, 16.7% only look at the surface
- A high proportion (30.6%) of farmers **never assess** their SOM
- Active SOM indicators are **not popular**, no difference in their use compared to Total SOM indicators

Case studies on 3 farms

Based on the results of the online survey as well as the follow-up interviews

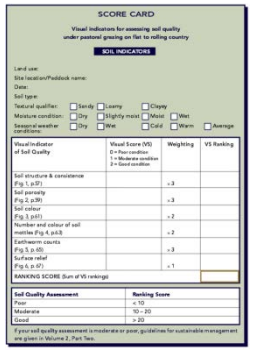
- **3** farms were identified to compare
- **3** different soil assessment tools in practice

(One horticulture and two dairy farms)

Case studies on 3 farms

Visual Soil Assessment (VSA); (SHEPHERD, 2000)

- Aimed at soil quality under pastoral grazing
- "**drop test**" to break aggregates
- Rates aggregate size distribution, soil porosity, soil colour, presence/quantity of mottles, earthworms and surface relief


SCORE CARD

Visual indicators for assessing soil quality under pastoral grazing on flat to rolling country

SOIL INDICATORS

Land use:
Site location/Paddock name:
Date:
Soil type:
Textural qualifier: ☐ Sandy ☐ Loamy ☐ Clayey
Moisture condition: ☐ Dry ☐ Slightly moist ☐ Moist ☐ Wet
Seasonal weather conditions: ☐ Dry ☐ Wet ☐ Cold ☐ Warm ☐ Average

Visual Indicator of Soil Quality	Visual Score (VS) 0 = Poor condition 1 = Moderate condition 2 = Good condition	Weighting	VS Ranking
Soil structure & consistence (Fig 1, p37)		x 3	
Soil porosity (Fig 2, p39)		x 3	
Soil colour (Fig 3, p41)		x 2	
Number and colour of soil mottles (Fig 4, p43)		x 2	
Earthworm counts (Fig 5, p 45)		x 3	
Surface relief (Fig 6, p 47)		x 1	
RANKING SCORE (Sum of VS rankings)			

Soil Quality Assessment	Ranking Score
Poor	< 10
Moderate	10 – 20
Good	> 20

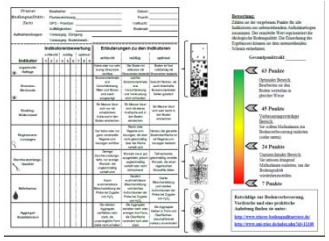
If your soil quality assessment is moderate or poor, guidelines for sustainable management are given in Volume 2, Part Two.

Healthy Grassland Soils (EBLEX-DAIRYCO, 2014)

- Aimed at grassland soil evaluation
- Rates size, shape, and appearance of aggregates, soil porosity, root growth, soil smell and colour, and earthworms

Trierer soil quality test (RUF and EMMERLING, 2014)

- So far only available in German
- Hands-on approach and uncomplicated steps
- Rates organic mulch layer, erosion signs, penetration resistance, earthworm casts, root dev., nutrient humus, aggregate stability



Case studies on 3 farms

Horticulture Farm	Mean BD (g/mL) per field	Mean HGS score	Soil structure qualification	Mean VSA score	Soil structure qualification	Mean Trier score	Soil structure qualification
Best field	1.19	1	Good : Friable	22	Good	50	Optimal
Worst field	1.23	2	Good : Intact	16	Moderate	41.5	Correct

Dairy Farm n°1	Mean BD (g/mL) per field	Mean HGS score	Soil structure qualification	Mean VSA score	Soil structure qualification	Mean Trier score	Soil structure qualification
Best field	1.06	1.2	Good : Friable	15.7	Moderate	44	Correct
Worst field	1.15	3	Moderate : Firm	11.7	Moderate	38	Correct

Dairy Farm n°2	Mean BD (g/mL) per field	Mean HGS score	Soil structure qualification	Mean VSA score	Soil structure qualification	Mean Trier score	Soil structure qualification
Best field	1.27	2	Good : Intact	16.5	Moderate	44	Correct
Worst field	1.32	3.9	Poor : Compact	9.8	Poor	41	Correct

[Capron C., 2015]

Case studies on 3 farms

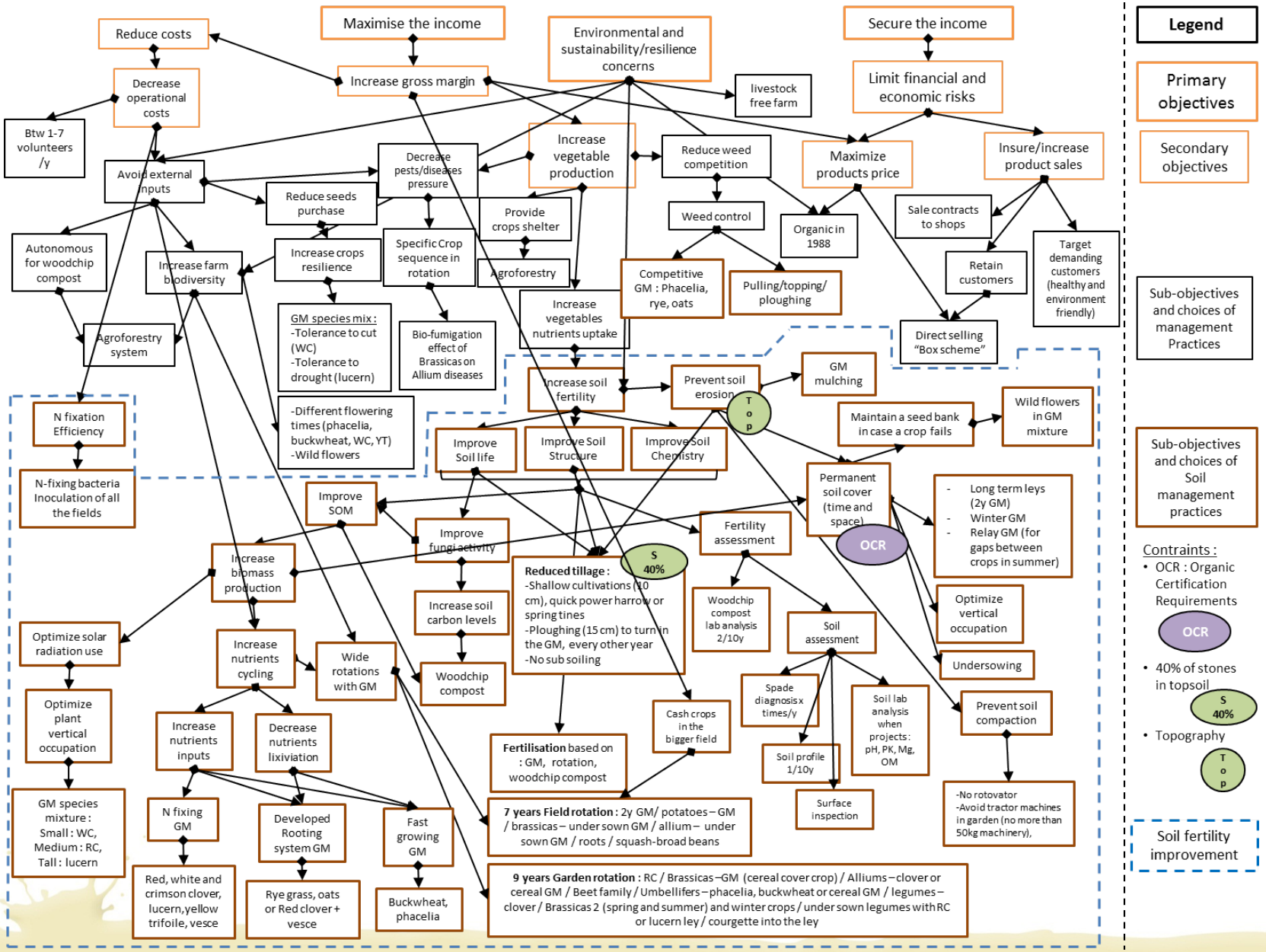
- Visual soil assessment methods identified a difference in SS
- However, the SS qualification didn't change with the change in score for VSA (1/3) and Trier (2/3); reasons?:
  - the HGS has a more sensitive scoring system
  - Higher number of repetitions for HGS and VSA
- HGS tends to overvalue SS; reasons?:
  - Earthworm counts in the scoring system of Trier and VSA

The studies were conducted in August (temperature, moisture…)

Limiting factors for farmers to assess soil

1=not a limiting factor, 5=highly limiting factor

Limiting factor	Score
Time (to take samples, conduct the test, interpret the results…)	2.9
Cost (to purchase test and equipment, labour…)	2.6
Knowledge (how to correctly conduct the test, interpretation of results…)	4



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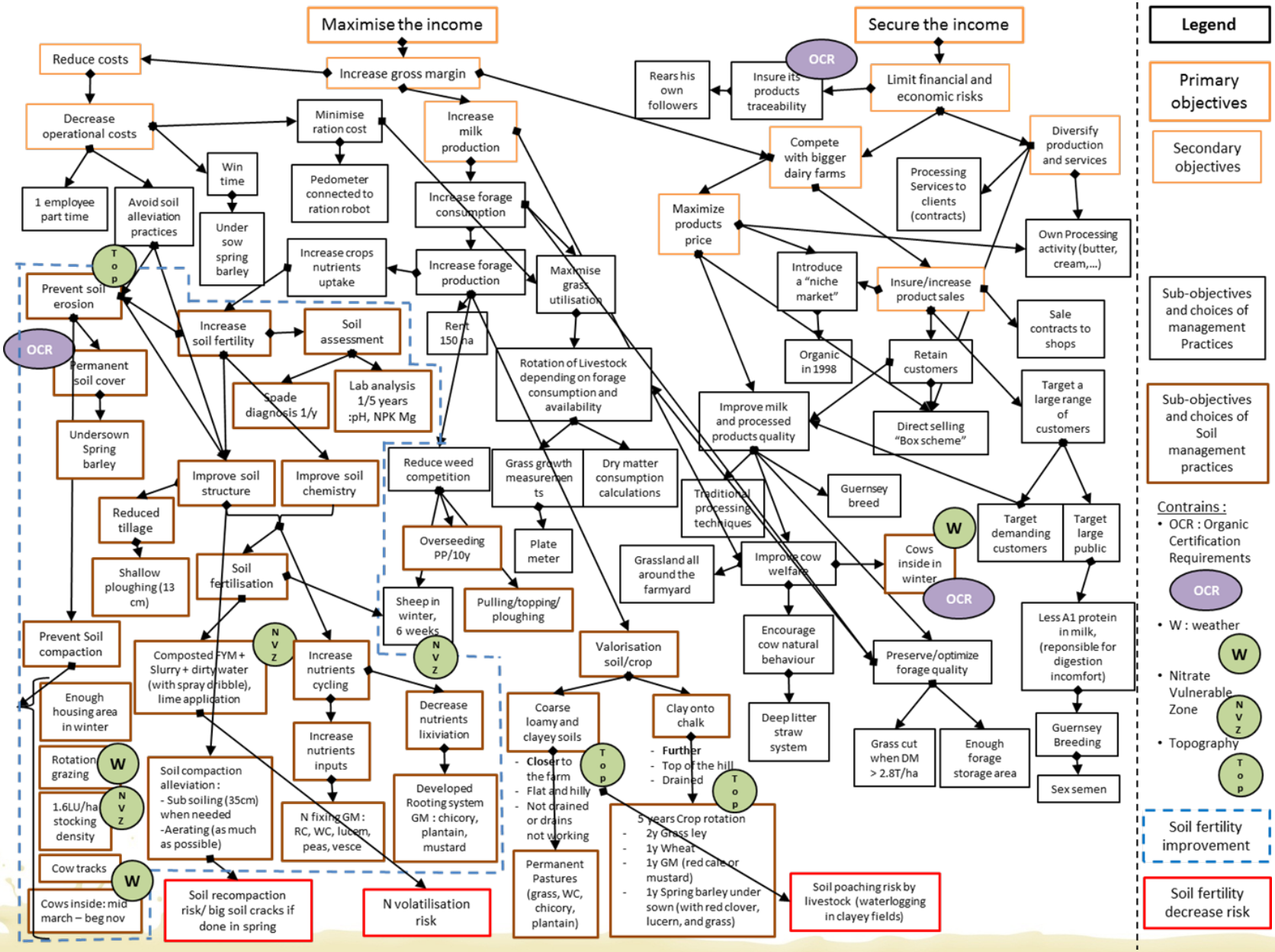

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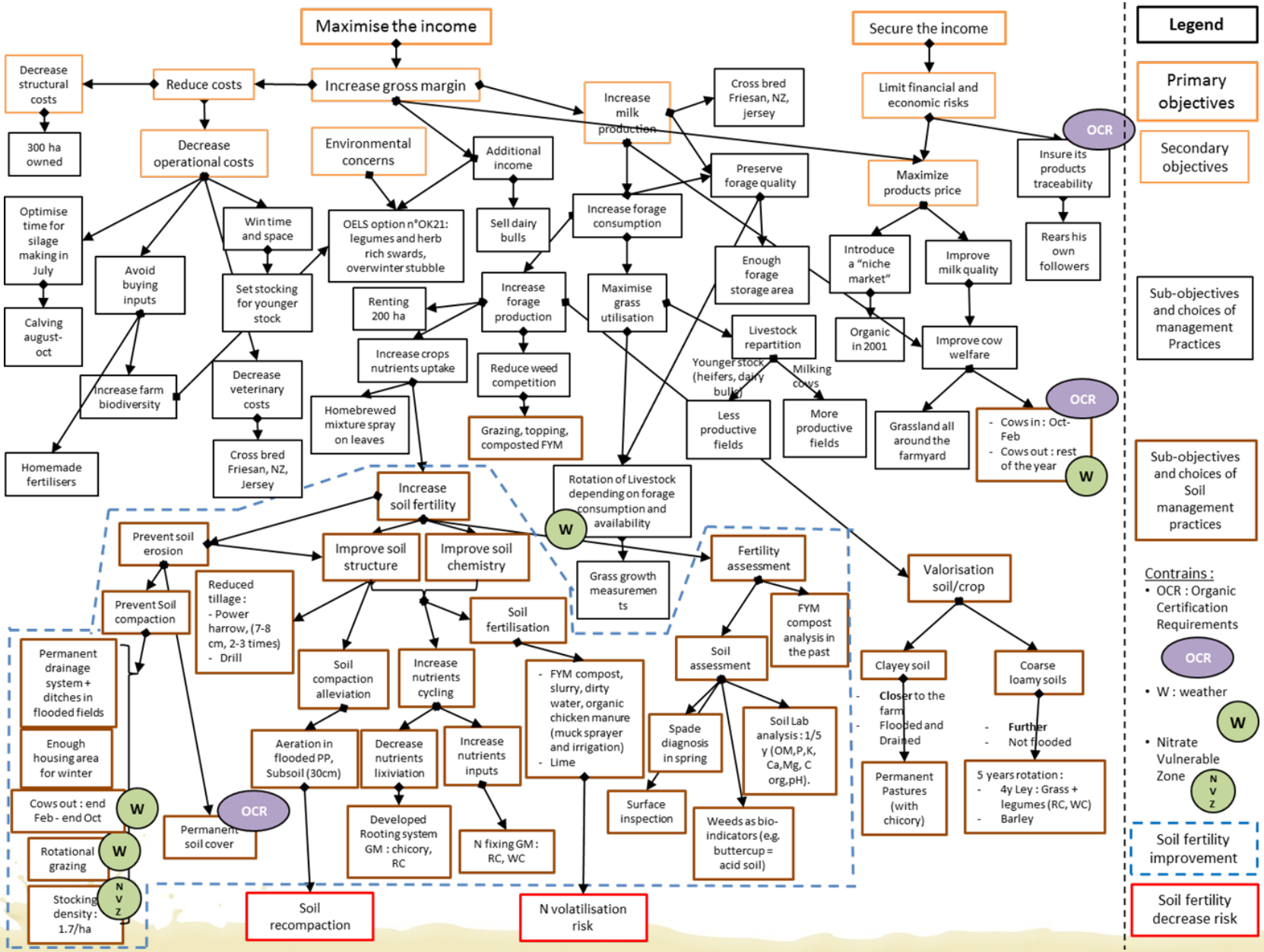

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SOLID Farmer workshop

Overall conclusions

- Farmers confirmed: **knowledge is a limiting factor** to assess and manage their soils
- Other determinant factors: inherent soil properties, production system characteristics, dependance on a third party

Farmers can improve their SS and SOM assessment

- A range of methods: Scoring system, Reference points (subjectivity and consistency), Repetition (representability of SS variability)
- Support of an advisor (subjectivity, interpret the results)
- Repeat assessment over time (monitoring) to develop experience-based indicators

Thank you

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