THE EU PUTS SOILS ON THE RESEARCH AGENDA: NOW WHAT?

Johan Bouma
em.prof soil science
Wageningen University

This presentation represents the opinion of the author and does not reflect conclusions and recommendations of the "Soil health and Food" Mission Board of "Horizon Europe 2021-2027"of which the author is a member.

The five Mission Boards of “Horizon-Europe”, 2021-2027.

(overall budget appr. 100 billion €)

1. cancer
2. adaptation to climate change
3. healthy oceans, seas, coastal and inland waters.
4. climate-neutral and smart cities.
5. **soil health and food.**

EU: Missions make a real difference in the lives of citizens and society as a whole. They boast the impact of EU-funded research and innovation by having ambitions , measurable and time-bound goals around issues that affect citizen’s daily lives.

The critical interim evaluation of the previous research program H2020 (2013-2020), chaired by Pascal Lamy found that “horizon Europe”(2021-2027) should:

1. make it easier for citizens to understand the value of investments in research and innovation.
2. maximise the impact of investments by setting clearer targets and expected impact when addressing global challenges.

Why attention for soils?

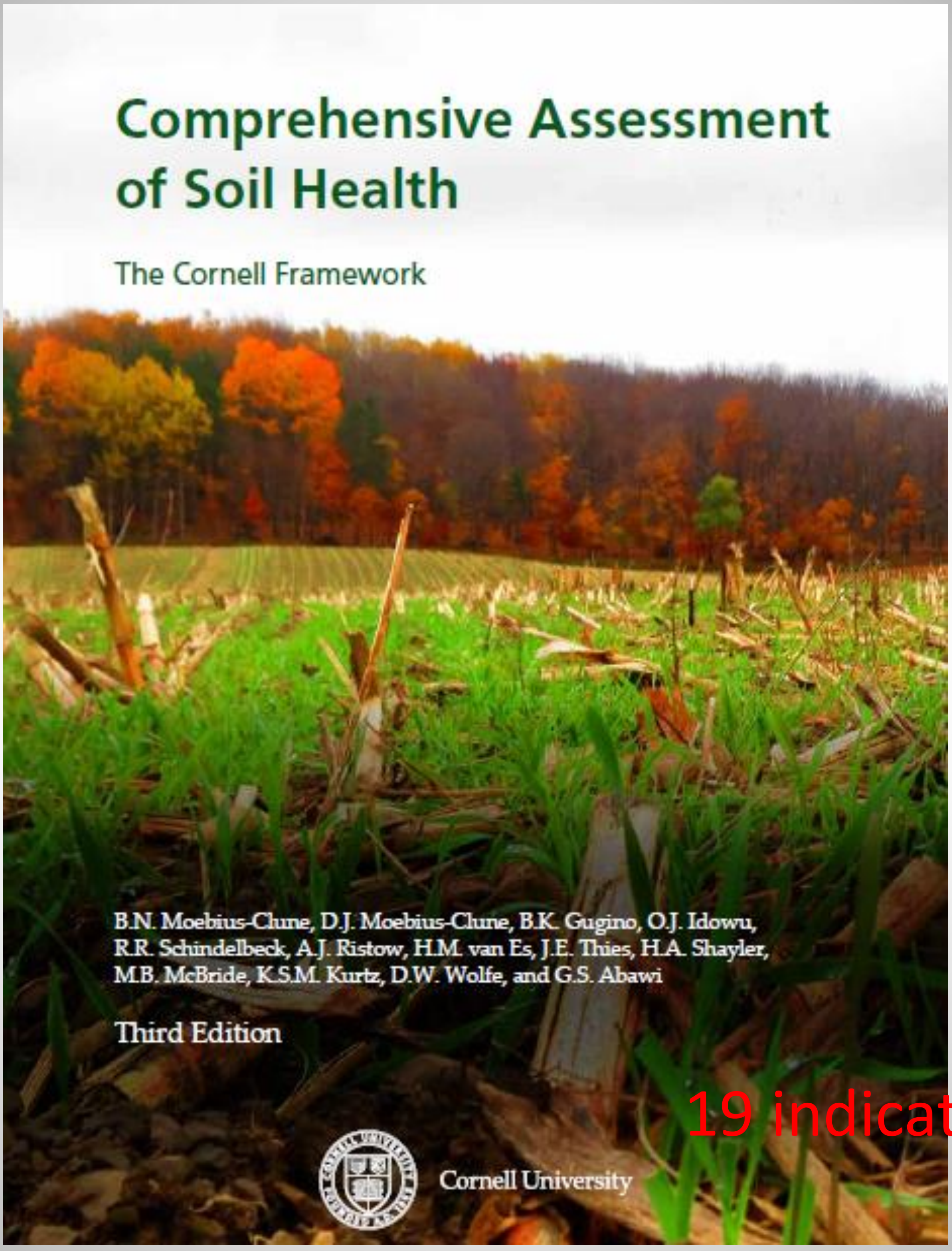
So far, environmental attention has been primarily been focused on water, climate and nature. In contrast to plants and animals, soils are invisible and therefore less the object of cuddling. The weather is directly experienced. But the need to protect soils is increasingly obvious also in the policy arena.
Threats to soil health have been pointed out repeatedly: erosion, contamination, loss of organic matter and biodiversity, compaction, salinisation, subject to floods and landslides and sealing by roads and housing.

An estimated 30% of soils of the world are degraded, has been reported many times. So?

Much research in the USA on Soil health:

1. Cornell University was the pioneer.
2. The National Soil Health Institute in North Carolina
3. The US Dept.of Agriculture.

USA: Soil Health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.



19 indicators.

Us – Soil Health Institute https://soilhealthinstitute.org/abo

SOIL HEALTH INSTITUTE

LEADERSHIP & TEAM

31 indicators

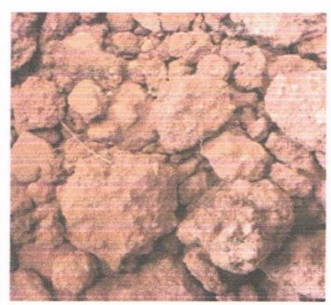
USDA United States Department of Agriculture

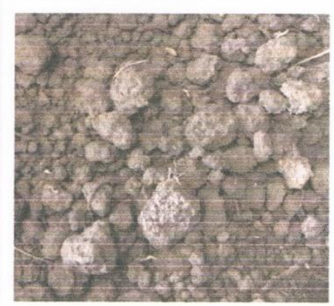
Natural Resources Conservation Service

May 2019

Soil Health
Technical Note No. 450-03

Recommended Soil Health Indicators and Associated Laboratory Procedures





11 indicators

Date Sampled: 03/11/2015

Agricultural Service Provider:
Mr. Bob Consulting
rrs3@cornell.edu

Given Soil Type:	Collamer silt loam
Crops Grown:	WHT/WHT/WHT
Tillage:	7-9 inches

Measured Soil Textural Class: **silt loam**

Sand: **2%** - Silt: **83%** - Clay: **15%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.14	37	
physical	Surface Hardness	260	12	Rooting, Water Transmission
physical	Subsurface Hardness	340	35	
physical	Aggregate Stability	15.7	19	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
biological	Organic Matter	2.5	28	
biological	ACE Soil Protein Index	5.1	25	
biological	Soil Respiration	0.5	40	
biological	Active Carbon	288	12	Energy Source for Soil Biota
chemical	Soil pH	6.5	100	
chemical	Extractable Phosphorus	20.0	100	
chemical	Extractable Potassium	150.6	100	
chemical	Minor Elements Mg: 131.0 / Fe: 1.2 / Mn: 12.9 / Zn: 0.3		100	

Overall Quality Score: **51** / Medium

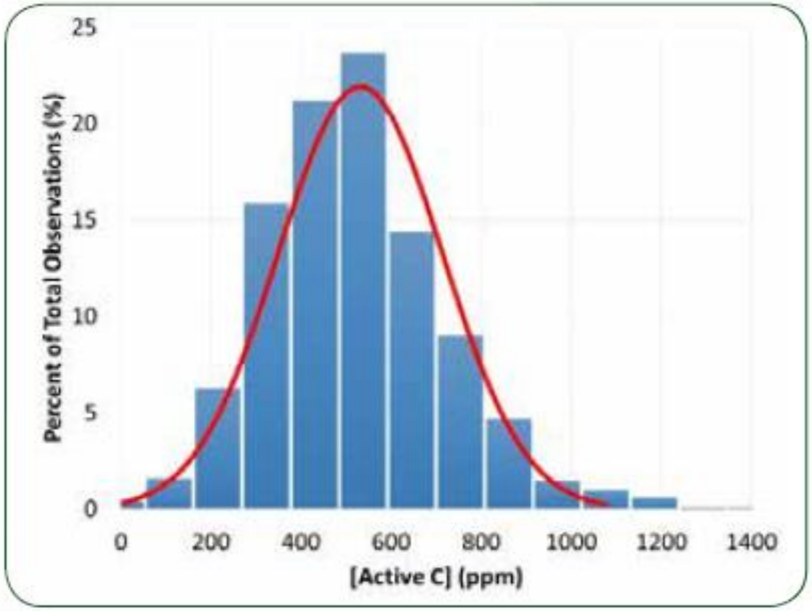


FIGURE 2.12. Example of the distribution of active carbon indicator data in medium textured soils used to determine the scoring curve.

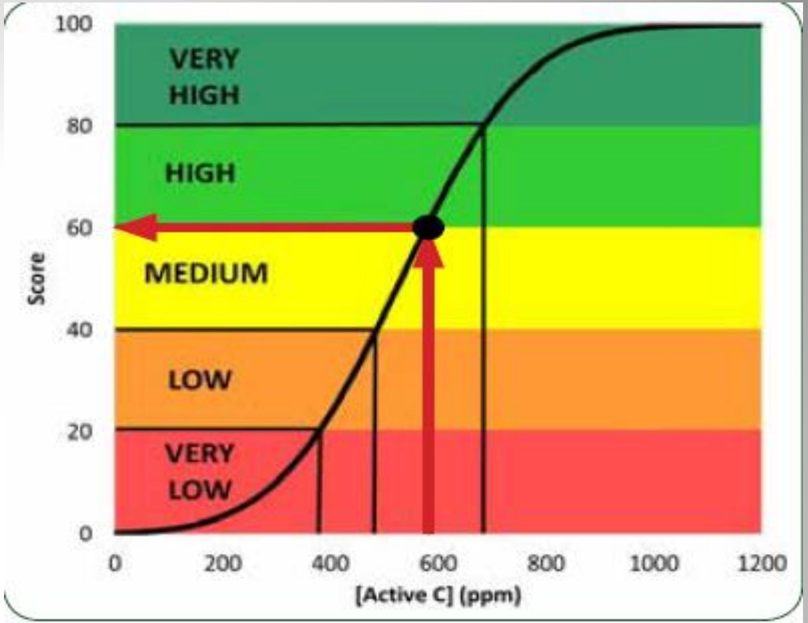


FIGURE 2.13. Cumulative normal distribution for scoring active carbon in silt soils. In this example, 60% of medium textured soil samples in the calibration set had Active C contents lower than or equal to the sample being scored.

Two questions:

1. Why just record data obtained, while critical thresholds for every soil and site is important?
2. Why only coarse, medium and fine texture? No soil classification? Soil series?

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ANTIGO SILT LOAM
STATE SOIL OF WISCONSIN
This plain was made thousands of years ago by rivers of water flowing from hills of melting glacial ice that lay a short distance north and east of here. The summer flood waters first laid down gravel, which was then covered by four feet of fertile windblown silt. The silt was slowly changed into productive soil by the action of forest roots and leaf fall. Under careful management by farmers, the soil has been further enriched since settlement and supports a versatile agricultural and forestry economy. Antigo silt loam, first identified through a resource inventory conducted in Langlade County in 1953, was named after the nearby city and occurs in areas across a dozen counties from Green Bay to Minnesota. In 1983, the Wisconsin legislature designated the Antigo silt loam as the official state soil to represent the soil resources of Wisconsin that serve as the foundation of life upon which plants, animals and human beings depend.

We have modified the US definition to focus on the UN Sustainable Development Goals (2015) signed up to by 193 governments with a committment to deliver by 2030:

EU: Soil health is defined as: the actual capacity of a specific kind of soil to function, contributing towards achieving the UN Sustainable Development Goals (SDGs).

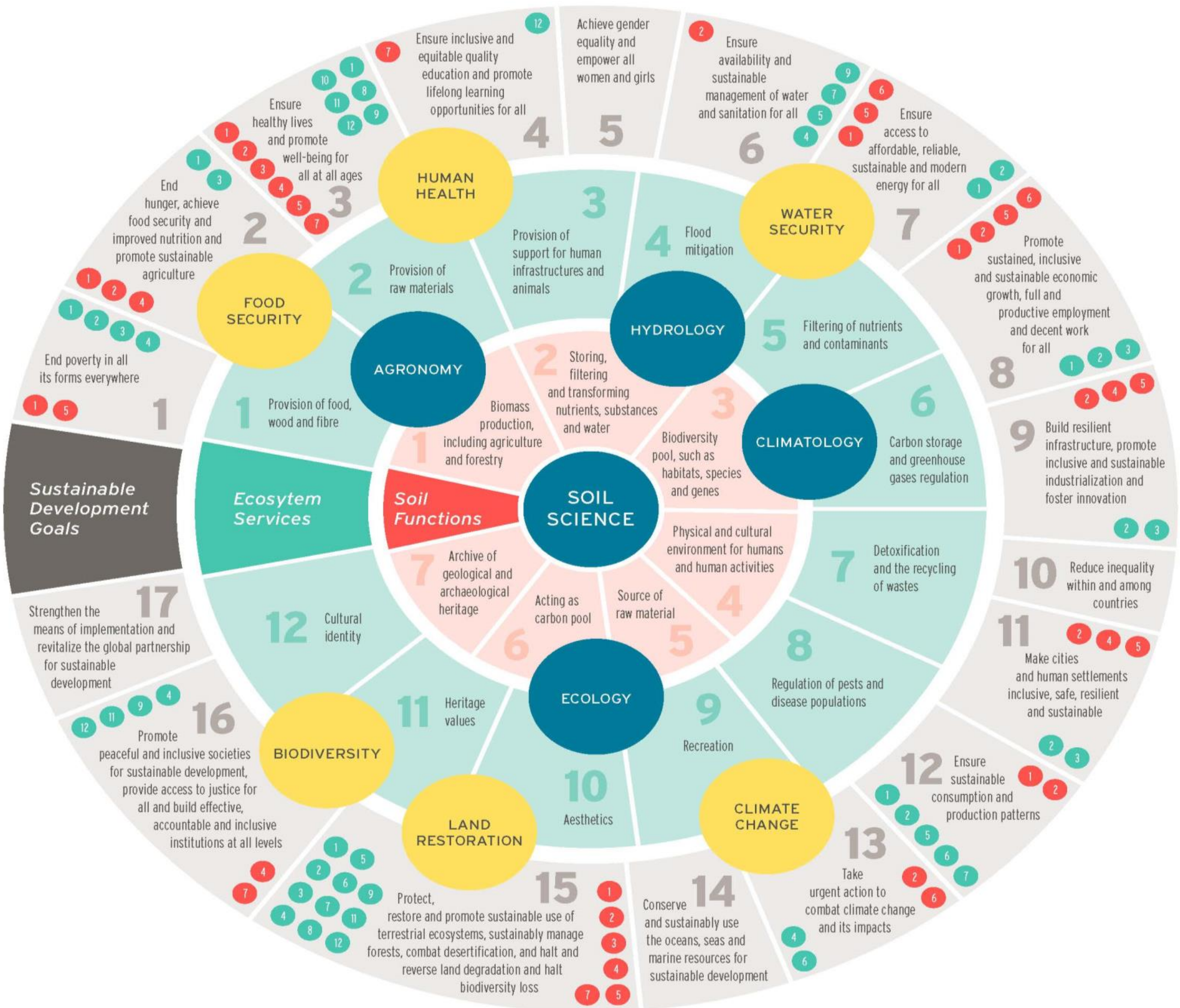
This shift has major consequences as we move out of the soil bubble and consider and judge soils as being parts of ecosystems.

The EU has now introduced the Green Deal including many area also covered by the SDGs. How the two will be merged is still to be worked out.


1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS


Mobilising research and fostering innovation
Transforming the EU's economy for a sustainable future
Increasing the EU's Climate ambition for 2030 and 2050
A zero pollution ambition for a toxic-free environment
Supplying clean, affordable and secure energy
The European Green Deal
Preserving and restoring ecosystems and biodiversity
Mobilising industry for a clean and circular economy
From 'Farm to Fork': a fair, healthy and environmentally friendly food system
Building and renovating in an energy and resource efficient way
Accelerating the shift to sustainable and smart mobility
Financing the transition
Leave no one behind (Just Transition)
The EU as a global leader
A European Climate Pact

A GRAPHICAL ABSTRACT



Soil functions (landmark program):

- **primary productivity**
- carbon sequestration
- water purification and regulation
- habitat for biodiversity
- nutrient cycling.

But soils cannot do it alone, they contribute to ecosystem services that, in turn, contribute to SDGs. This calls for considering interdisciplinarity and the role of management.

Interdisciplinary ecosystem services ,contributing to SDGs:

- Biomass production, including crops (SDG2)
- Improving ground- and surface water quality (SDG6)
- carbon capture for climate mitigation (SDG 13)
- limiting greenhouse gas emissions (SDG13)
- biodiversity protection and enhancement. (SDG15).

Untill now Soil Sciene has not contributed to the targets and indicators for the SDGs (except for SDG15). We can and should do better than that!

Bouma, J., L. Montanarella and G.E.Vanylo. 2019. The challenge for the soil science community to contribute to the implementation of the UN Sustainable Development Goals. Soil Use and Management. (doi:10.1111/sum.12518)

Sustainable development in the European Union

Monitoring report on progress towards the SDGs in an EU context

2019 edition

EUROSTAT SUPPORTS THE SDGs

eurostat

Putting soils into the SDGs. (15 proposed targets).

SDG1 NO POVERTY
Area of marginal agricultural land.
SDG2 ZERO HUNGER
Area under sustainable farming
Area subject to drought and floods
SDG3 GOOD HEALTH AND WELL BEING
Area of polluted and non polluted soils
Availability of healthy food in terms of contents of heavy metals and biocide residues
SDG4 QUALITY EDUCATION
Educational courses focusing on defining and delivering ecosystem services
SDG6 CLEAN WATER AND SANITATION
Presence of on-site wastewater treatment in absence of municipal treatment systems.

SDG7 AFFORDABLE AND CLEAN ENERGY
Area of soils used for energy-crop production. How much is marginal?
SDG11 SUSTAINABLE CITIES AND COMMUNITIES
Area of soils within city limits allowing city greening
SDG13 CLIMATE ACTION
Area of soils where active carbon capture for climate mitigation is feasible
Exploratory studies on location-specific effects of climate change on SDGs by 2100.
SDG15 LIFE ON LAND
Soil biodiversity in a landscape context.
SDG 16 Peace, justice and strong institutions.
Legislation to protect soils in landscapes with cultural or archaelogical significance **.**
SDG 17. Partnerships for the goals
Holistic policies enhancing sustainable agricultural development starting with a soil health assessment
Reduction of the EU global soil footprint..

Where does soil health fit in?

How can soil health contribute to delivering ecosystem services that also depend on input of other disciplines as well as on management practices?

Hypothesis: a healthy soil will make a higher contribution to ecosystem services than an unhealthy one.
But realize that poor management of an healthy soil can strongly reduce such contributions while also good management of an unhealthy soil can improve contributions **.**

We have defined soil health but how do we measure it? The Cornell protocol offers a procedure but does this work?

Be silent fot a change and let plant roots tell us what soil health is all about!

Conditions for optimal plant root growth define indicators for soil health:

1. Lack of chemical pollution.
2 .Adequate infiltration rate of water at the soil surface.
3. Soil structure that allows roots to penetrate the soil and reach all parts (descriptions and bulk densities).
4. Adequate supply of nutrients. (can be improved quickly)
5. Biodiversity allowing, a.o. uptake of nutrients (%C=proxy)
6. Soil moisture and temperature regimes that result in functioning roots in well aerated soil with adequate moisture supply.(estimates: e.g. drainage class or simulations)

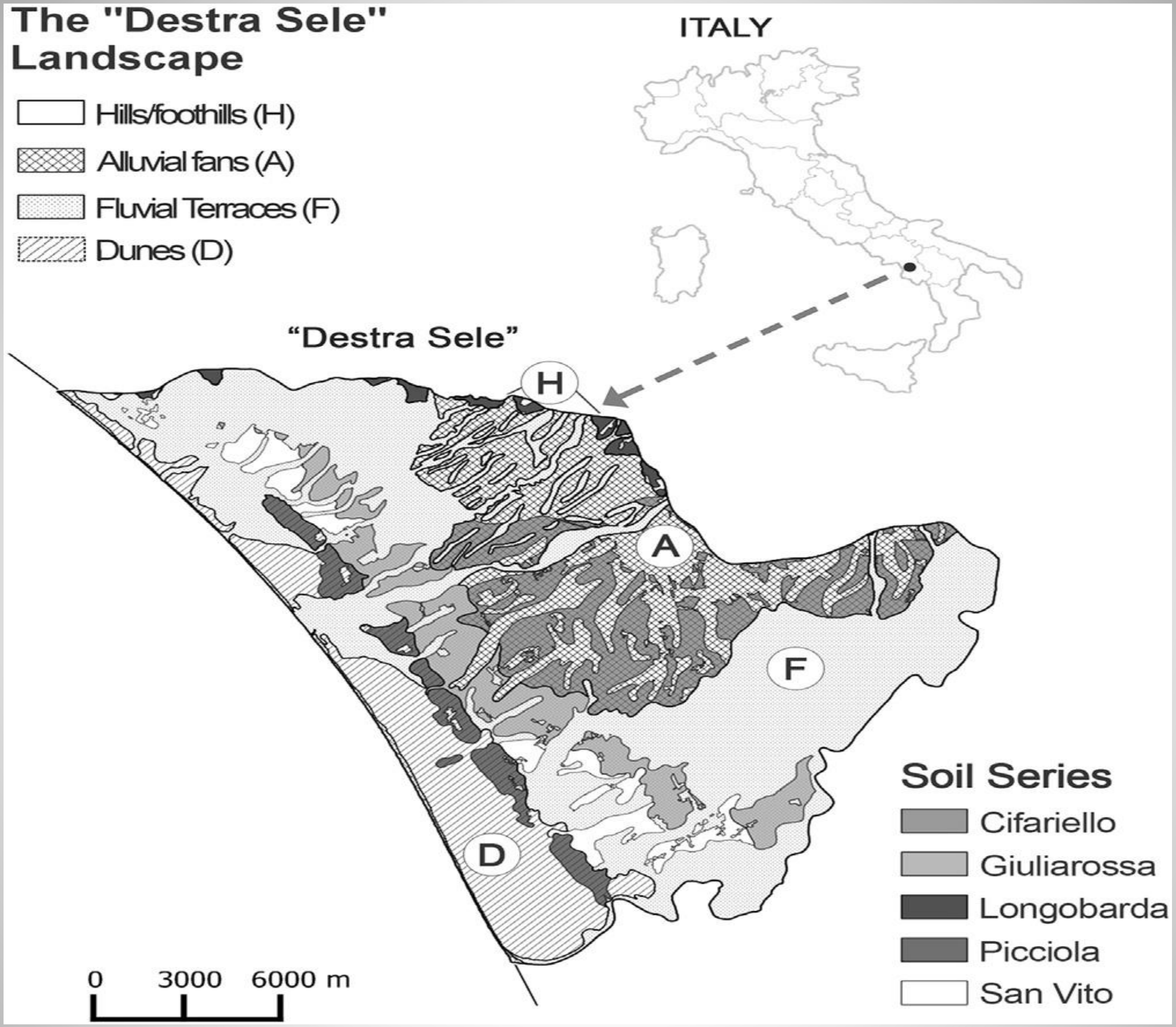
This can all be measured and thresholds should be be defined that will be different for different soils in different climate zones.

Two ways to determine a soil health index.

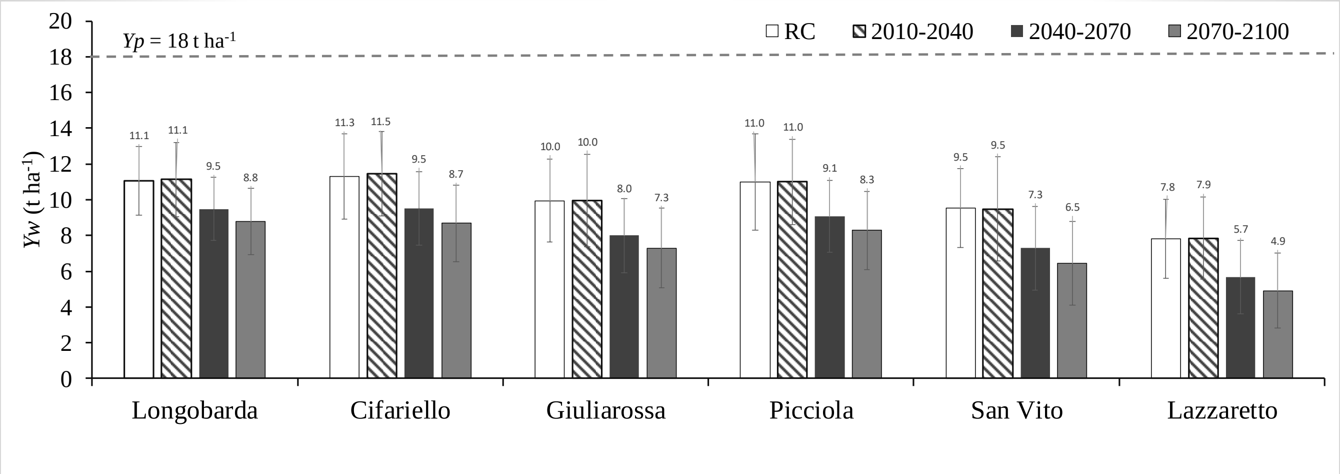
1. The Cornell method, as discussed above. Problematic, but can be improved by defining thresholds and stratify by soil type.

2. Join forces with agronomy and define absolute values for potential production (Yp) (radiation, temp., enough water/nutrients, no pests/deseases); water-limited yield (Yw) as Yp but with actual water supply and Ya (actual yield): The “Yield Gap” program (Martin van Ittersum). Modeling (being fed by the 5 mentioned indicators for soil health!) is essential in any case to explore future climate scenarios.

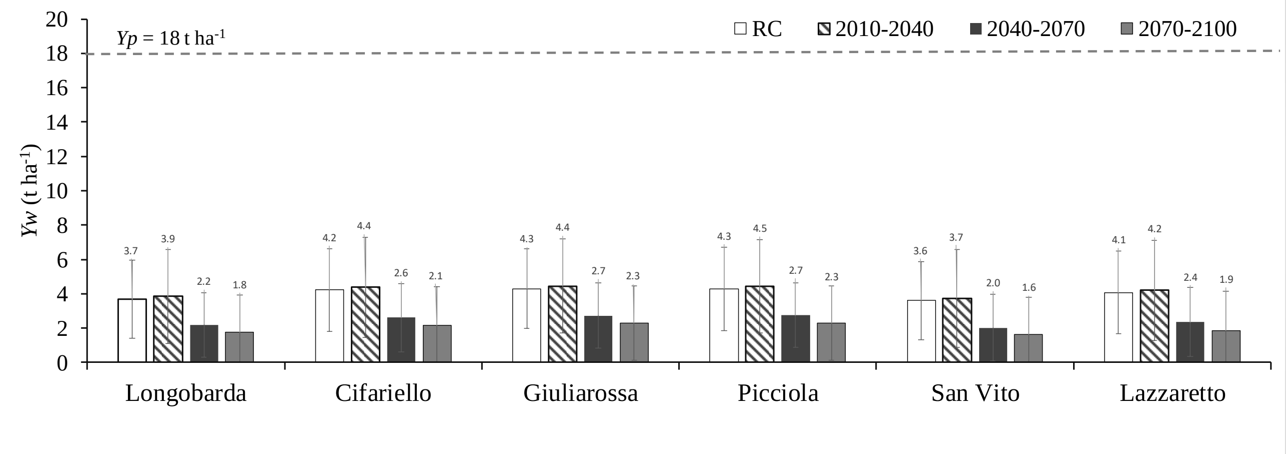
   Soil health index: (Ya/Yw) x 100.



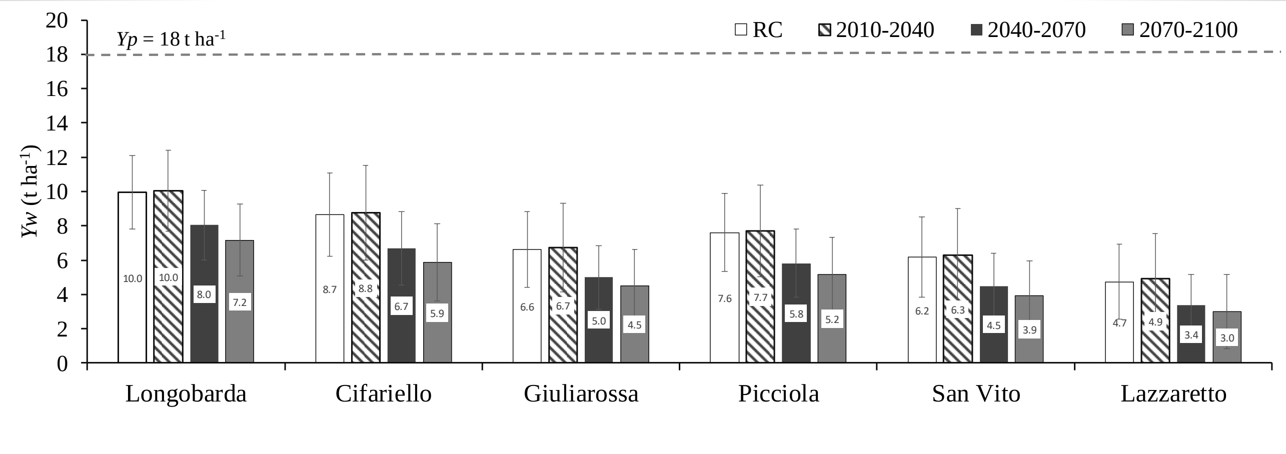
Bonfante, A. and J.Bouma. 2015. The role of soil series in quantitative Land Evaluation when expressing effects of climate change and crop breeding on future land use. Geoderma 259-260, 187-195. (http://doi.org/10.1016/j.geoderma2015.06.010)



Yw for six healthy soils expressed for four climate periods.



Yw for six unhealthy soils with a plowpan expressed for four climate periods.



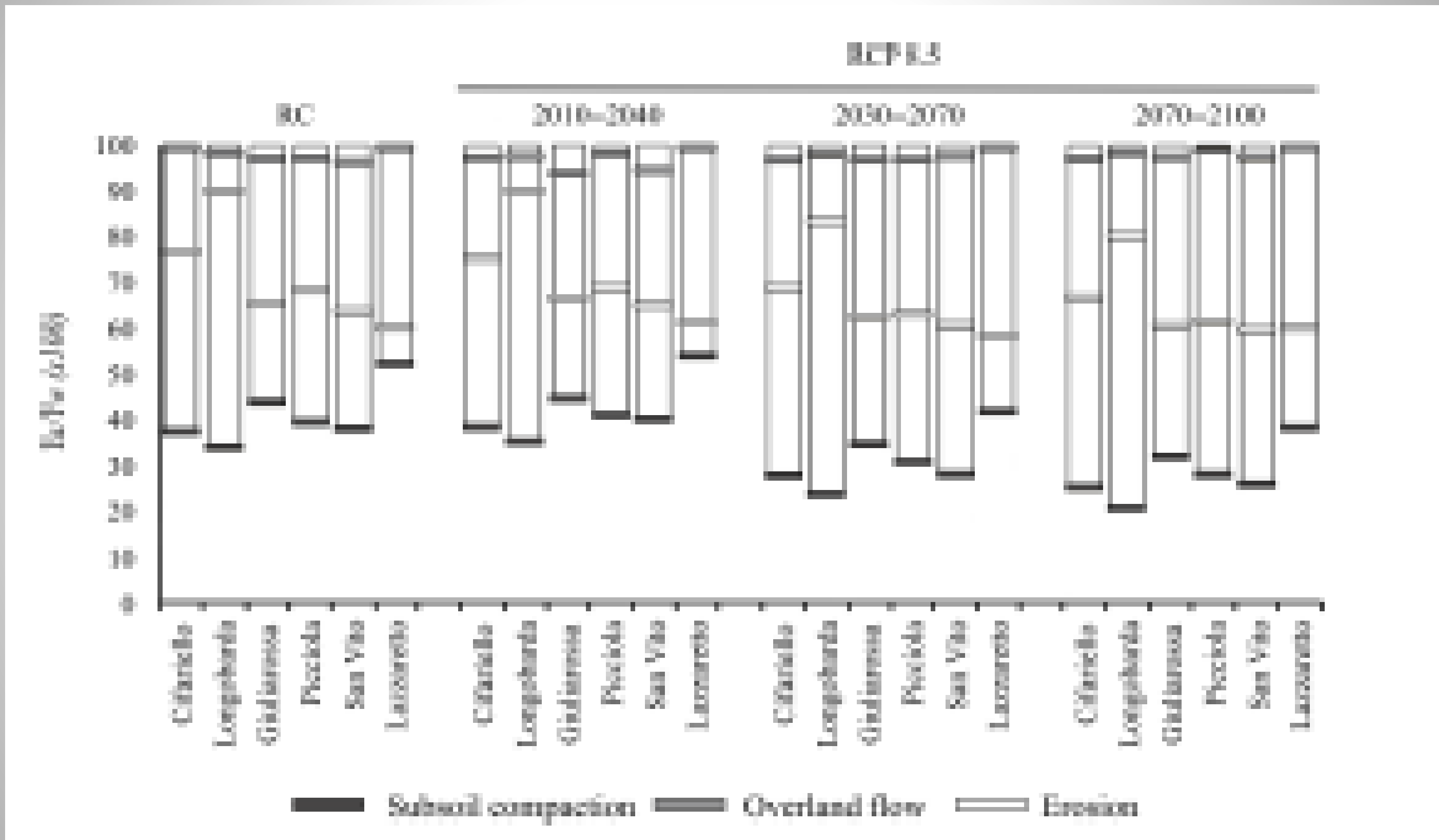
Yw for four six unhealthy soils after erosion, removing 20 cm of soil. Expressed for four climate periods.

But a sand and a clay can both be healthy, but they are still quite different in their behavior. But you can never change a sand in a clay, nor should you try!

If you are born to be a dime, you will never be a quarter!

That’s why we can propose to define soil quality as the range of soil health values that is characteristic for given soil type. This requires field work to find out the range of Ya/Yw values, refecting effects of various phenoforms. This acts as a “soilometer”: the actual Ya has a spot on this range and a number!

Soil quality is defined as the inherent capacity of a specific kind of soil to function, contributing towards achieving the UN Sustainable Development Goals (SDGs).



Bonfante, A., Terribile, F., and Bouma, J. 2019. Refining physical aspects of soil quality and soil health when exploring the effects of soil degradation and climate change on biomass production: an Italian case study. SOIL 5, 1-14. (https://doi.org/10.5194/soil-5-1-2019).

A warning: the soil science community cannot afford a repeat of the soil quality discussion:

Bünneman, E.K., G.Bongiorno, Z.Bai, R.E.Creamer, G. De Deyn, R.de Goede, L.Fleskens, V.Geissen, Th.W.Kuyper, P.Mäder, M.Pulleman, W.Sukkel, J.W.van Groenigen, L.Brussaard. 2018. Soil Quality: a critical review. Soil Biology and Biochemistry: (https://doi.ord/10.1016/j.soilbio.20178.01.030).

Recommendations:

1. Farmers and land managers did not play a role in developing soil quality criteria. This should change.
2. Soil quality is integral part of environmental quality
3. Novel soil quality tools are needed.
4. Fundamental re-design of farming systems is needed
5. Engage with UN-SDGs.

Not conclusive and: there is no measurement method so far.

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The critical interim evaluation of the previous research program H2020 (2013-2020), chaired by Pascal Lamy found that "horizon Europe"(2021-2027) should:

1. make it easier for citizens to understand the value of investments in research and innovation.
2. maximise the impact of investments by setting clearer targets and expected impact when addressing global challenges.

Three key issues deserve particular attention when addressing the policy and citizen arena’s:

1. The potential of soils to contribute to climate mitigation.

Still much discussion but let’s see which soils in which climate zones have the potential to increase %C with proper management.

Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt

4 PER 1000
CARBON SEQUESTRATION IN SOILS FOR FOOD SECURITY AND THE CLIMATE

The quantity of carbon contained in the **atmosphere** increases by **4.3** billion tons every year

+4.3 bn tons carbon / year

CO_2 emissions

Forests ⊖⊖

Oceans ⊖⊖

Human activities ⊕⊕⊕⊕

Deforestation ⊕

⊖ *absorption* ⊕ *emission*

The world's **soils** contain **1 500** billion tons of carbon in the form of organic material

absorption of CO_2 by plants

storage of organic carbon in soils

1 500 bn tons carbon

If we increase by 4‰ (0.4%) a year the quantity of carbon contained in soils, **we can halt the annual increase in CO_2 in the atmosphere,** which is a major contributor to the greenhouse effect and climate change

increased absorption of CO_2 by plants :

farmlands, meadows, forests…

+4‰ carbon storage in the world's soils

= more fertile soils
= soils better able to cope with the effects of climate change

HOW CAN SOILS STORE MORE CARBON?

The more soil is covered, the richer it will be in organic material and therefore in carbon. Until now, the combat against global warming has largely focused on the protection and restoration of forests. In addition to forests, we must encourage more plant cover in all its forms.

- *Never leave soil bare and work it less, for example by using no-till methods*
- *Introduce more intermediate crops, more row intercropping and more grass strips*
- *Add to the hedges at field boundaries and develop agroforestry*
- *Optimize pasture management – with longer grazing periods, for example*
- *Restore land in poor condition e.g. the world's arid and semi-arid regions*

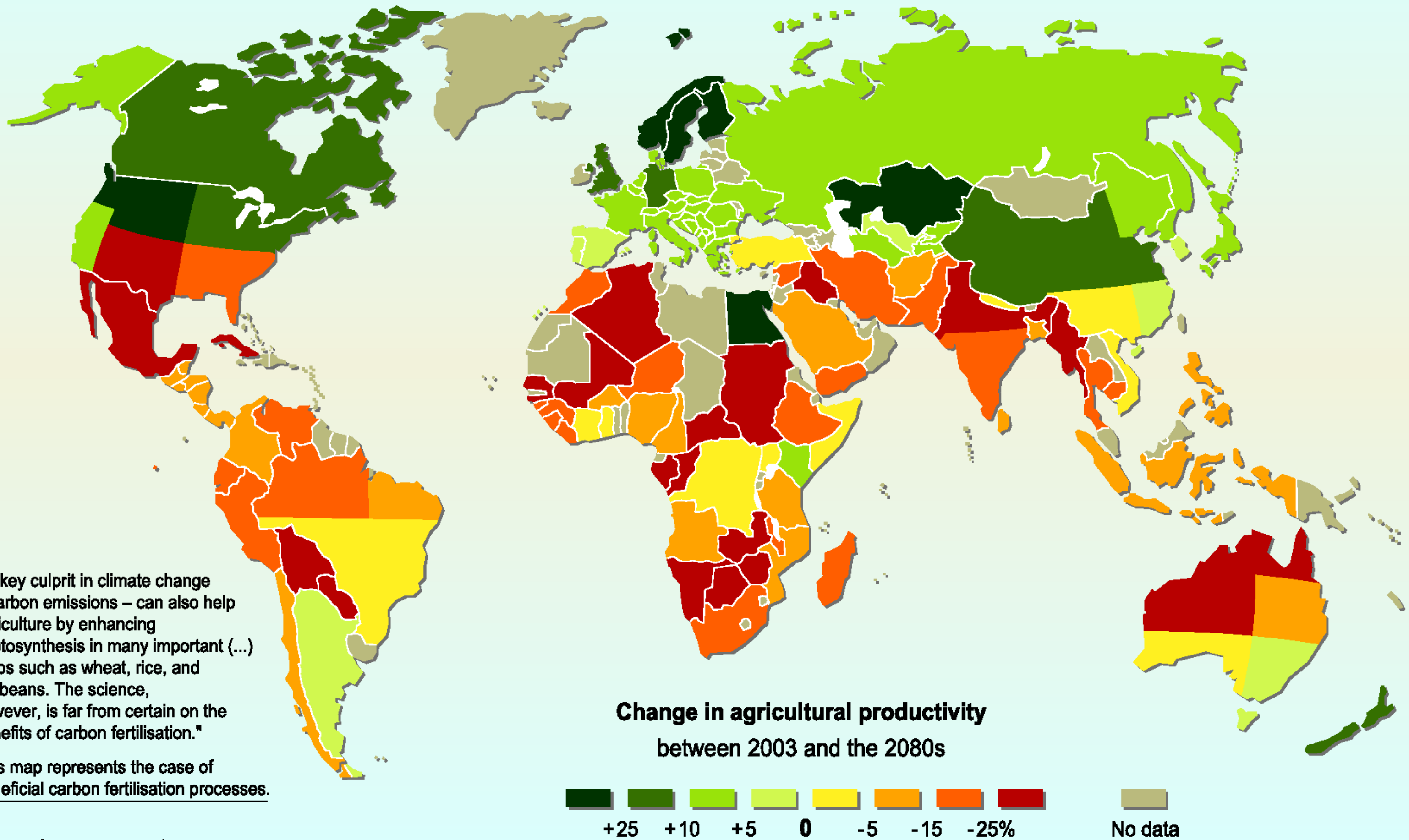
*"This international initiative can reconcile the aims of **food security** and the **combat against climate change,** and therefore engage every concerned country in COP21."*

Stéphane Le Foll, French Minister of Agriculture, Agrifood and Forestry

2. Will there be enough healthy soils in 2050 to feed 10 billion people, most of them living in cities?

Right now there is enough food in the world. Still, 825 million people are hungry due to war, Waste and poor governance and corruption. 1.2 billion people are obese! But what will be conditions in 2050? No data yet!

Projected impact of climate change on agricultural yields



" A key culprit in climate change – carbon emissions – can also help agriculture by enhancing photosynthesis in many important (...) crops such as wheat, rice, and soybeans. The science, however, is far from certain on the benefits of carbon fertilisation."

This map represents the case of beneficial carbon fertilisation processes.

Source: Cline W., 2007, *Global Warming and Agriculture*.

3. How to do research in the information society?

Realize that farmers have to act like jugglers handling five balls at the same time: make a living by producing and selling good quality products, preserve water, biodiversity and nature quality and promote climate mitigation.

Stop fragmented research and focus on the overall “system”. Avoid overly complex management and computer models: document “lighthouse” farms and let farmers tell their story!

Make measurements documenting the quality of water, air, nature and biodiversity because many unjustified claims are often being made.

(see work Rogier Schulte who also advocates emphasis on lighthouse studies).


9:41
HydraGO Battery
HG000001 100%
Location
Keith's Soil Lab
Sample Time 2018/09/05 13:20:45
Soil Moisture 34.20 %
Surface Temperature +26.4 C
Bulk EC (TC) 0.61 S/m
Pore Water EC 1.81 S/m
Raw Real Dielectric +22.876
Loss Tangent 0.98
Latitude 45.568673
Longitude -122.535929
SAMPLE
SAVE
HydraGO
Portable soil sensor
pplications: agriculture, scientific
esearch, watershed management,
reenhouses, ground-truthing, soil
uality assessments, soil surveys.


PICARRO
PRODUCTS SOLD
GREENHOUSE GAS AND TRACE GAS ANALYZERS


PP SYSTEMS
TARGAS-1


CIRAS-3


NEW YORK

What to do now?

1. Select interesting “lighthouses” in major soil and climate areas, covering farms, nature areas and city greens.
2. Determine, by applying threshold values, how well ecosystemservices are provided by making **measurements** of production levels, water quality, carbon capture, greenhouse gas emissions and biodiversity.
3. Define soil types and check soil health by applying thresholds of five indicators. If “unhealthy”:
4. Determine how soil health can be improved by soil management,studying results obtained in comparable lighthouses and what is reported in literature.
5. Explore how soil health of any given soil in any given climate zone,will react to climate change.

And lets ask all of those that work with soil, such as farmers, other land users and politicians whether or not they feel that the soil health concept can help them to do a better job!

Avoid that the ”soil health” circus will remain a top-down concept that does not register with the people that have to do the real work! No need for more white-elephants!

To answer this we have initiated a WU student challenge:”Make all soils healthy again”. (http://wur.eu/soilchallenge)

Three questions:

1. What is soil health and how can it be measured?

2. How can land users and policy makers use soil health information to do a better job?

3. What are effective ways of communicating soil health to a wider audience (general public)?

PEDOLOGISTS OF THE WORLD UNITE!!