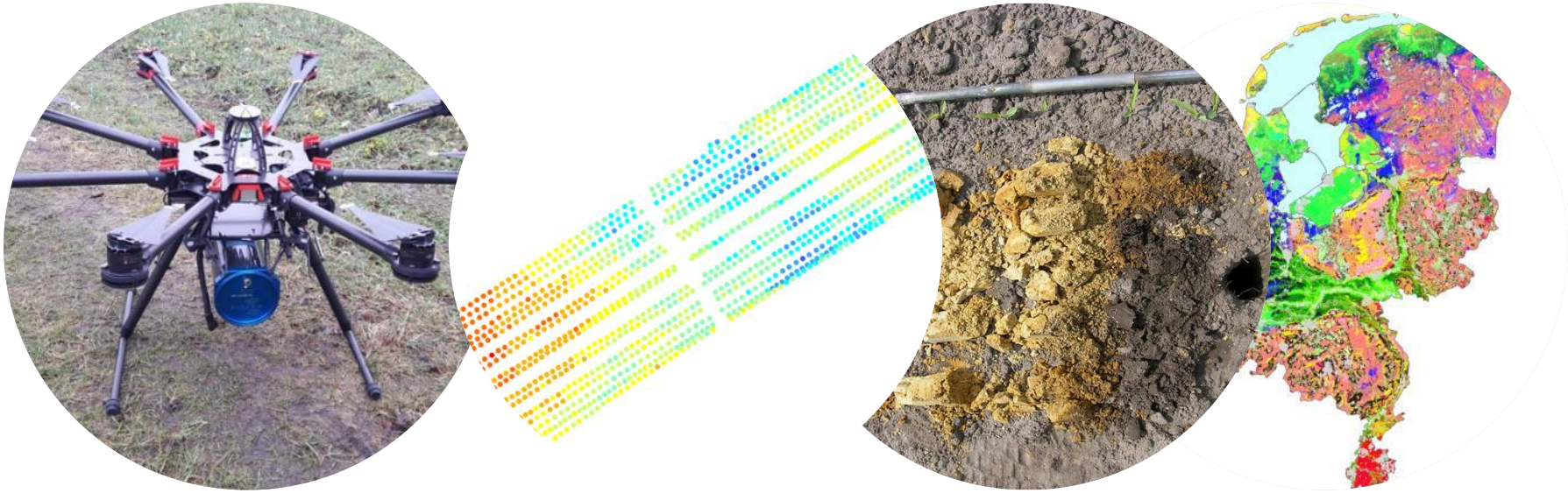
Structured Procedure for Selection of Suitable Soil Data Acquisition Techniques

30 May 2019, Martin Knotters and Fenny van Egmond



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Why do we need a structured approach?

- To identify discrepancies between information (user) need and availability
- To select methods for additional data collection in an efficient and cost effective way

Why do we need a structured approach?

To identify discrepancies between information need and availability:

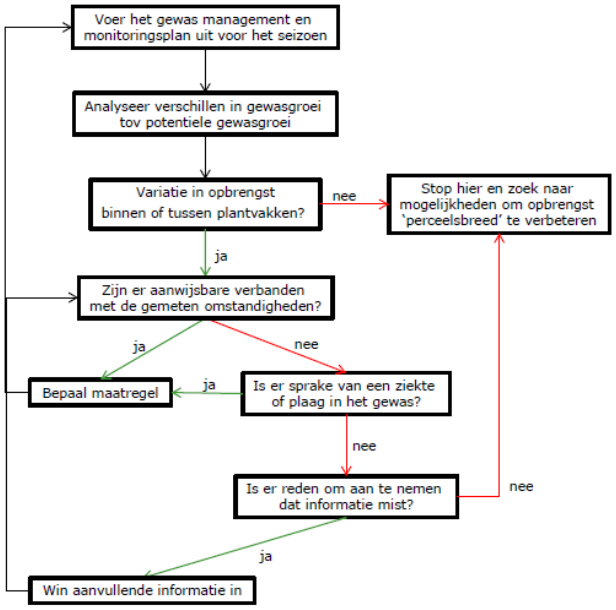
- **What information** is needed to answer the question?
- **Which question**: direct, indirect and multiple questions
- Is the information **presented in a user ready** form?
- **Cost efficiency**: start with existing information
- Many **more types of data** are (or can be) more readily available
- Data available at different **scales, accuracies**

- **To prove the relevance of soil data**

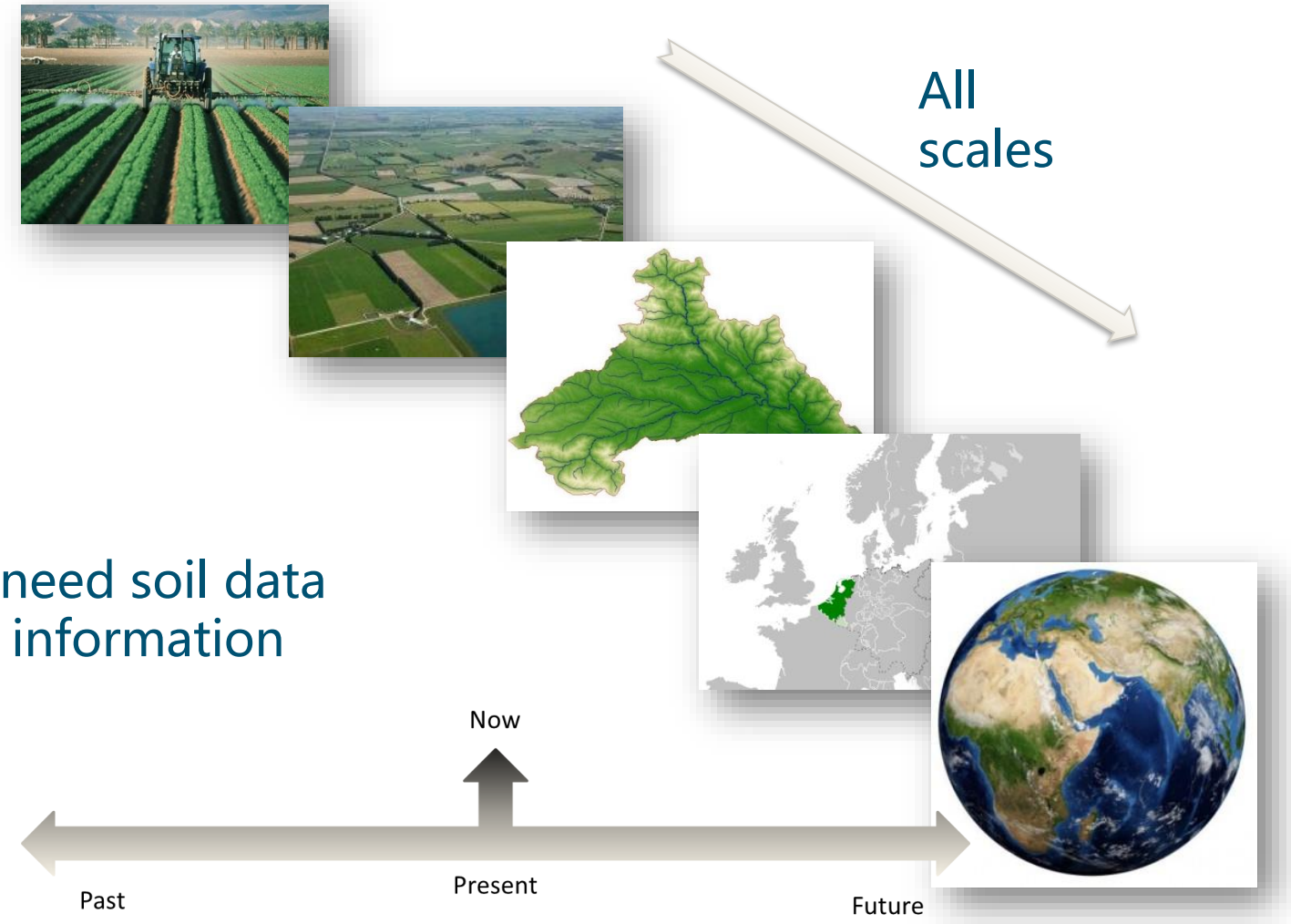
Why do we need a structured approach?

To select methods for additional data collection in an efficient and cost effective way:

- **Question** instead of technique **oriented**
- Choice often based on **expert knowledge, availability** (, interest)
- What is the trade-off between **accuracy and quantity**
- Many **techniques** and **covariate** data more readily available from various **platforms**
- **Cost efficiency** for governmental and commercial clients
- **Objective** and **consequent** method in team



Methods applicable at all scales



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Slide courtesy: Peter Wilson (CSIRO)

Information need versus availability

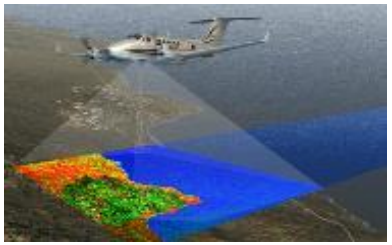
Method by De Gruijter et.al. (2006)

- Target universe (outer boundaries)
- Domain of interest (more precise)
- Target variable (qualitative or quantitative)
- Target parameter (type of statistic)
- Target quantity (combination of domain, variable and parameter)
- Type of result (qualitative or quantitative, eg. (degree of) compliance)
- Accuracy measure:
    - Eg. standard error, confidence interval etc.
    - % correctly classified
- Accuracy requirement (threshold)

How to bridge the gap?

- Data search or mining
- Up- or downscaling maps
- Making derived maps (functions, properties)
- Acquiring new information:
    - Landscape analysis based soil mapping
    - Geostatistical soil sampling or profile description in combination with kriging or machine learning
    - Use of proximal soil sensors
    - Using satellite information
    - Combination of these
- *How to select?*

Scales

Point	Field	Region	Country	Continent
Proximal + lab	Proximal + drones + airborne + satelites	Airborne + drones + satelites	Satelites + airborne	Satellites + airborne
				
Soil profiles Samples Fieldwork VISNIR XRF Temp. Moisture	VISNIR GPR Gamma-ray EM/EC Magnetics	VISNIR Gamma-ray EM Radar Magnetics	VISNIR Gamma-ray EM Radar Magnetics	VISNIR Gamma-ray EM Radar Magnetics

Value of information

The most effective remedy for supplementing and improving information is the one that **answers the question against minimal costs**, where the **costs are not higher than the gain** in terms of improved *value of information:*

The gain of supplementation and improvement of information (Morgan et al., 1990)

If data collection is effective and efficient, more can be done or updated with the same budget/timeframe

Field scale drainage case

- Field hydrologic situation changed due to nature area
- Farmer claims crop damage at water authority
- Do costs of investigation balance against reduced error (increased accuracy) in damage assessment and compensation/measures?

Field scale drainage question

- Target universe: field, before and after situation change
- Domain of interest: % yield depression in both periods*
- Target variable: relevant soil and water properties (sub-soiltypes, soil (texture) layers, groundwater levels)
- Target parameter: % yield depression
- Target quantity: crop damage per year in euro's per period
- Type of result: quantitative
- Accuracy measure: standard error
- Accuracy requirement: not known

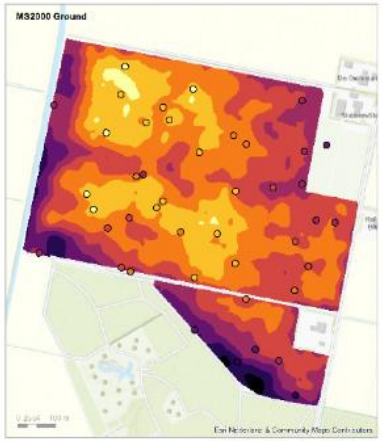
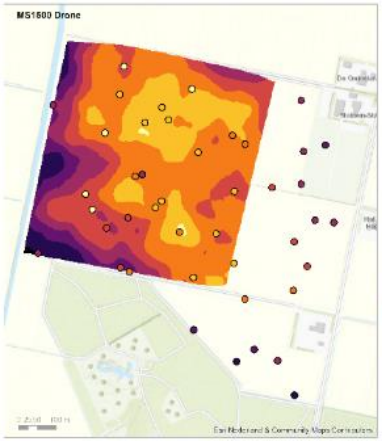
** Tables exist to translate soil and water properties to yield depression for Dutch situations (waterwijzerlandbouw.wur.nl)*

Field scale drainage question

- National inventory not timely
- Local inventory not available
- New quick inventory by auger: soil layers and water features
- Big differences in peat thickness found, pattern not clear
- GPR with calibration augerings: peat depth, thickness, depth of drainage pipes
- Validation (augering)
- Adequate information for damage assessment and measures
- Cost calculation (inventory, GPR, calibration, validation, analyses)
- Better estimate of additional cost possible in new cases

Gammaspectrometer on UAV

Data for Value of Information estimate 0-50 µm

Map	Ground	UAV	Standard
Median absolute error	10.6/ 3.6	8.6/ 4.1	6.6
Cost/ha*	€ 6/ 63	€ 14/ 70	€ 81
Resolution			

*costs based on 15 samples/40 ha, 50 m line spacing, with regional/local calibration

- Costs are greatly reduced with regional calibration
- Costs: Carborne < UAV < walking/sampling

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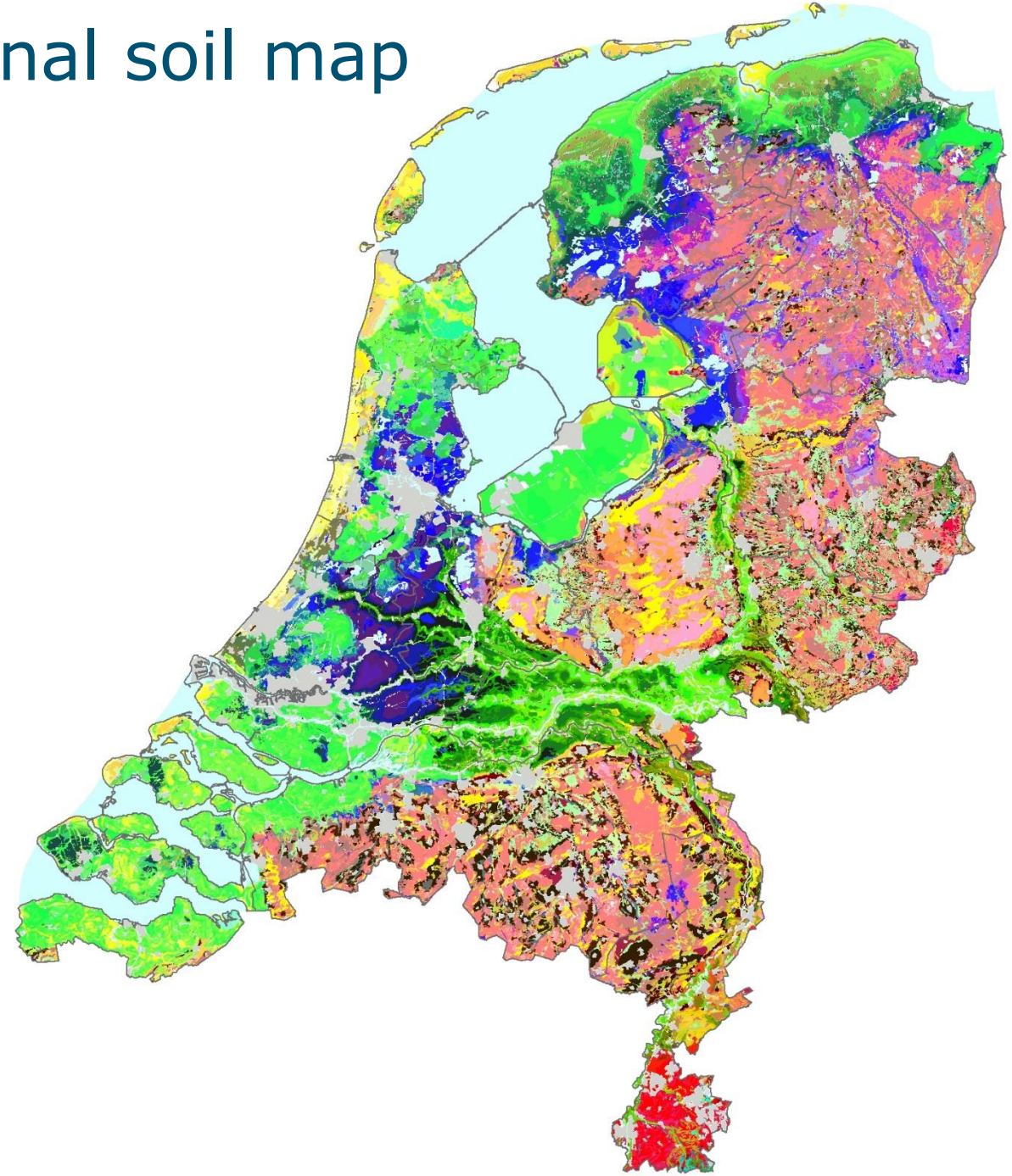
Dutch national soil map 1:50.000



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National inventory

- Does the national inventory answer user needs?
- Difficult to quantify given the range of uses:
  - Land use planning
  - Agriculture
  - Infrastructure
  - Nature conservation etc.
- Should therefore be accurate according to specifications and reflect current situation
- Scalable product needed to answer all needs
- Quantitative information needed to answer all needs
- But let's start with *accurate* and *current* first

National inventory - recommendations

- No explicit **accuracy requirement**
- **Quality criterion**, historically grown **70% map purity**, if precisely defined
  - 70% strict map purity: on 70% of the map all soil properties are correctly classified. Seldom achieved in practice, see Marsman and De Gruijter (1986)
  - **Each soil property** separately is correctly classified on 70% of the map
  - On average, all soil properties are classified correctly on 70% of the map. Some features are much less accurate than others.
- Substantiate the quality criterion with **risk analyses** and adjust if necessary
- The method of **data collection** must then be selected in such a way that this quality criterion can be achieved at the **lowest possible cost**

Business case Dutch Key Registry Subsurface

- Government spends yearly **6,5 billion** in **infrastructural projects**
- **Failure costs** estimated at **20 %**; 1.3 billion per year
- Many unforeseen costs are **geo related**
- If better soil and geology information cause a decrease of failure costs by **3 %**; **39 million**
- Costs for **data infrastructure**: **40 million in 8 year** (2.5 million for soil)
- Keeping **soil information up to date yearly less than 1 million**:
    - Soil information (profiles, properties, maps)
    - Geomorphology
    - Geology to 2-3 km
    - Groundwater models and data

National inventory - literature

- Klingebiel (1966): estimated cost-benefit ratio soil map, **'lifespan' up to 25 years:**
  - **1:46** for extensively used land,
  - **1:61** for moderately intensively used areas with mixed agriculture
  - **1: 123** for intensively used areas
  - **the costs of a soil map that is used for several purposes are already payed off in the first year**
- Giasson et al. (2000): calculated cost-benefit ratio 1: 50,000 soil map, lifespan of **20-year**:
  - **1:122** for a farming region

Proposed workflow

- Start with **(real) question**!
- Determine the information question and availability to **determine the gap**
- Determine the **most efficient data acquisition method**
- Estimate **costs** to determine **value of information**
- Calculate (and validate if possible) **cost benefit result**
- **Describe choices and publish all**

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Conclusions and recommendations – What?

If we want to 'sell' soil information products, be it scientific, institutional or commercial, we need to:

- Answer user needs
- Prove (added) value of soil information,
- Calculate real cost benefit (including environmental)
- Be efficient and adequate in our choices
- Work together in data, share results, describe user cases
- Make this a standard aspect of your reporting and workflow

Remarks

- **Not all value can be expressed in monetary terms**
  - Environmental performance/ecosystem services
  - Food security (LDN)
  - Quality of life and environment
  - Long term benefits, for instance income security by soil resilience in changing conditions
- **Knowledge** and understanding (of soil) is still needed to **interpret** the information

Let’s bridge the gap

Thank you for your attention.

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