Using clay to make farmland climate proof

provincie Gelderland

Rijkswaterstaat
Ministry of Infrastructure and Water Management

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Soil - water pressures in sandy soils

Soilver februari 13th

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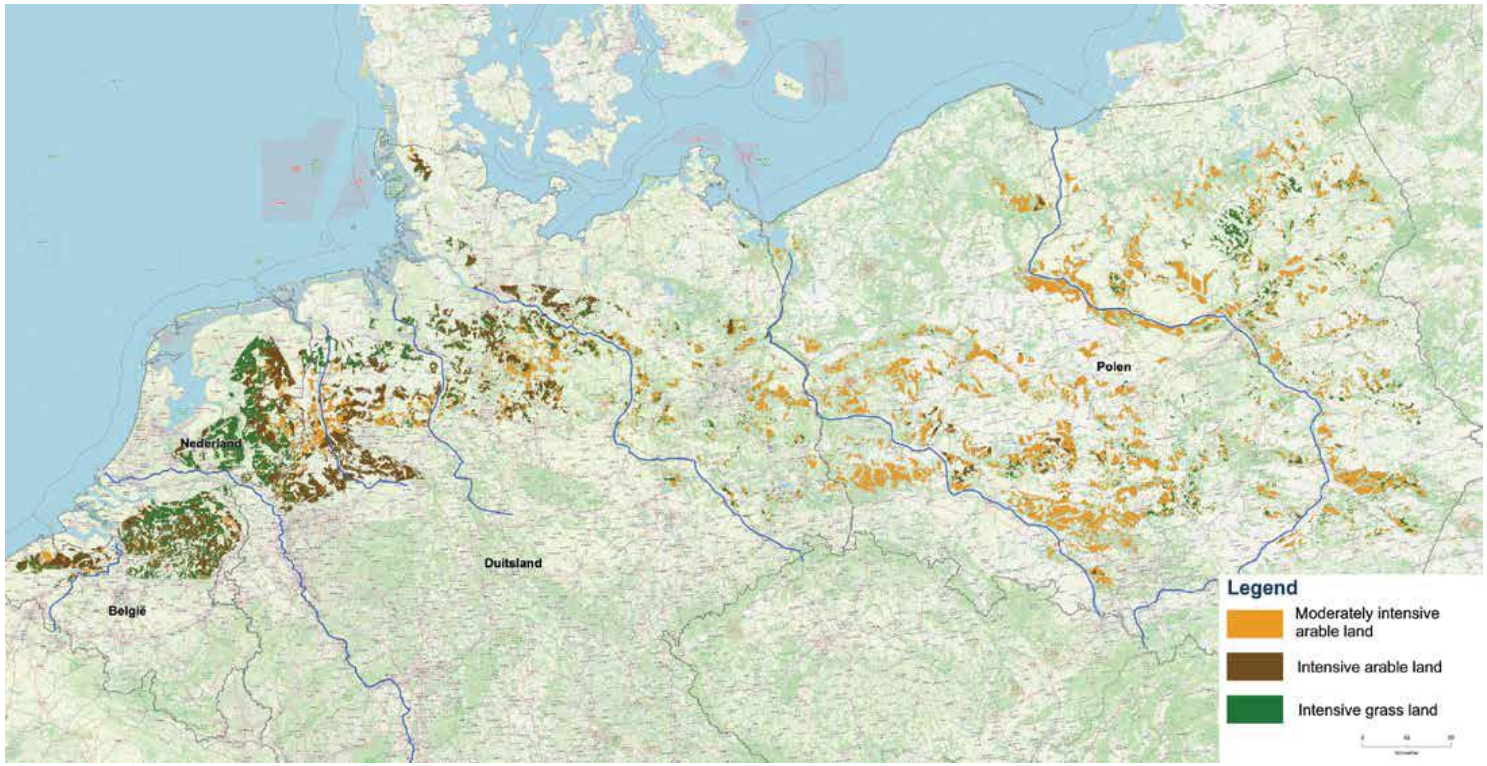
Background

Climate vulnerability of sandy soils

- Agriculture has begun to suffer from the effects of climate change
- Crop yields decline during prolonged droughts
- Sandy soils are particularly vulnerable
- The agricultural sector faces the challenge of making these sandy soils, in interaction with farming systems, resilient to the effects of climate change

European Sand Belt

Intensive agriculture



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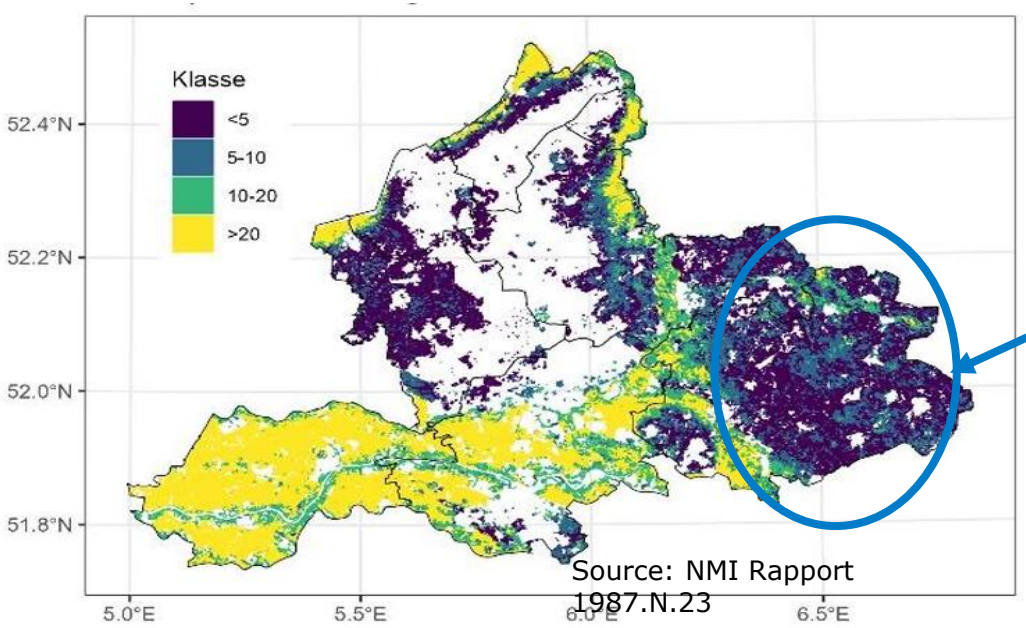

Source: NMI Rapport 1987.N.23

- Agriculture 47,1%
  - Agricultural land 230.000 ha, 12 % of NL
  - 70% Grassland
- Nature 26,3%
- Urban 23%
- Water 3,6%

- Sandy agricultural soils
- Strategic groundwater resources

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Scoring Soil Ecosystem Services

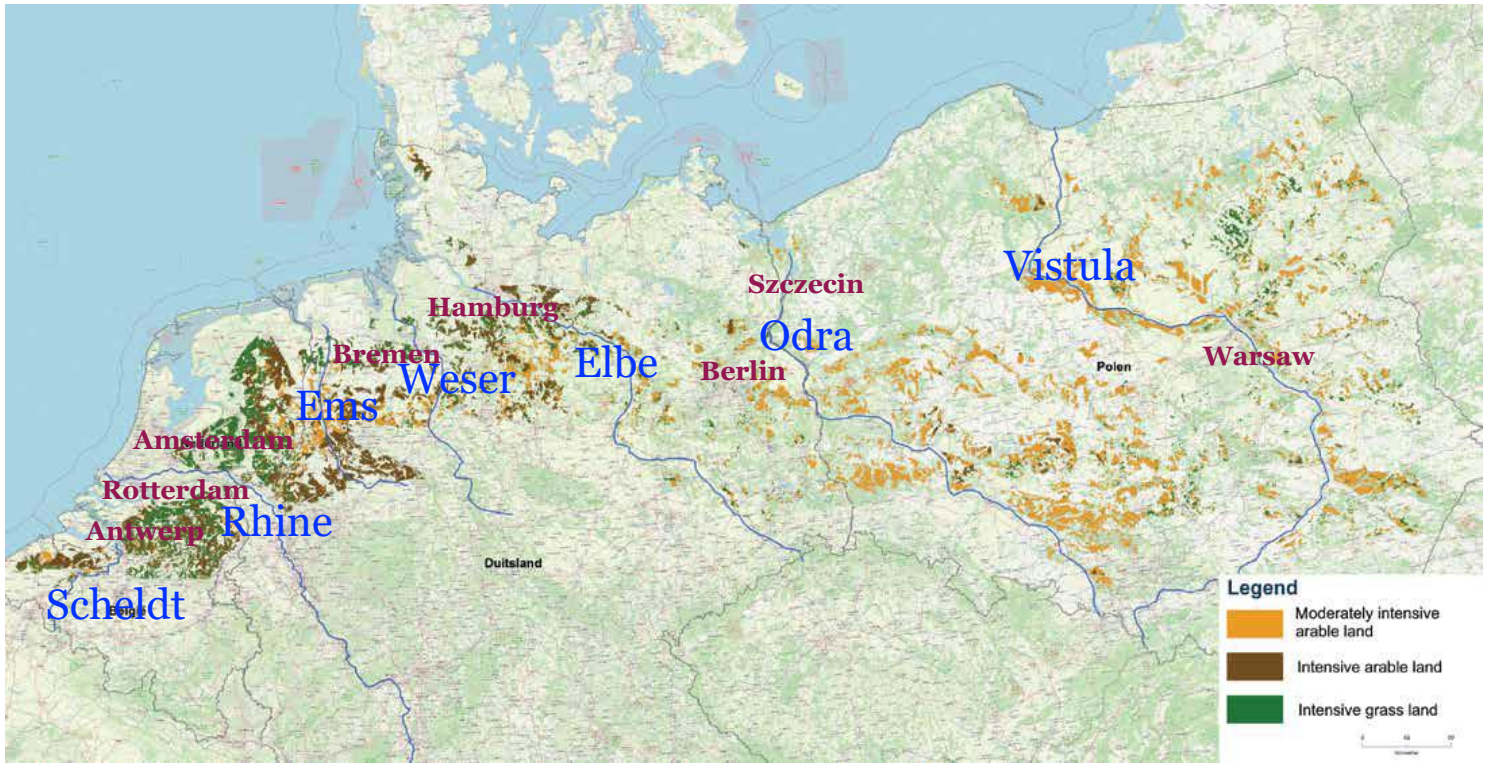
- Soil quality related to ecosystem services (ESS)
  - Primary production
  - Water regulation and natural attenuation
  - Climate regulation and carbon sequestration
  - Nutrient cycling
  - Soil biodiversity and Habitat supply
- Soil indicator set for agricultural soils (BLN)
- Insight in functioning and improving ESS
  - Measures in land management
  - Upgrading sandy soils

Existing measures on sandy soils include:

- Additional green manure
- Adapted crops and crop rotation
- Leave crop residues on land
- Composting
- Include ‘perennial’ grassland in crop rotation

European Sand Belt

River valleys near sandy soils



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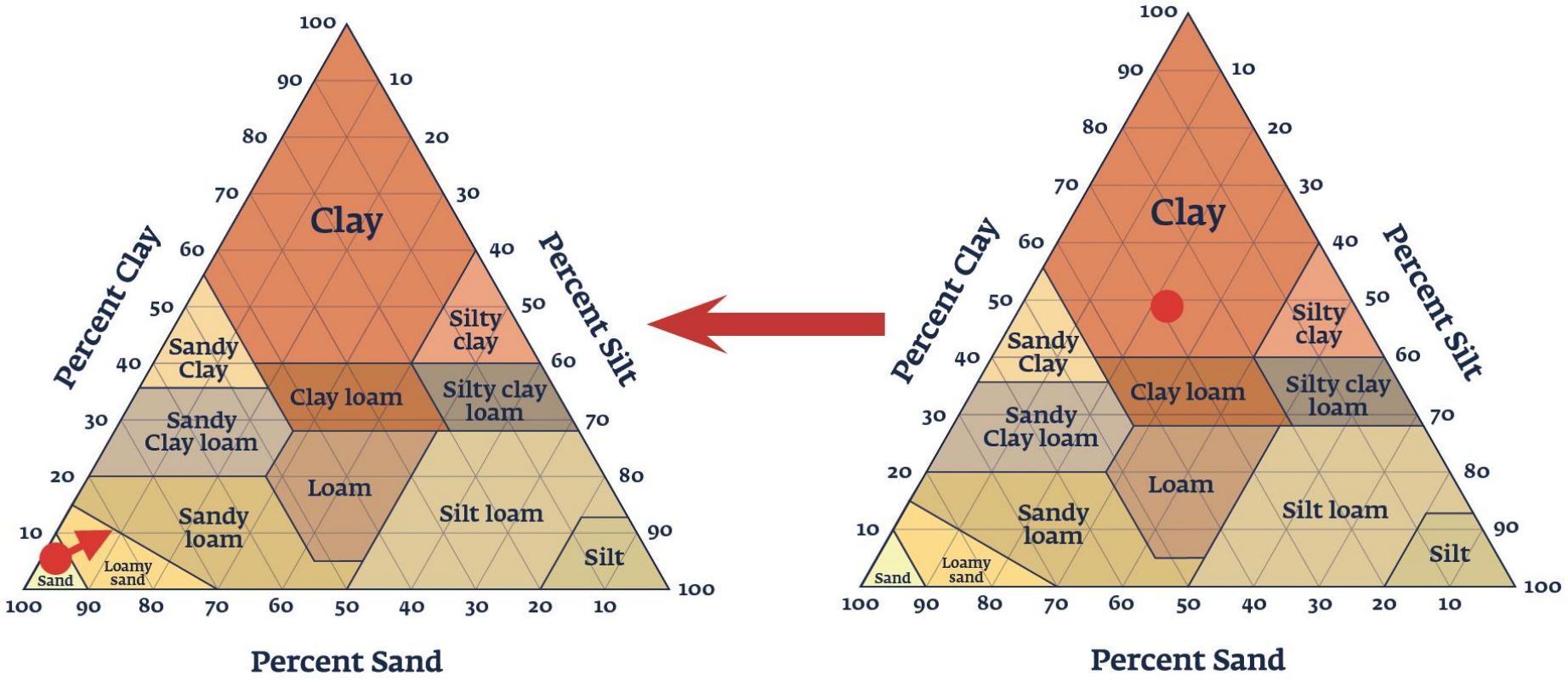
Using clay: from sand to loamy sand



https://youtu.be/OozlMQ7k5hI

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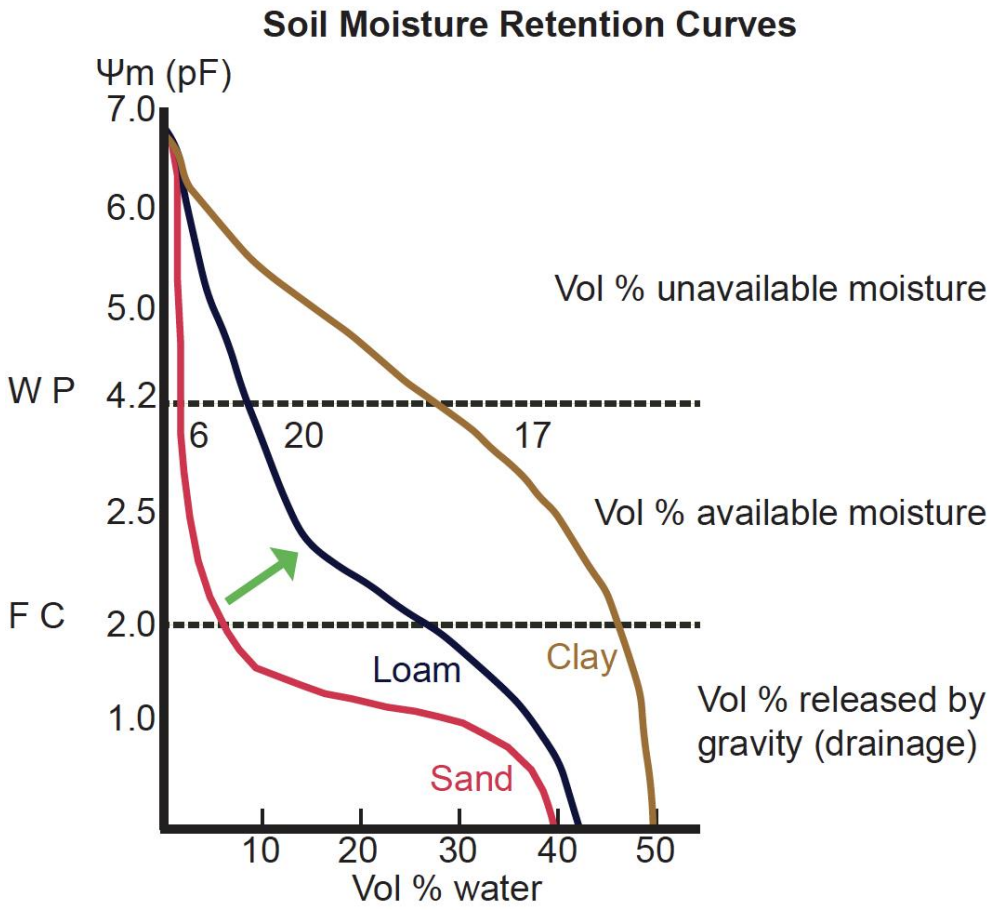
More fines = more water retention



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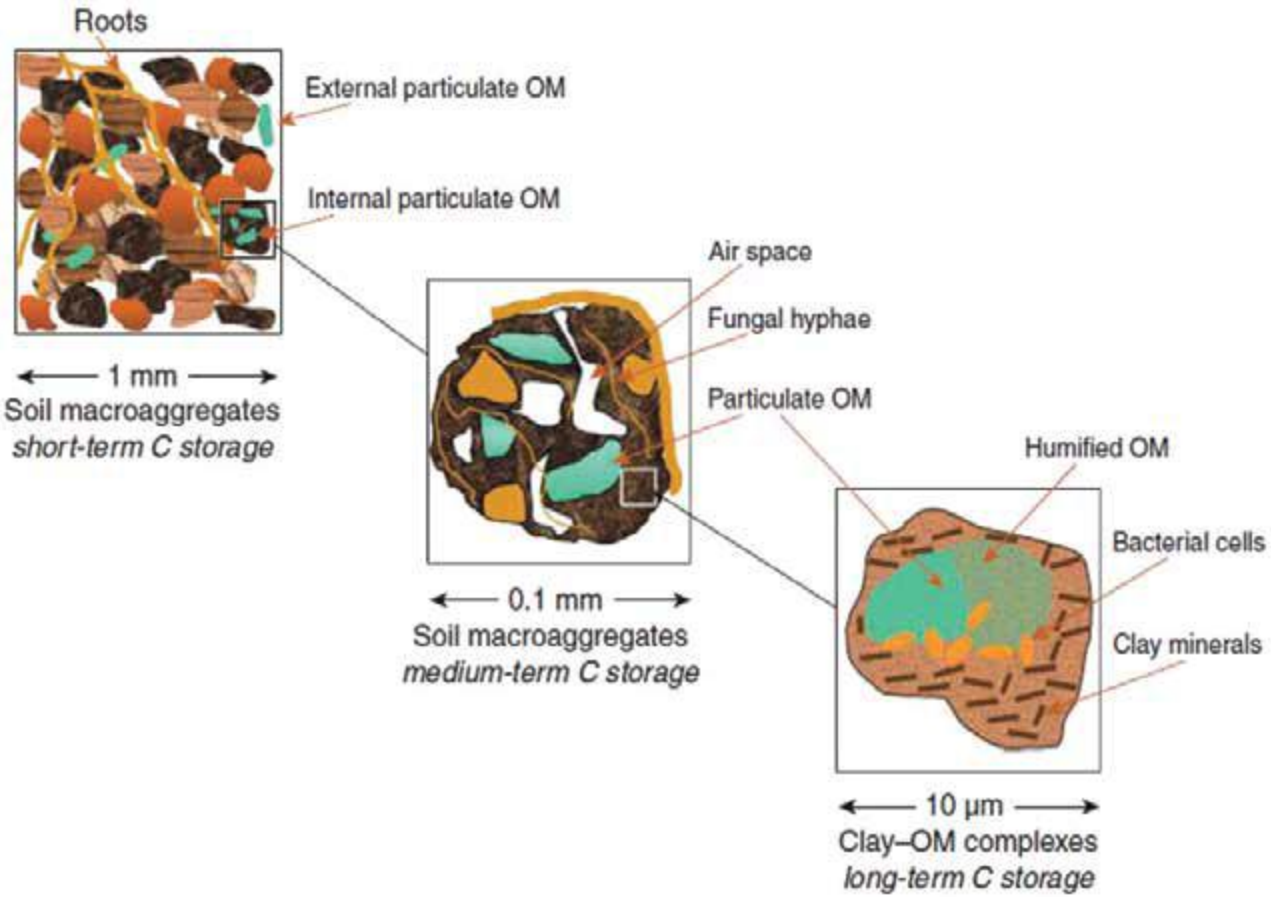
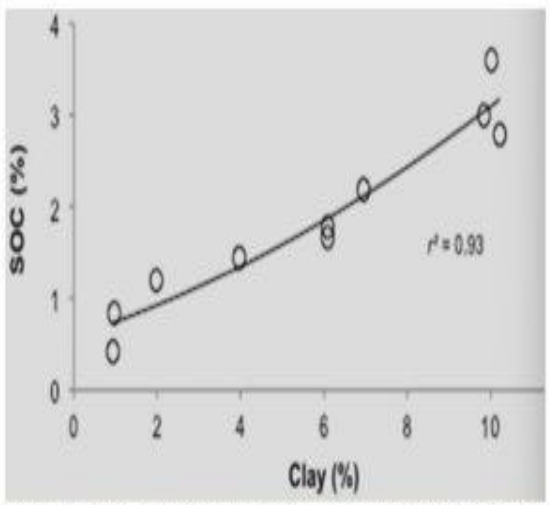
More Soil Organic Matter = more water retention



From Jones & Donnelly, 2004, https://doi.org/10.1111/j.1469-8137.2004.01201.x.

Soil organic carbon in relation to clay content

29 years after clay application into sand



Figuur 2. Bodemgebonden organisch koolstof (SOC, %) in relatie tot kleigehalte (% < 2µm) in de 5 cm toplaag van een zandige bodem 29 jaar na toevoeging van kleiig residu uit de bauxietindustrie [14].

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Approach

- Increase soil water and carbon retention using available clay from land developments
- 1-3 cm / year for 2 to 4 years, target 8% lutum (particles < 2 µm)
- Connect civil engineering/public works and agriculture

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Experiences and observations

- Roots penetrate clay clods
- Need for irrigation 3-4 days later
- Higher Cation Exchange Capacity
- Higher effective nitrogen uptake = less leaching
- More worms per hectare
- Higher dry matter yields, >10%
- More starch in maize

Dealing with challenges

- Turnaround in land development chain
- No bricks, stones, rubble
- Faster wear of manure (/clay) spreaders

- Future: use of clay from sludge slightly contaminated (Soil directive, reuse soils)

Turnaround in land development chain

Transformation of thinking and behaviour

- Field/demo days - direct contact with farmers
- Upgrade sustainability models with long-term chain impacts (like SCBA)
- Adapt planning and procurement procedures - relocation of released soil as integral part of land development
- Market place: released clay soils and asking farmers

Socio-economic impact

Societal cost-benefit analysis (SCBA)

- First assessment report February 2025
- Final assessment foreseen Q1 2027

Cost items

- Transport costs for clay
- Clay processing costs (landfill or application to fields)

Benefit (= effect +/-) items

- Environmental impacts: CO2, PM10, NOx transport & application
- Soil fertility benefits: saved feed purchase costs due to increased grass/maize quality (protein and starch content) & quantity
- CCA / Water retention benefits: saved irrigation costs; water supply costs*; garden damage
- CCM benefits: reduced CO2-eq emissions due to less fodder / compound feed use & reduced oxidation or increased fixation
- Pest suppression benefits: reduced crop protection costs
- Water quality benefits: less environmental and public health damage due to less leaching of nutrients and plant protection products into water
- Biodiversity benefits: appreciation by the general public, higher milk quality, improved animal health

Cost-benefit statement	Canal near Amster-dam (100 km)	Waal river floodplains (50 km)
Clay transport costs	10,788	5,394
Clay application costs	1,369	1,369
Total costs per hectare	**12,157**	**6,763**
Related environmental effects (CO2, NOx, PM10)	-417	-220
Soil fertility benefits (savings for fodder/compound feed)	15,190	15,190
CCA benefits (savings on irrigation and water supply)	8,050	8,050
CCM benefits (less compound feed use, more C-capture)	4,946	4,946
Savings on crop protection	74	74
Water quality benefits (less environmental and health damage due to less leaching of nutrients and plant protection products)	1,593	1,593
Biodiversity benefits (public appreciation, milk quality, animal health)	8,408	8,408
Total benefits per hectare	**37,845**	**38,042**
Balance (societal benefits minus costs)	25,688	31,279
Ratio (societal benefits divided by costs)	3,11	5,63

Sensitivity analysis

What if agricultural benefits are disappointing?

- Halving crop quality & quantity benefits means that ratios drop from 3.11 - 5.63 to 2.32 - 4.21

What if CCM benefits from soil extend beyond 10 years?

- If duration is doubled, they become significantly larger, but not dominant

What if transport distances are greater than the 50 and 100 km used?

- Breakeven distance under disappointing agricultural benefits is 240 km

What if a shorter than the long standard 100-year SCBA term is used?

- For a term longer than 30 years, the measure pays off to society, even in the case of disappointing agricultural benefits

Transition & upscaling

- Towards high quality re-use of clay (soil) instead dumping or low quality re-use
- In 2027 700 ha in treated with clay
- Knowledge sharing within the sand belt (Netherlands, Belgium, Germany and Poland)
- Community of practice
- Agenda setting for environmental policy
  - Extra CO_2 emission due to transport of soil versus beneficial effects on soils
  - Legal restrictions by soil quality regulation

LIFE CO2SAND is a joint project of Rijkswaterstaat and the Province of Gelderland.

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Thank you for your attention

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