Using clay to make sandy farmland climate proof

LIFECO2SAND.EU

Increasing resilience and carbon sink of sandy farmland

Climate change adaptation

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

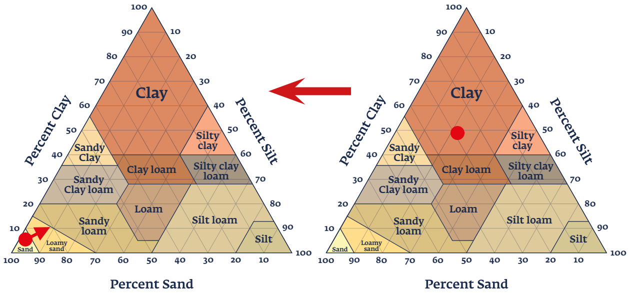
Climate change mitigation

In the national Climate Agreement, the Dutch agriculture sector aims to achieve an additional sequestration of 0.5 Mtonne CO2-eq/year by 2030 by increasing soil organic matter and reducing N2O emissions on farmland.

Circular economy

An estimated 1 Mtonne of fertile clay and loam, released from Dutch public works, is disposed of each year as if it were waste. However, this is excellent material to use for increasing the resilience of sandy farmland. In addition, Australian research shows that sandy soils enriched with clay and loam sequestered on average 1.9 tonnes of CO2-eq/year more over a 29-year period compared to sandy soils without such enrichment.

The pictures depict freshly excavated clay from a floodplain where space is made for flood alleviation (right) and drought-prone sandy soil where this clay finds a new use (left).



Texture triangles of sand (left) and clay (right). Arrows show the sandy soil shifting towards loam after enrichment with clay.

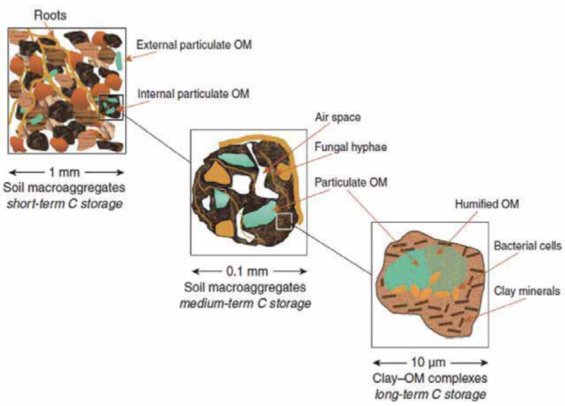
Sandy soil.

A thin layer of clay is added.

Over time, the clay mixes with the sandy soil due to weathering, cropping, soil life and/or tillage.

Stabilisation of organic matter

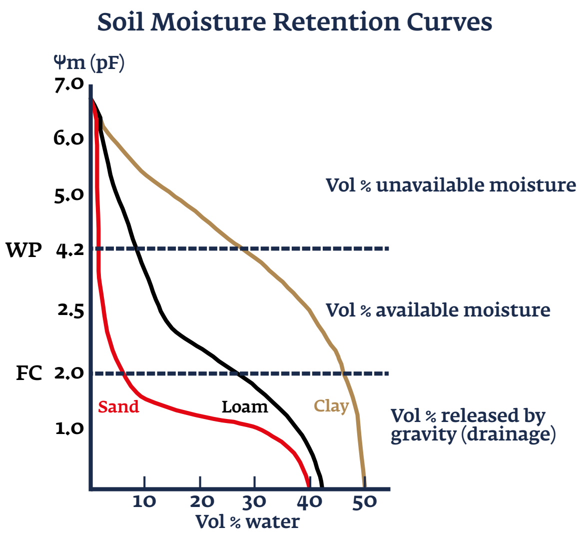
Clay released from projects is transferred to sandy soils in use as arable or pasture land. 1 to 3 cm of clay are applied, say once a year, until the rooted layer contains 8% lutum. From that level it is called loamy sand. The clay minerals bind the organic matter (carbon), thus preserving it better. In addition, clay minerals contribute to better aggregation of the soil, making it less likely to break down. This allows the soil as a whole to store more carbon.



Model of aggregate organisation showing the location of soil organic matter (OM) within the soil matrix, with turnover times. From Jones & Donnelly, 2004, https://doi.org/10.1111/j.1469-8137.2004.01201.x. The lower right box shows clay minerals binding organic matter for the long term by forming clay-OM complexes.

Water retention and availability

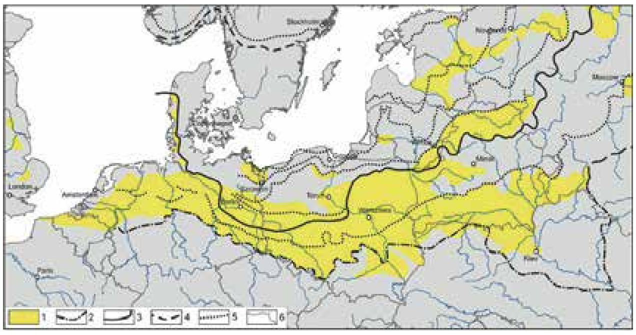
Both the amount and availability of water in the soil is important for plants. Both increase when sand becomes loamy due to the added clay. This enables stronger crop growth.



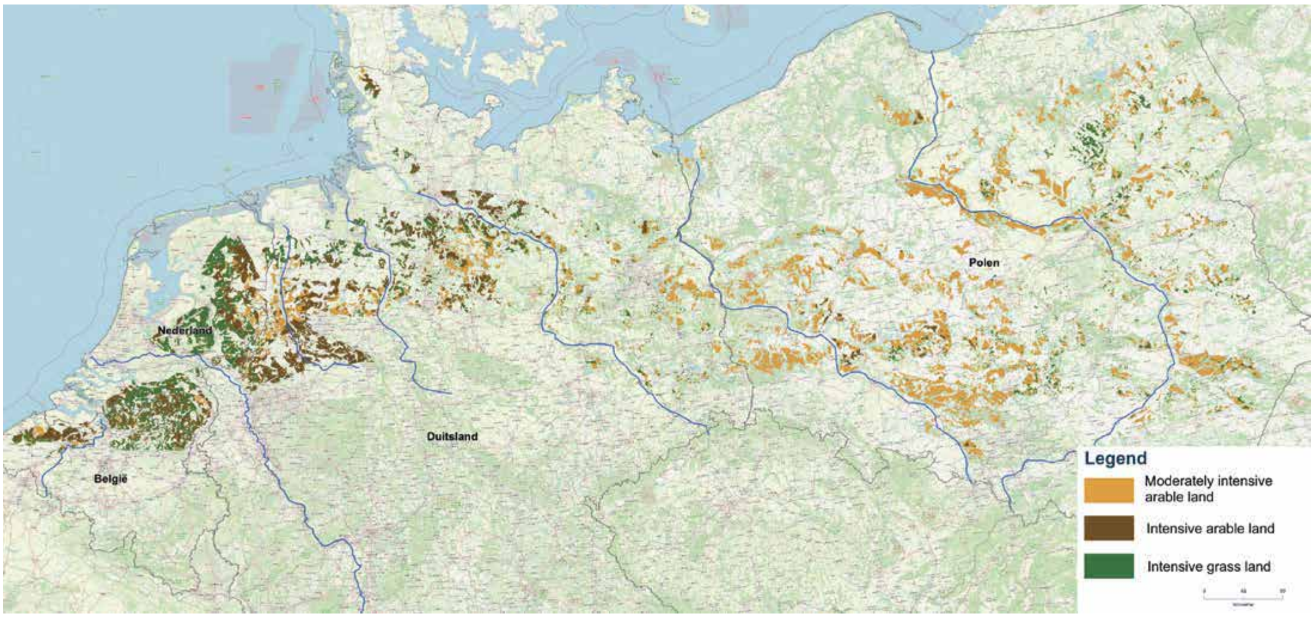
Water retention curves for sand, silt and clay. Shown is the soil suction stress (pF) as a function of moisture content (volume%). The difference in moisture percentage at field capacity (FC) and wilting point (WP) is the percentage of plant available water, in this graph 6% for sand, 17% for clay and 20% for loam (similar to clay-enriched sand).

Potential and challenges

Target area: European sand belt
The southern and eastern regions of the Netherlands lie on the European sand belt formed in the Pleistocene. This belt consists of drought-prone sandy soils and extends from Flanders to Belarus. It is largely used for intensive agriculture. LIFE**CO2**SAND focuses on this region and develops long-term solutions to its challenges: low water retention, leaching of nutrients and pesticides, low soil organic matter.



Map of the European sand belt formed in the Pleistocene.



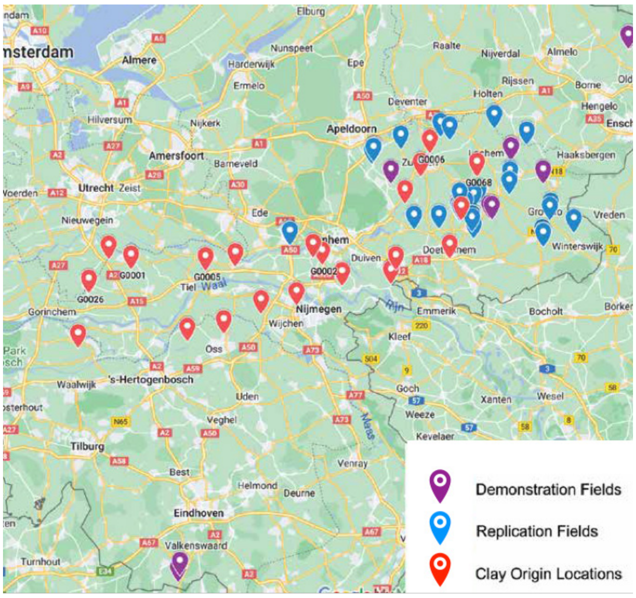
Map showing the parts of the European sand belt in intensive agricultural use.

Think and act differently
Large quantities of clay are released during land development works such as nature development, infrastructure, housing, construction and river widening. Only some of it is suitable for traditional applications such as dykes and ceramic industry. The remainder does not easily find its way to drought-prone agricultural land. The biggest hurdle to take starts with land development initiators. They are used to leaving the reallocation of released clay to contractors.

Finding a destination then becomes secondary to meeting the project schedule, leaving high-quality applications out of the picture. LIFE**CO2**SAND aims to adapt planning and procurement procedures to include high-quality reallocation of fertile soil as an integral part of urban planning and public works right from the start. That is why LIFE**CO2**SAND provides for a transformation in thinking and behaviour throughout the land development chain, starting with the initiators. These are mostly public authorities.

Decision-supported tendering
To facilitate this change in thinking and behaviour, LIFE**CO2**SAND has co-developed a model to value released soil for different purposes. The model uses data on GHG emissions during transport, chemical, physical and biological quality, ecosystem services to be provided and an inventory of possible destinations (timing, distance). It can be used throughout all project phases from the very first exploration to procurement. Before mainstreaming this model, it will be empirically tested in a tender for a major river widening in mid-2024. The model rewards bidders for high-quality use of released soil. Improvement of sandy soils is a possible outcome.

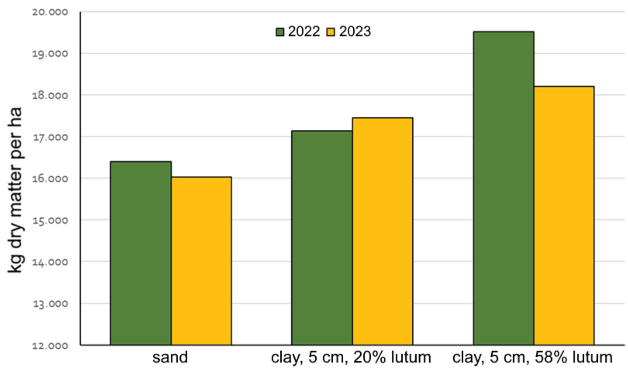
Approach and first results



Map showing locations of demonstration fields, projects releasing clay and replications realised.

On-farm demonstration fields

Six farmers have established 1 or 2 demonstration fields each. By applying a thin layer of clay every year for 2 to 4 years, they increase the lutum content of the soil to 8%. From this percentage, the soil is better able to stabilise organic matter. The result is better water retention and carbon sequestration.



Graph showing increasing yields on sandy soil after clay application.

Farmers: approach hits home

By the end of 2023, 33 replications had started, over a total area of 185 ha (goal: 700 ha by 2027). Of these, 37 ha have already reached the 8% lutum target. The clay released was from 5 areas of origin, including restoration of meanders of a stream as part of another climate adaptation project a major railway construction, nature development and preparation of land for housing development.

Higher yields, less nitrate leaching

Scientific results from Wageningen University & Research on De Marke experimental farm show that amending sandy topsoil with clay leads to higher dry matter yields. In addition, effective nitrogen uptake is higher, reducing the risk of nitrogen leaching. Finally, the number of worms per hectare is higher in soils where clay has been added, improving soil structure.

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