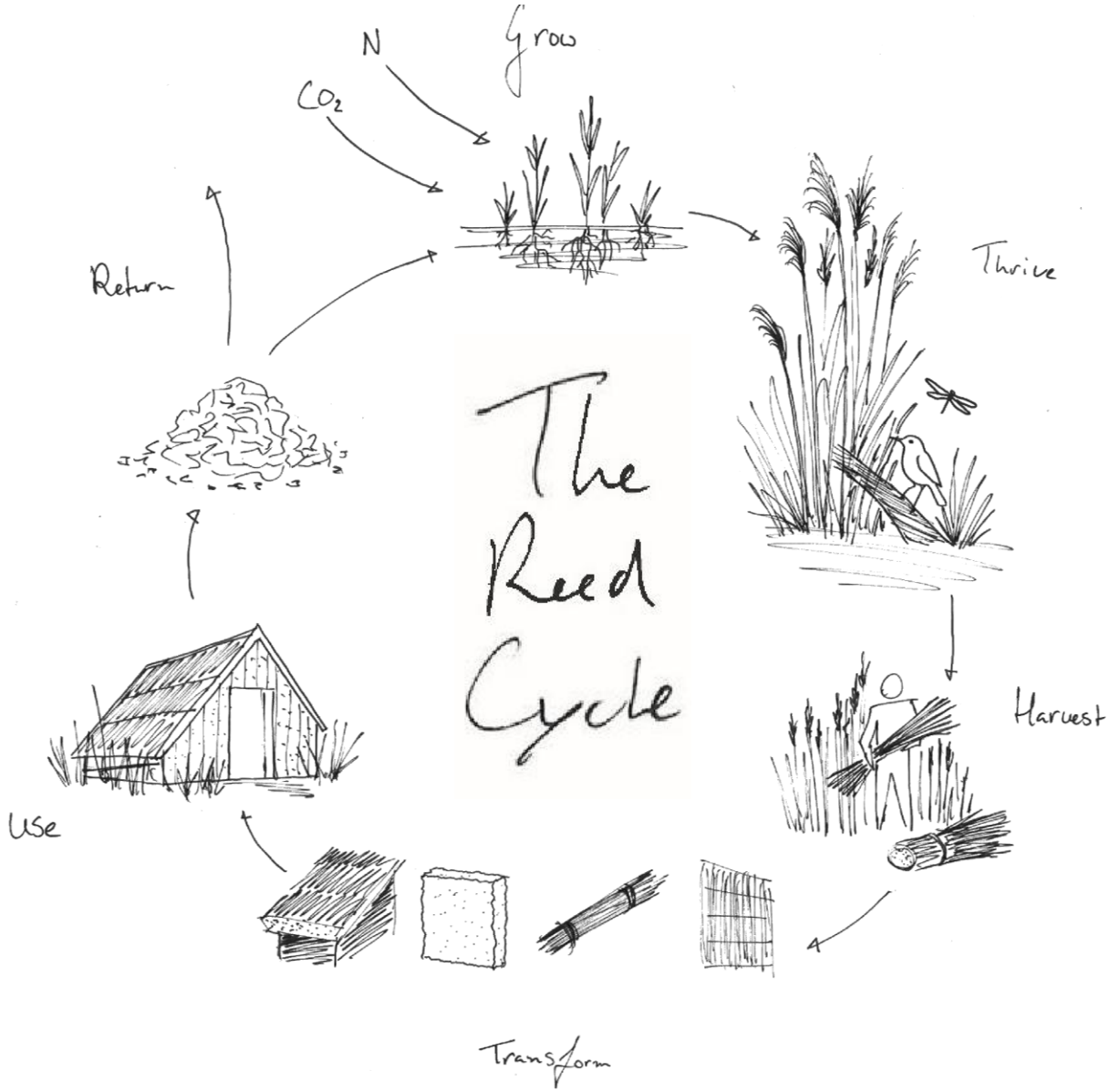
THE REED CYCLE

How Constructed Wetlands and Biomaterial Architecture Close the Nitrogen Loop

Bas de Kruif
5097584


N
Grow
CO_2
Return
Thrive
The Reed Cycle
Harvest
Use
Transform


WAAROM?

Uitstoot

Gelderland zit tot over zijn oren in de stikstofcrisis, maar gaat zijn grote uitstoters niet opzoeken

Als deze 25 boeren stoppen, lijkt de stikstofcrisis voorbij. Maar zo simpel is het niet

Koeien of natuur: de stikstofcrisis dwingt partijen tot ingrijpende keuzes

Bouw nieuwe stallen verboden: provincies en rijk samen naar de rechter

30 maart om 15:35 • Aangepast 30 maart om 18:58

Boeren in Groningen voelen druk van de banken in stikstofcrisis. 'Is dit alle ellende waard?'

Biologische melkveehouder kan stikstofcrisis verkleinen

Advies aan politiek: stevige aanpak stikstofcrisis nodig

POLITIEK PETER SMIT

De veevoermaatregel is van tafel maar de stikstofcrisis is nog lang niet ten einde

Van vogels tot eikenbos: stikstof nekt leven op de Veluwe

02 mei 2021 05:01
Laatste update: 03 mei 2021 08:24

2.3K NUJI-reacties

Trouw

Hoe te veel stikstof krekels ziek maakt. 'We zagen zelfs kannibalistisch gedrag'

Koen Moons 19 oktober 2025, 12:02

Abonn

Een snelle uitweg uit de stikstofcrisis is er niet

Stikstof De Tweede Kamer debatteert donderdag over het stikstofprobleem, dat steeds nijpender wordt. Acht vragen en antwoorden.

deVolkskrant

NIEUWS

Politieke impasse over stikstof kost Nederland bijna 15 miljard euro per jaar

Bouw duizenden woningen op de tocht: stikstofcrisis dreigt Barneveld vrijwel lam te leggen

Premier Schoof vertilt zich ernstig aan stikstofdrama

Nederlandse bouwbedrijven zijn getreuzel in stikstofcrisis zat: 'Iedereen staat in de wachtstand'

Onderzoek FTM: Ede is epicentrum van de stikstofcrisis

Kabinet wil uitstoot stikstof in 2035 halveren

Rob Jetten (D66) wil steun voor bouwsector in stikstofcrisis: 'Vangnet hard nodig'

Wouter de Heij: 'Stikstofcrisis is een juridisch moeras'

Groei ASML bedreigd door net- en stikstofcrisis

Schoof: 'Overleg om Brainport van stikstofslot af te krijgen', nodig voor bouw campus ASML

Noord-Brabant wil stikstofslot openbreken, maar boeren vertrouwen niets meer

Eindeloos wachten op een woning aan de Nieuwe Waterweg: Hoek van Holland zit gevangen in de stikstofcrisis

Bij het stikstofprobleem wordt veel geschreeuwd en weinig naar elkaar geluisterd

Maatschappelijke organisaties liepen boos weg bij belangrijk stikstofoverleg met kabinet

Soepelere Europese regels voor boeren lossen de Nederlandse mest- en stikstofcrisis niet op

De natuur heeft niets aan nieuwe stikstofplannen van kabinet

nrc

ACHTERGROND

'Wij vangen de klappen op' – provincies voelen zich door het kabinet alleen gelaten in de stikstofcrisis

Stikstofcrisis bedreigt bouw van honderden woningen in Harderwijk: 'We maken ons zeker zorgen'

deVolkskrant

Opinie Cartoons Podcasts

NIEUWS

Milieuorganisatie stelt ultimatum: tientallen rechtszaken als minister niet binnen twee weken stikstofcrisis aanpakt

Wethouder wil uitzondering voor haven in stikstofcrisis: 'Het begint nu echt pijn te doen'

Boerenclubs willen dat overheid leiding neemt in stikstofcrisis

woensdag 21 januari 2026 om 17:04 uur

Een op vijf ondernemers gaat gebukt onder stikstofcrisis: deel vreest snel faillissement

Stikstofcrisis raakt ondernemers hard in Midden-Nederland

18 AUG 2025, 18:24 • REGIO

Stikstofcrisis: PvdD eist 75% krimp veestapel, CDA waarschuwt voor 'hakken in het zand'

25 oktober 2025 16:47 door Sebastiaan Scheffer

Liander 171 miljoen extra kwijt aan stroomnet door stikstofcrisis

Noodkreet provincies: bouw half miljoen woningen in gevaar. 'Politiek, doe iets aan netcongestie en stikstofprobleem'

De Groene Amsterdammer

Waarom techniek de stikstofcrisis niet gaat oplossen

Veehouders en belastingbetalers investeerden de afgelopen tien jaar 2,4 miljard euro in emissiearme stallen die nauwelijks blijken te werken...

23 apr 2025

Stikstof zet bouw 244.000 woningen op slot en economische schade van €93,5 miljard dreigt

Formerende partijen en landbouw willen vaart maken: 'Spoedwet stikstof voor de zomer'

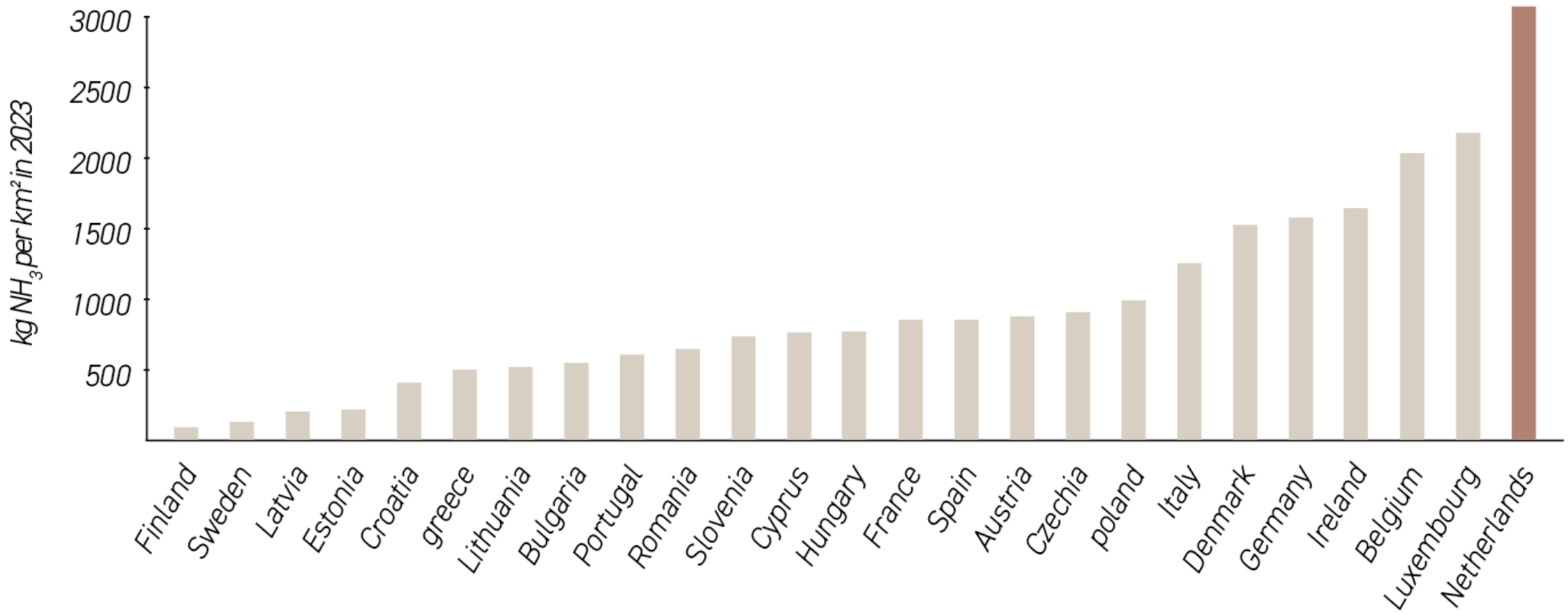
NIEUWS POLITIEK PETER SMIT 21 JAN 2026 OM 16:39 UUR

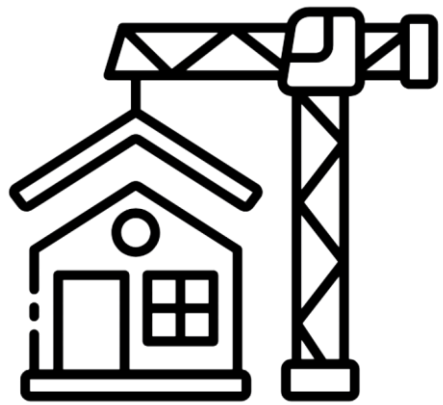
Nieuwe stikstofaanpak Brabant stuit op weerstand: 'Geen perspectief voor boeren'

Eindhoven Airport heeft natuurvergunning nodig na meer stikstof

Brussel tikt Nederland op vingers over geld, stikstof en huizen; 'meer investeren in hernieuwbare energie'

Stikstofcrisis bedreigt bouw van honderdduizenden woningen: 'Heel slecht nieuws'


kg NH_3 per km^2 in 2023
3000
2500
2000
1500
1000
500
Finland
Sweden
Latvia
Estonia
Croatia
greece
Lithuania
Bulgaria
Portugal
Romania
Slovenia
Cyprus
Hungary
France
Spain
Austria
Czechia
poland
Italy
Denmark
Germany
Ireland
Belgium
Luxembourg
Netherlands



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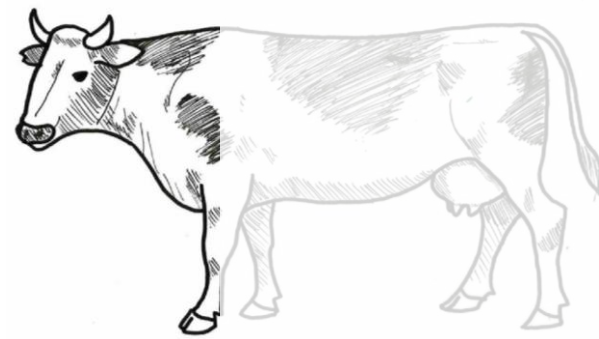
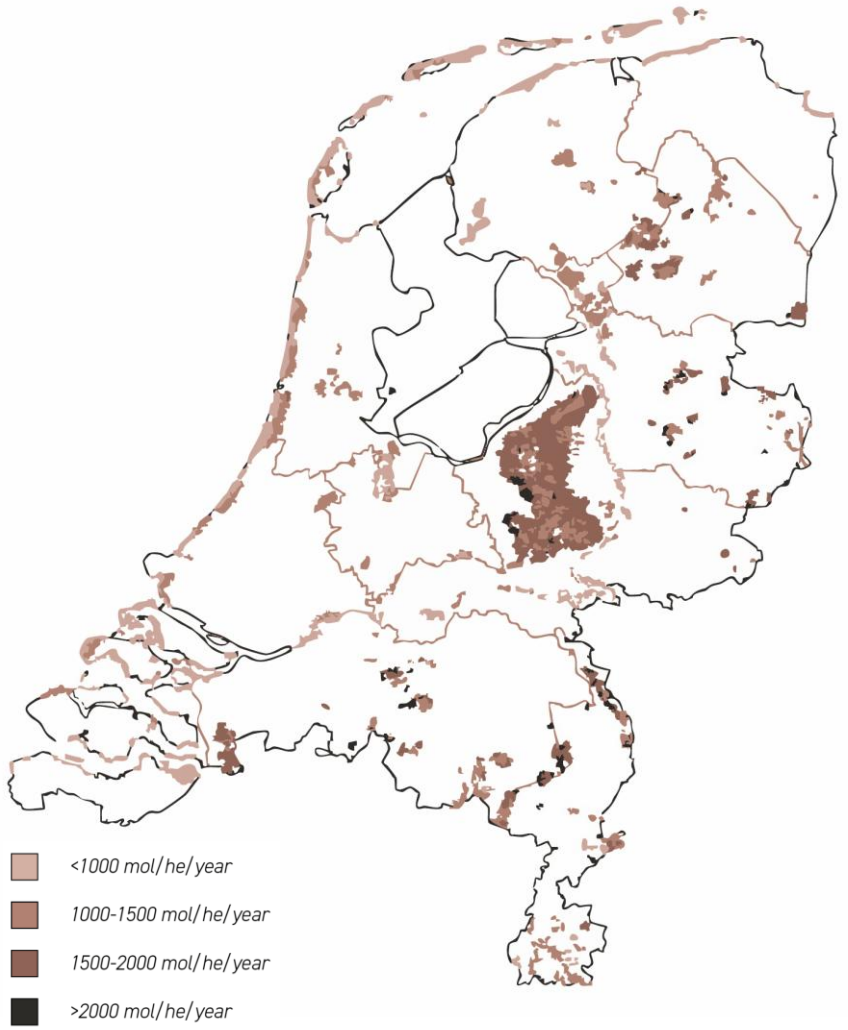
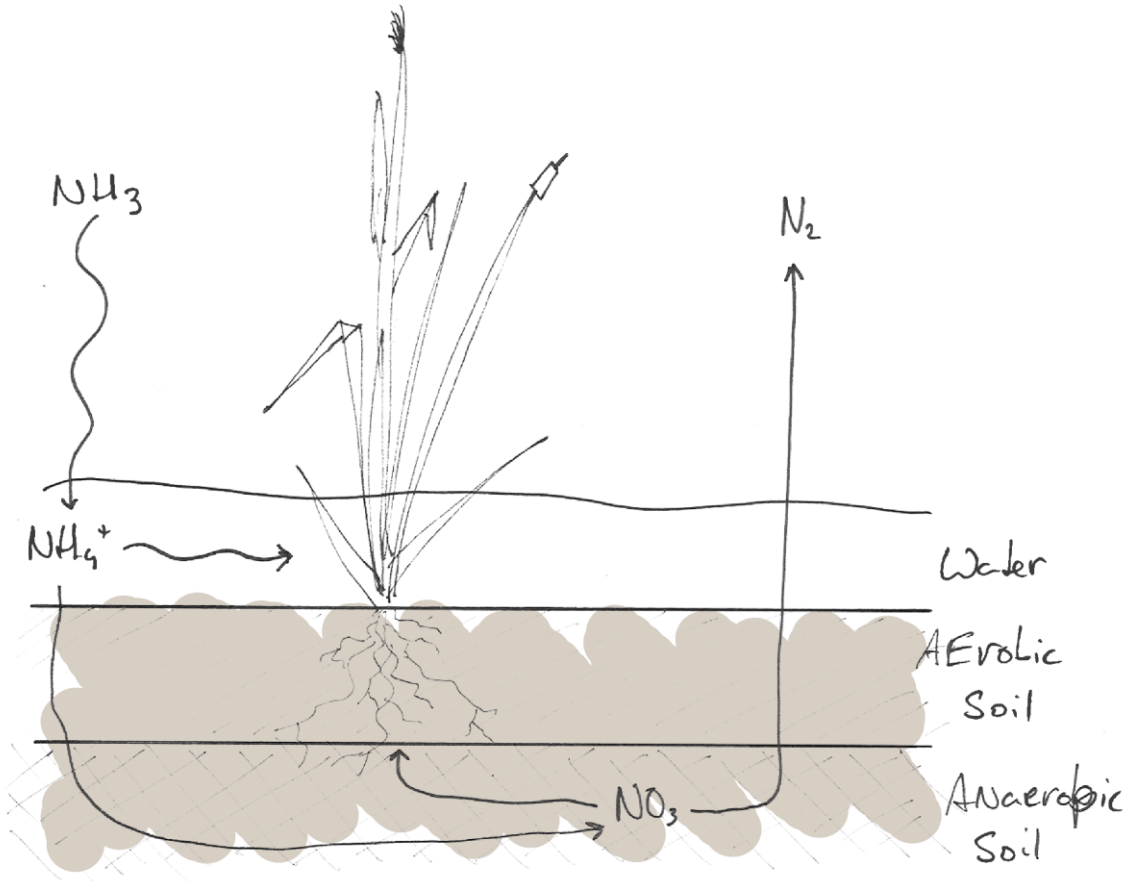


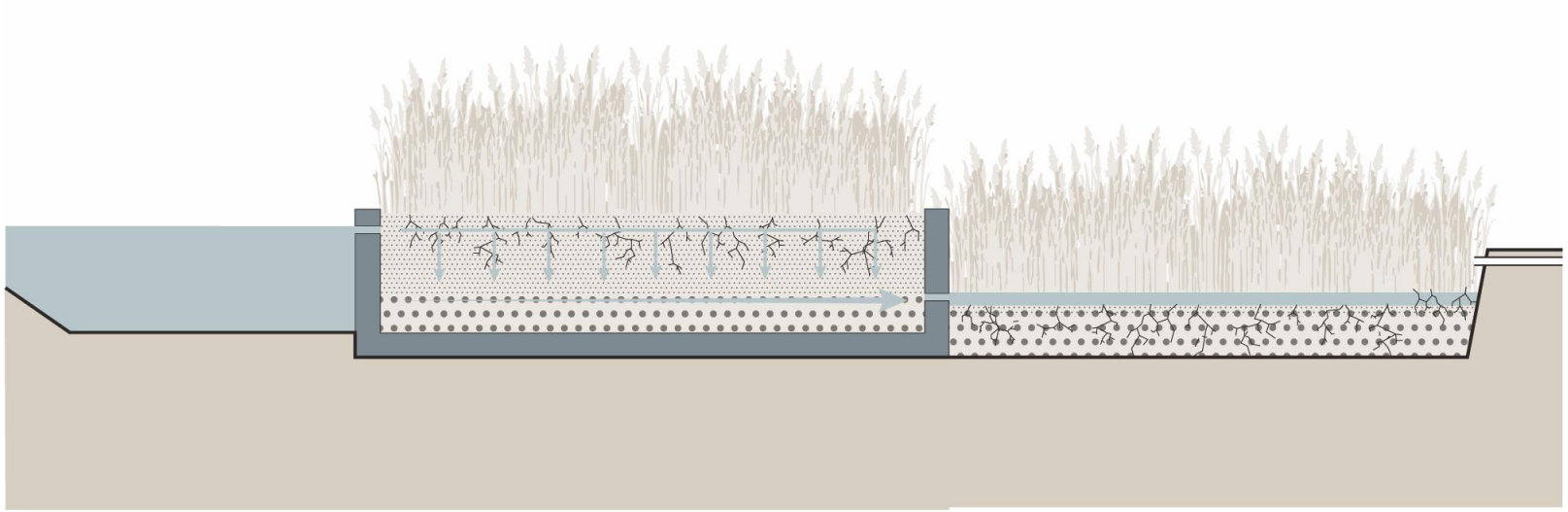
Natura2000 & landbouw



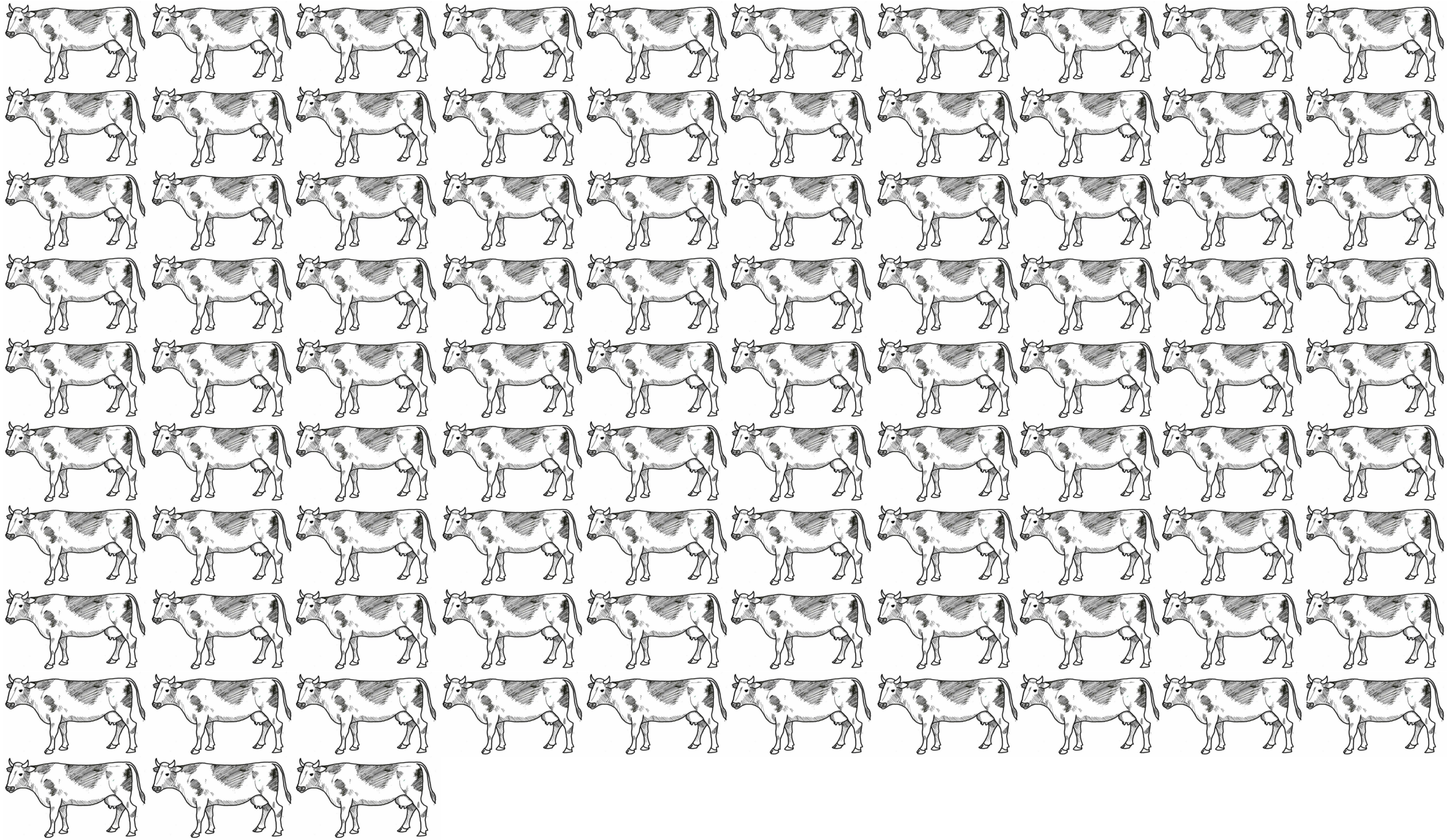
Overschrijding kritieke depositiewaarde natura2000 gebieden

RIET

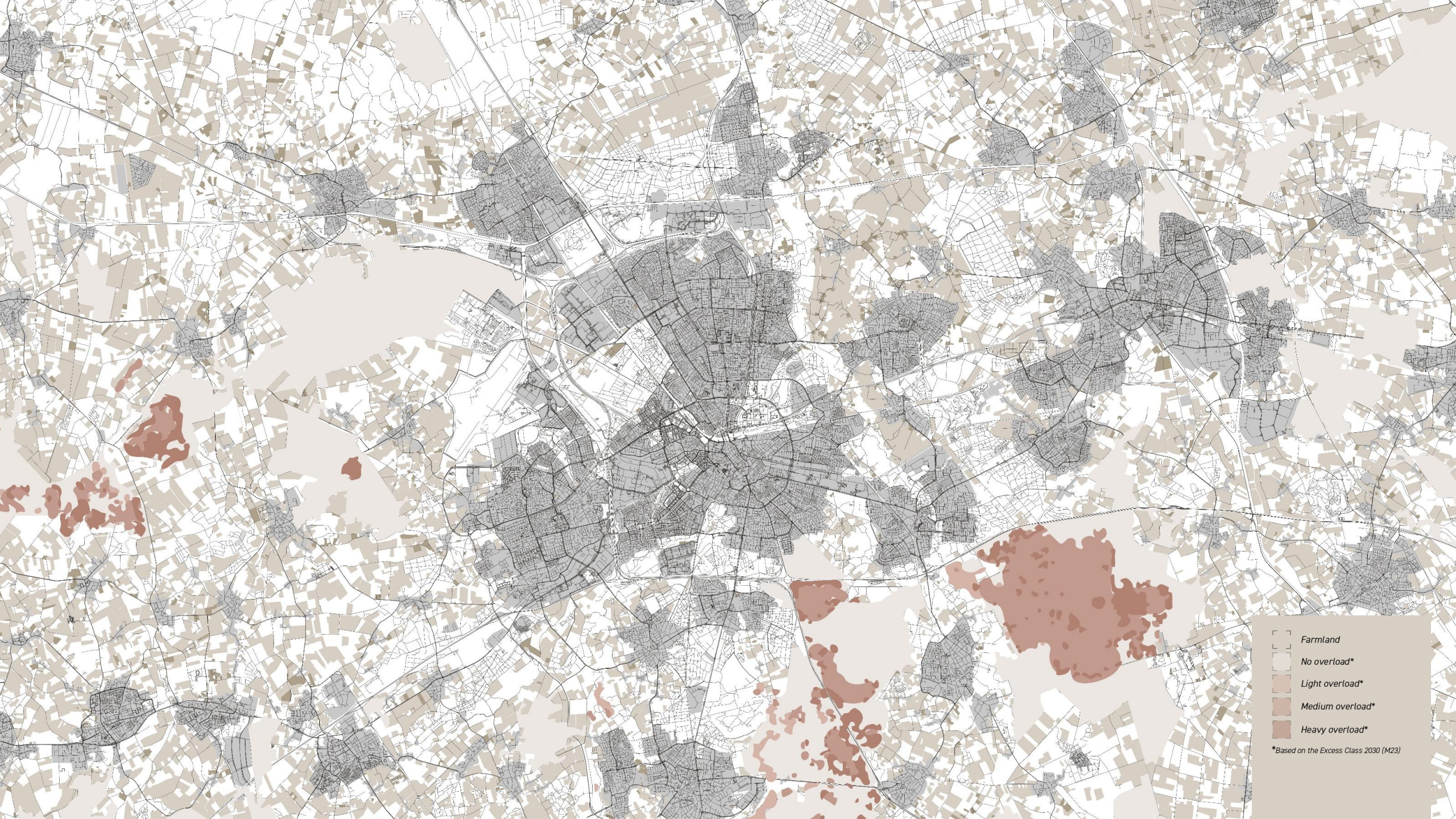

NH_3
N_2
NH_4^+
Water
AErobic
Soil
NO_3
Anaerobic
Soil



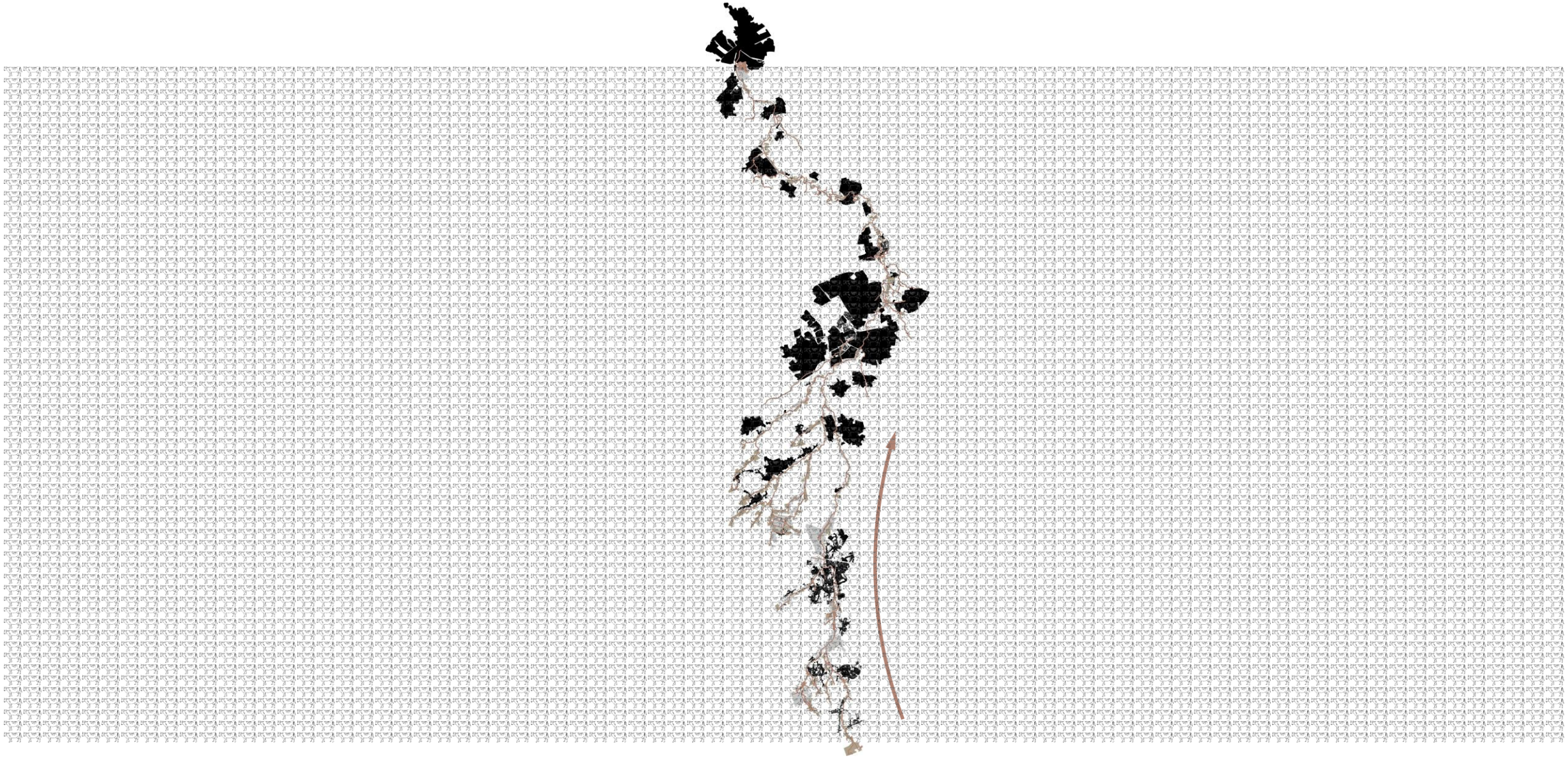
Hybride helofytenfilter ontwerp



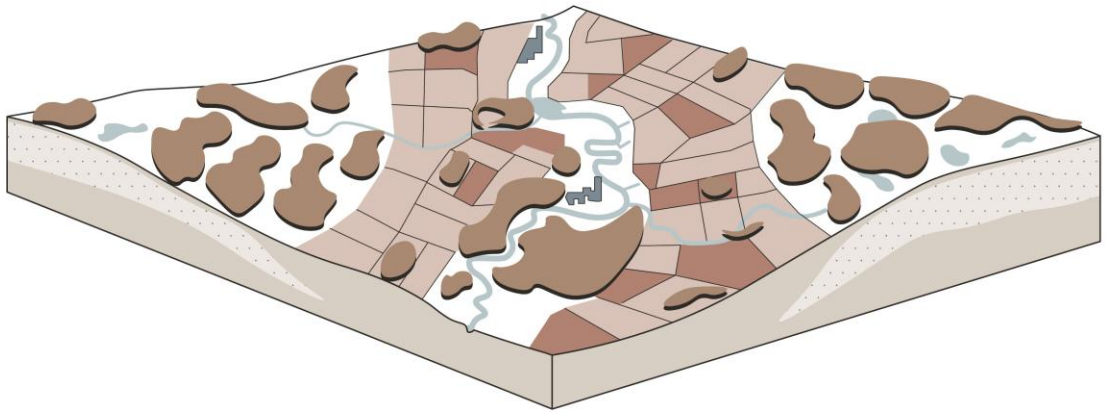

EINDHOVEN


Farmland
No overload*
Light overload*
Medium overload*
Heavy overload*
*Based on the Excess Class 2030 (M23)

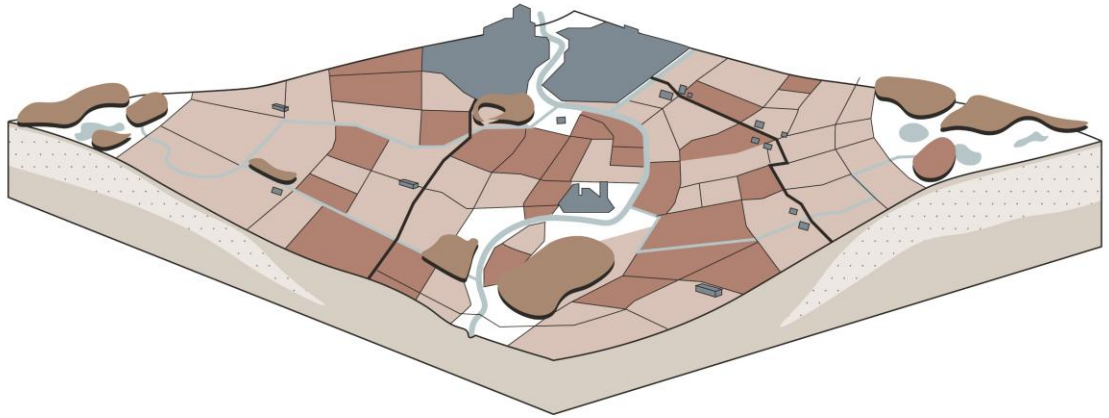
Dommelloop



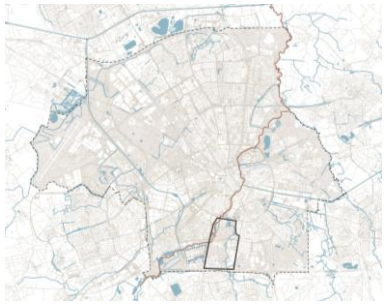
Dommelloop

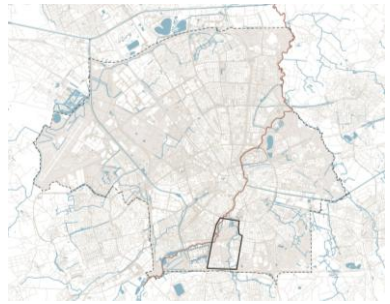


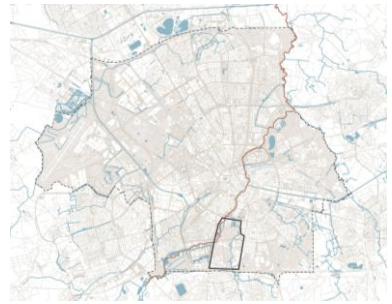
Historisch dommellandschap



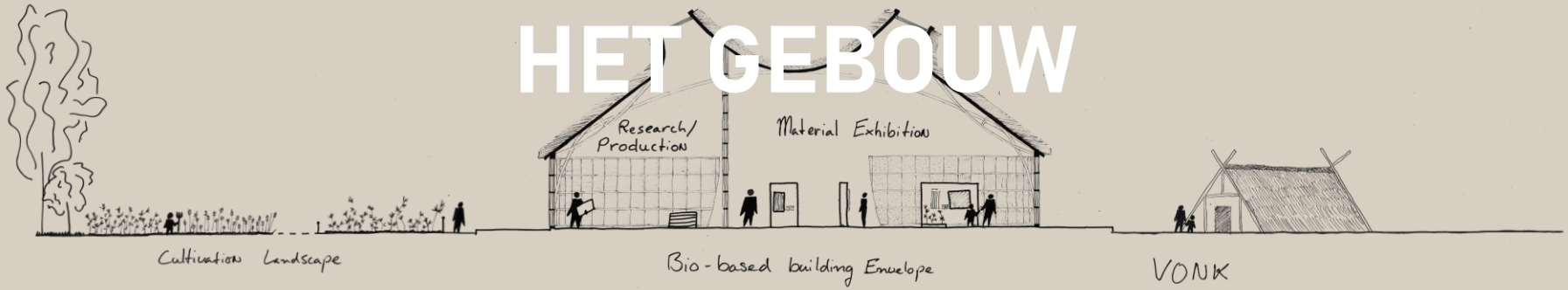
Huidig dommellandschap

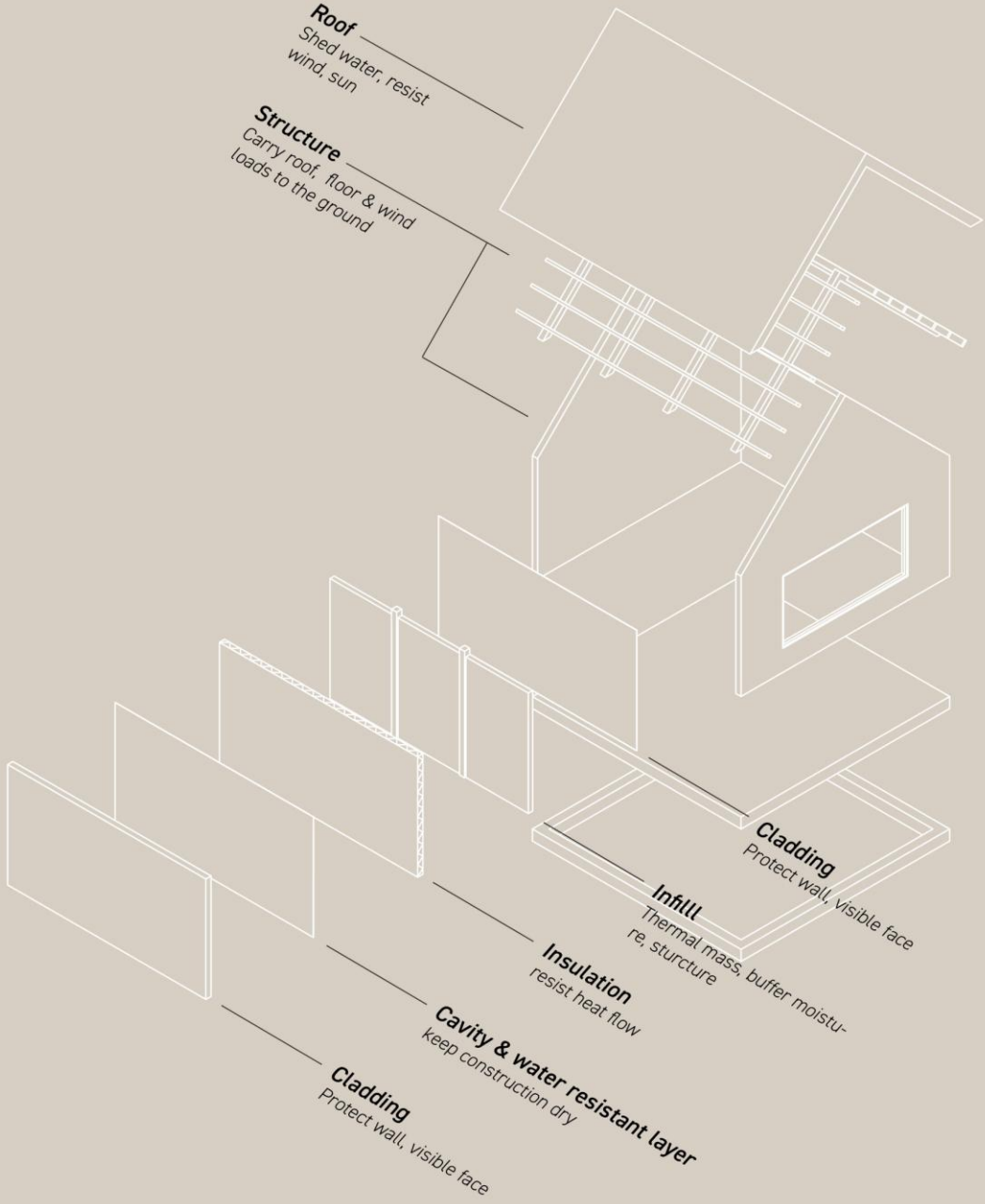


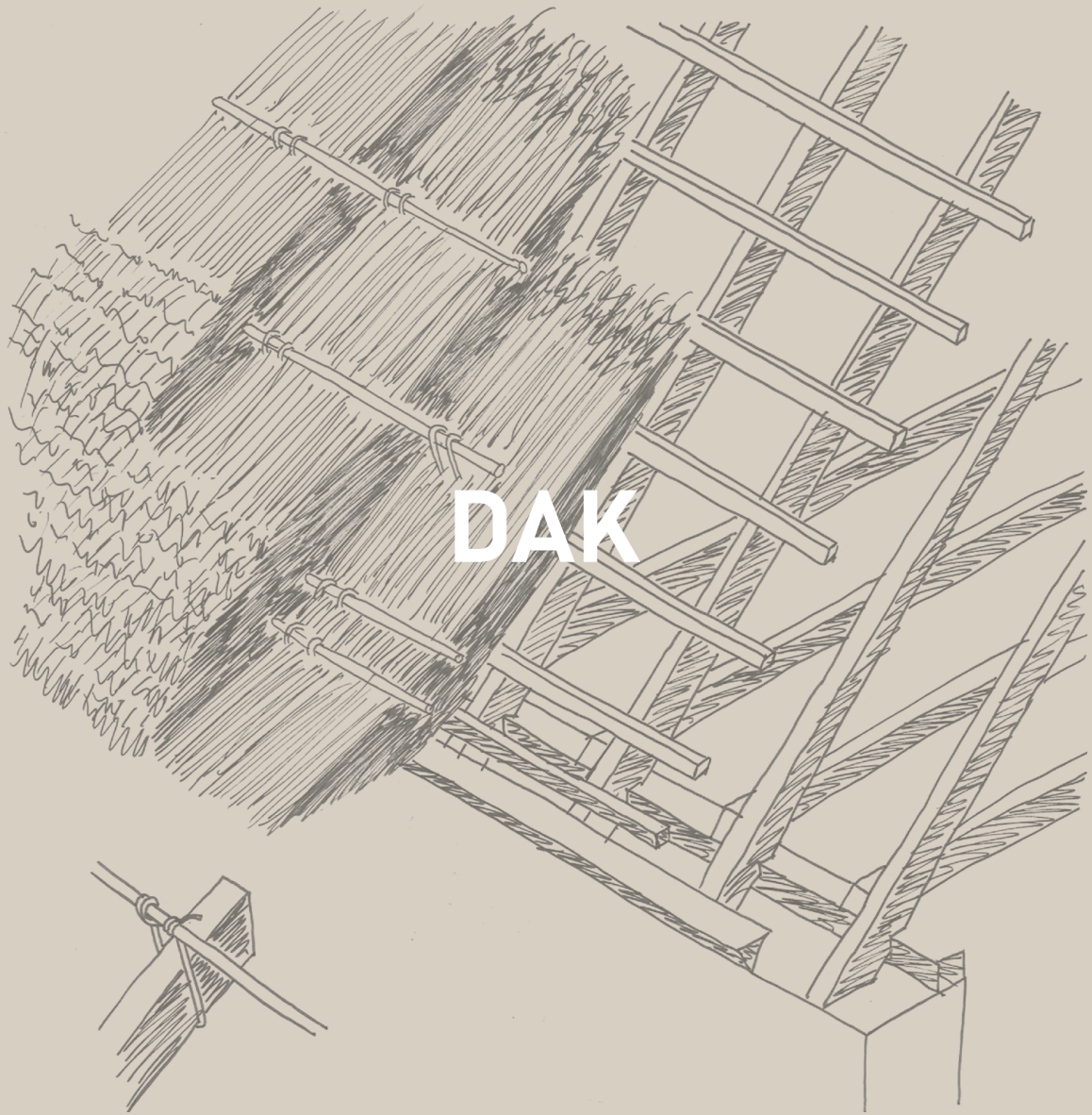


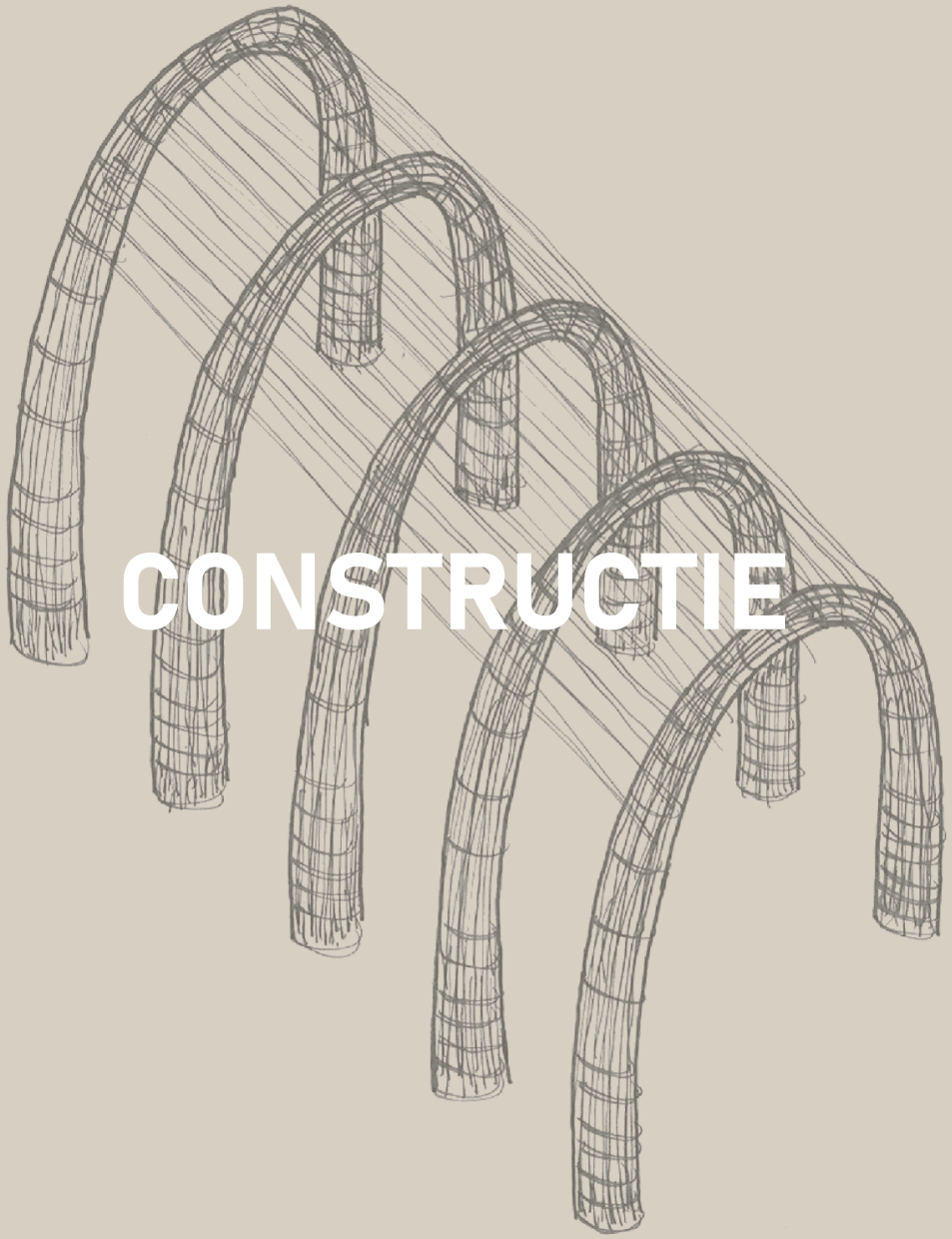


HET GEBOUW

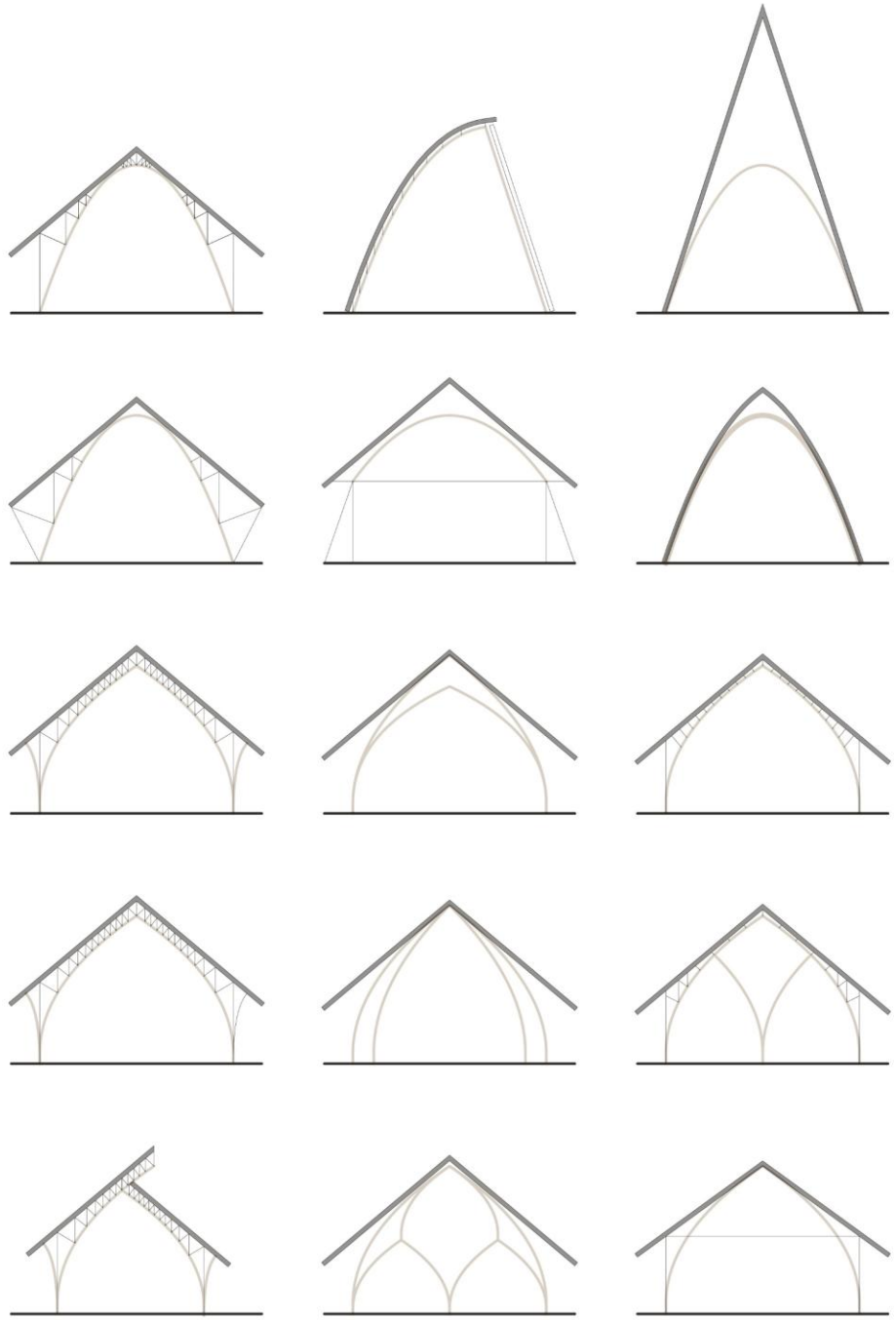

Research/
Production
Material Exhibition
Cultivation Landscape
Bio-based building Envelope
VONK


Roof
Shed water, resist wind, sun
Structure
Carry roof, floor & wind loads to the ground
Cladding
Protect wall, visible face
Infilll
Thermal mass, buffer moistu-re, sturcture
Insulation
resist heat flow
Cavity & water resistant layer
keep construction dry
Cladding
Protect wall, visible face


DAK

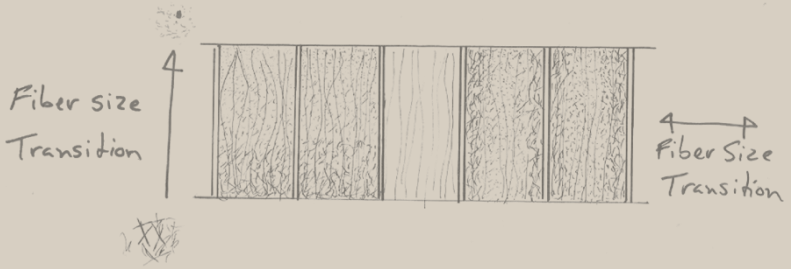


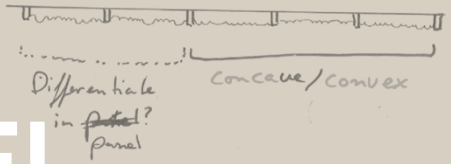
CONSTRUCTIE



GEVEL

use water wave reflection as ~~down~~ uplighting?

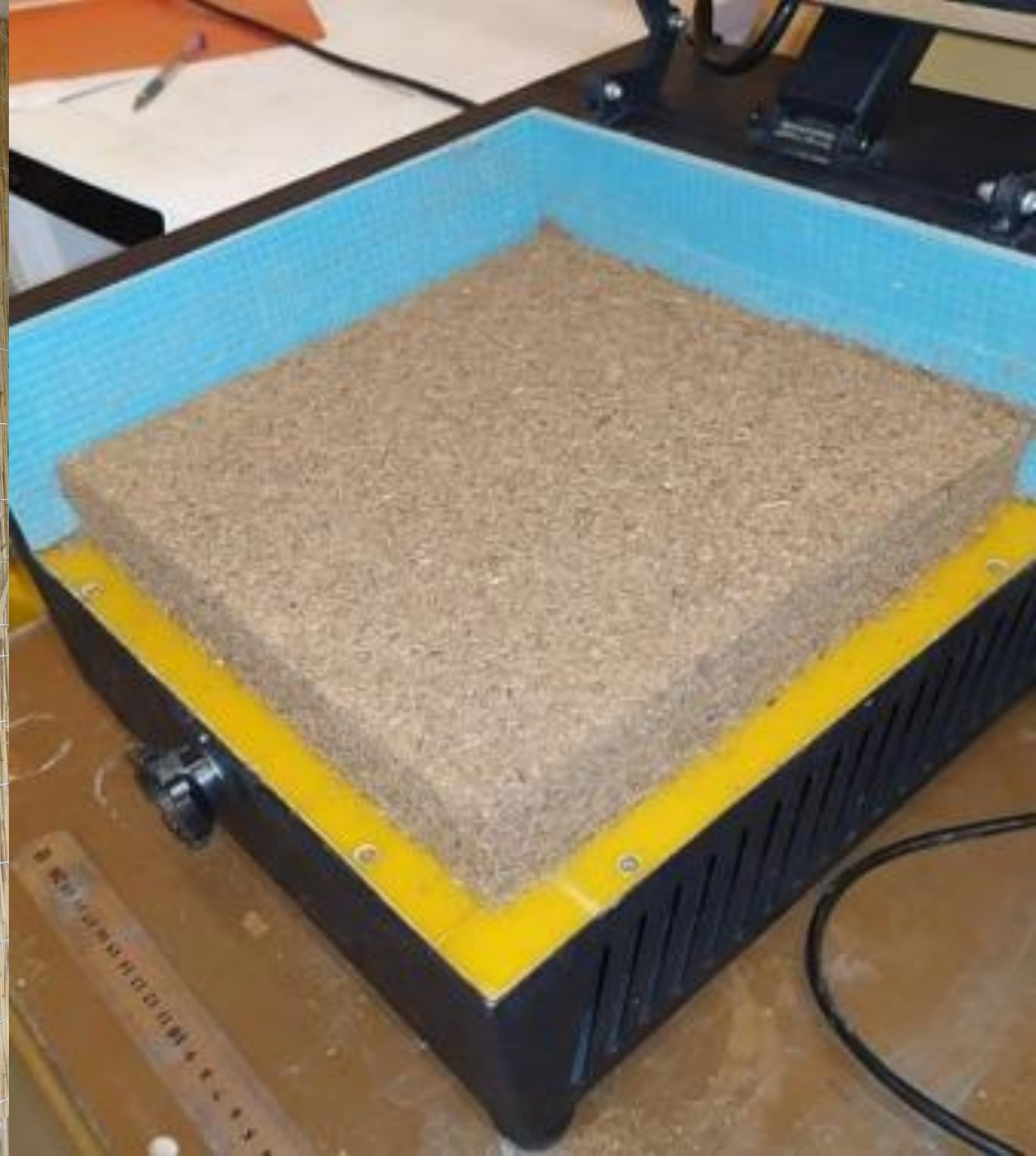


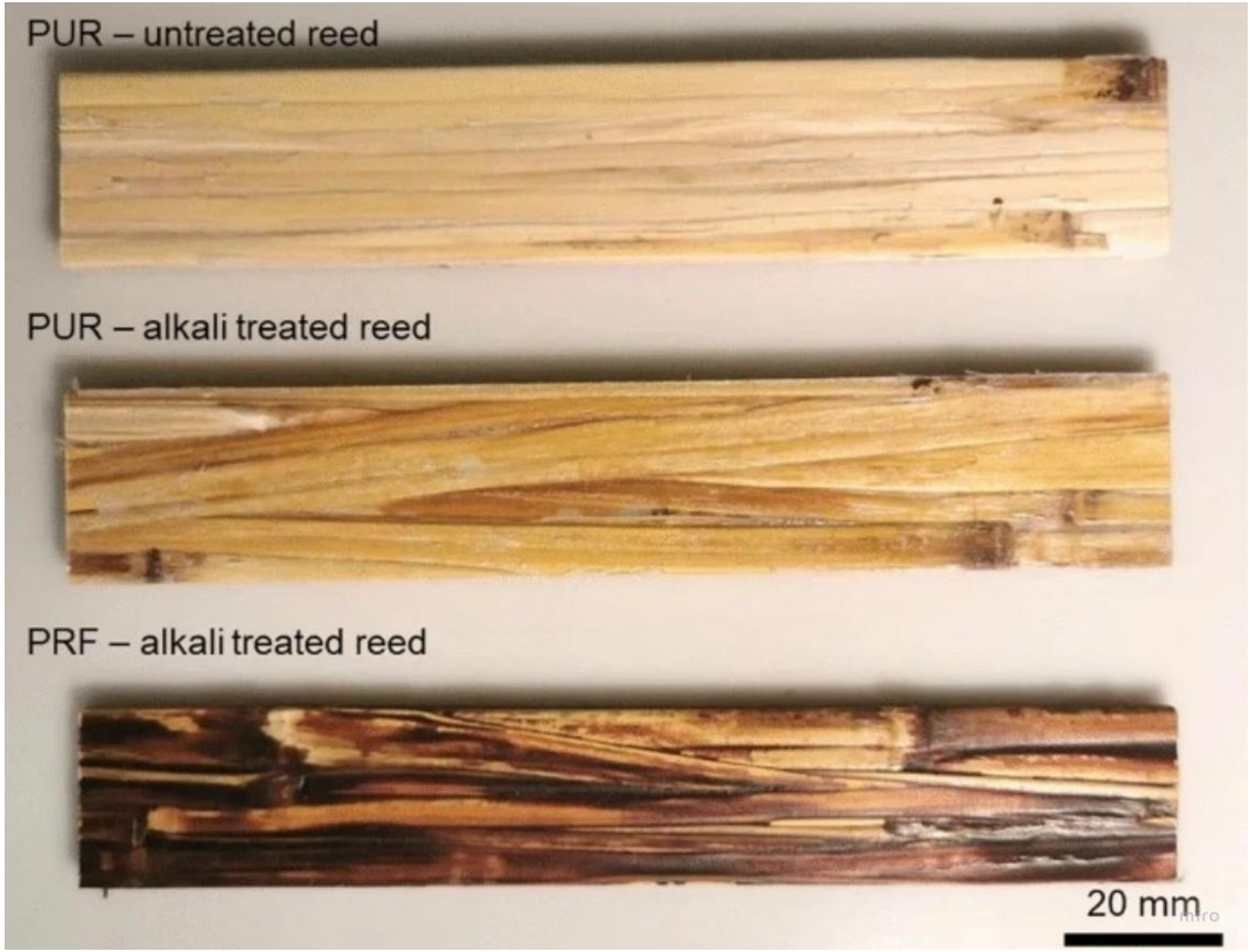


prehistoric-esque half-wood?

→ Maybe show these shapes in larger fiber size?

→ Maybe Function dictates facade rythm?




PUR – untreated reed
PUR – alkali treated reed
PRF – alkali treated reed
20 mm

Starch binder 50 mm fibers
8 g starch - 80 ml Water 15 g

Starch binder 15 mm fibers
8 g starch - 80 ml Water 15 g

Starch binder 5 mm fibers
8 g starch - 80 ml Water 15 g

Soy protein binder 50 mm fibers
5 g soy - 12 ml water - 0,4 g lime 15 g

Soy protein binder 15 mm fibers
5 g soy - 12 ml water - 0,4 g lime 15 g

Soy protein binder 5 mm fibers
5 g soy - 12 ml water - 0,4 g lime 15 g

Casein binder 50 mm fibers
6 g casein - 18 ml water - 0,8 g lime 15 g

Casein binder 15 mm fibers
6 g casein - 18 ml water - 0,8 g lime 15 g

Casein binder 5 mm fibers
6 g casein - 18 ml water - 0,8 g lime 15 g

Starch binder: light, semi-brittle, uneven bonding

Source: Plant-based polysaccharide (corn, potato, wheat).
Mechanism: Hydrogen bonding when water evaporates.
Behaviour: Low viscosity, penetrates well but limited cross-linking.
Moisture: Sensitive to prolonged humidity.
Fire: Combustible, no inherent fire resistance.
Liu, M. et al. (2013) Starch-based adhesives: structure and performance.

During pressing, a large amount of binder was squeezed out, showing low viscosity and internal cohesion under pressure. The panels are relatively light and the binder visually translucent, as it dries clear. The material is moderately strong but irregular. The 50 mm fibers show loose zones and weak cohesion, likely due to insufficient penetration and mechanical interlocking. Shorter fibers (15 mm) result in smoother surfaces and better binder distribution, indicating that starch performs better with finer fiber matrixes. Overall, the composite is quite brittle and sensitive to local inconsistencies in fiber density.

Soy protein binder: strong and well distributed

Source: Plant protein (soy flour).
Mechanism: Protein denaturation + cross-linking during curing.
Behaviour: Strong, slightly more flexible than starch.
Moisture: High sensitivity unless modified.
Fire: Organic – combustible, but can char.
Protein-based adhesives: bonding mechanisms of casein adhesives, Haddad, J. et al. (2013)

Panels show high strength and good internal cohesion. The binder remains visually transparent and allows the reed texture to remain visible. Fiber bonding appears more homogeneous than starch or casein, with fewer loose zones. The composite feels compact and mechanically stable across all fiber lengths. The binder shows consistent performance across fiber variations.

Caseïn binder :strong but unevenly distributed

Source: Milk protein.
Mechanism: Lime activates casein into calcium caseinate, creating strong mineral-protein bonds.
Behaviour: High strength, rigid matrix.
Moisture: Moderate water resistance after curing.
Fire: Slightly improved performance due to mineral (lime) content.
Du, G. et al. (2017) Soy protein adhesives: modification and bonding performance. Journal of Industrial Crops and Products.

The tests show high overall strength and medium weight. The initial white chocolate smell disappeared after curing. A slight yellow tint is visible. Although structurally strong, binder distribution appears inconsistent, particularly in longer fibers. Some areas feel under-bonded, suggesting that either higher binder content or improved mixing may be required. The composite feels dense and rigid, with good cohesion but a lot of room for optimization in homogeneity.

Tannin binder 50 mm fibers
6 g starch - 16 ml Water - 0,7 g lime 15 g

Tannin binder 15 mm fibers
6 g starch - 16 ml Water - 0,7 g lime 15 g

Tannin binder 5 mm fibers
6 g starch - 16 ml Water - 0,7 g lime 15 g

Tannin binder: visible but brittle

Source: Tree bark extract (polyphenols).
Mechanism: Phenolic-type cross-linking reactions.
Behaviour: Rigid and brittle matrix without plasticizers.
Moisture: Good resistance once cured.
Fire: Better charring behaviour due to phenolic structure.
Tannin adhesives: A century of development, Roux, A. (2016)(2015)

The panels are extremely brittle. The 50 mm sample fractured completely, while 15 mm and 5 mm samples show chipped edges and corner failure. Black spotting is visible, likely from lime reaction. The panels have a darker brown coloration and slightly glossy, reflective surface. The material feels rigid but fragile, suggesting strong but inflexible cross-linking behaviour.

(Bio) Epoxy binder 50 mm fibers
3 g epoxy resin - 5 g hardener 15 g

(Bio) Epoxy binder 15 mm fibers
3 g epoxy resin - 5 g hardener 15 g

(Bio) Epoxy binder 5 mm fibers
3 g epoxy resin - 5 g hardener 15 g

(Bio)epoxy: highest strength, non-reversible

Source: Partially plant-based thermoset resin.
Mechanism: Chemical cross-linking polymerization (irreversible).
Behaviour: Highest mechanical strength.
Moisture: Good resistance.
Fire: Depends on formulation; combustible but structurally stable.
Grau, E. et al. (2016) Bio-based epoxy resins: synthesis and applications. Polymer Chemistry.

Panels are highly cohesive and visually transparent. Mechanical strength is the highest among all tested binders. The natural reed smell disappears completely and is replaced by a noticeable chemical odor during curing. The composite is dense, strong, and structurally reliable, but lacks the material reversibility of the bio-based binders.

Starch is an abundant, renewable carbohydrate binder with adhesive properties, but is highly hydrophilic and often modified to improve performance.

Structural strength ●●○○○
Low mechanical bonding without modification

Durability ●●○○○
Poor in humid/outdoor environments without protection

Fire resistance ●●●○○
Organic but tends to char without propagating flame

Water resistance ●○○○○
High water sensitivity unless chemically modified

Sustainability ●●●●◐
Highly renewable and biodegradable

Soy protein adhesives can achieve moderate bond strengths after denaturation or cross-linking and are widely studied as wood adhesives

Structural strength ●●●○○
Moderate bonding without denaturation

Durability ●●●○○
Susceptible to moisture and biological degradation

Fire resistance ●●◐○○
Combustible but mineral fiber reduces flame spread

Water resistance ●●○○○
Improved over starch but still sensitive

Sustainability ●●●●○
Highly renewable and biodegradable

Casein reacts with calcium ions to form calcium caseinate, meaning chalk significantly improves bonding and water resistance in cold conditions

Structural strength ●●●●○
Calcium crosslinking improves internal bonding

Durability ●●●○○
Acceptable if protected from prolonged moisture

Fire resistance ●●○○○
Protein combustible but mineral fiber reduces flame spread

Water resistance ●●●○○
Improved via calcium caseinate formation

Sustainability ●●●●○
Bio-based but animal-derived

Tannins are plant-derived polyphenols capable of forming adhesive networks, but without thermal curing their crosslinking is limited, unless chemically activated.

Structural strength ●●○○○
Cold pressing limits crosslink density, increases brittleness

Durability ●●●○○
Moderate; sensitive to humidity cycling

Fire resistance ●●●●○
Aromatic phenolic structure

Water resistance ●●○○○
Still moisture-sensitive unless crosslinked

Sustainability ●●●●◐
Highly bio-based and low toxicity

Bio-epoxy systems cure chemically at ambient temperature, forming a crosslinked thermoset network even under cold pressing. Chalk increases stiffness and fire performance.

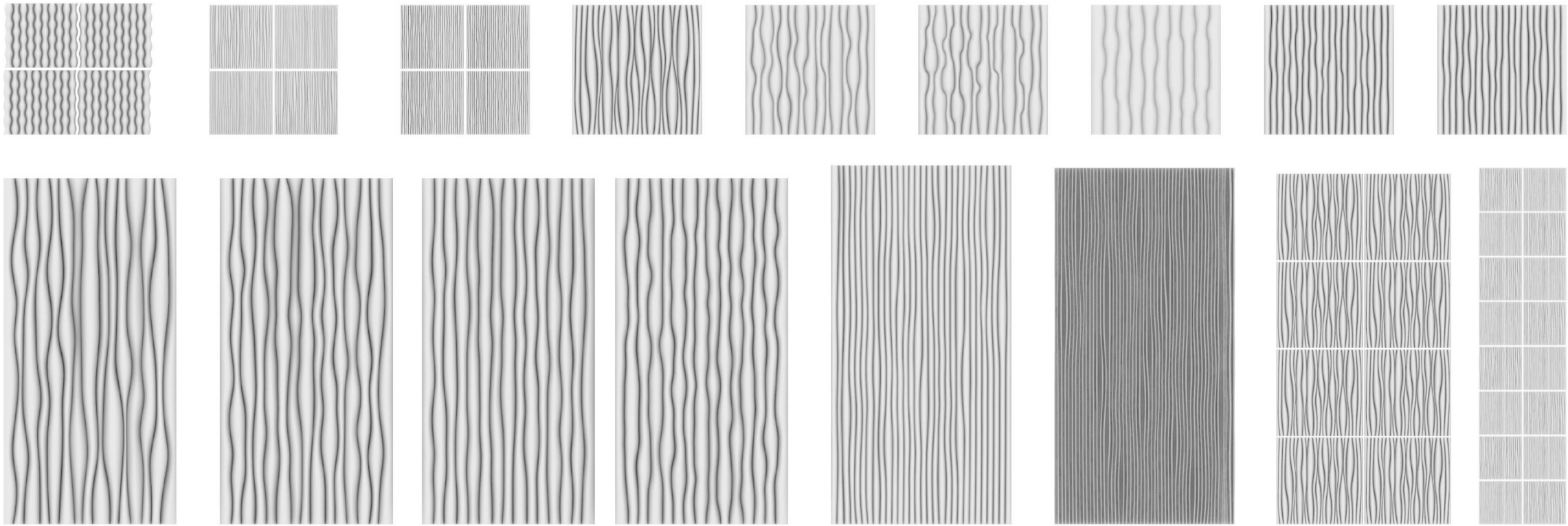
Structural strength ●●●●○
Strong fiber adhesion and matrix cohesion

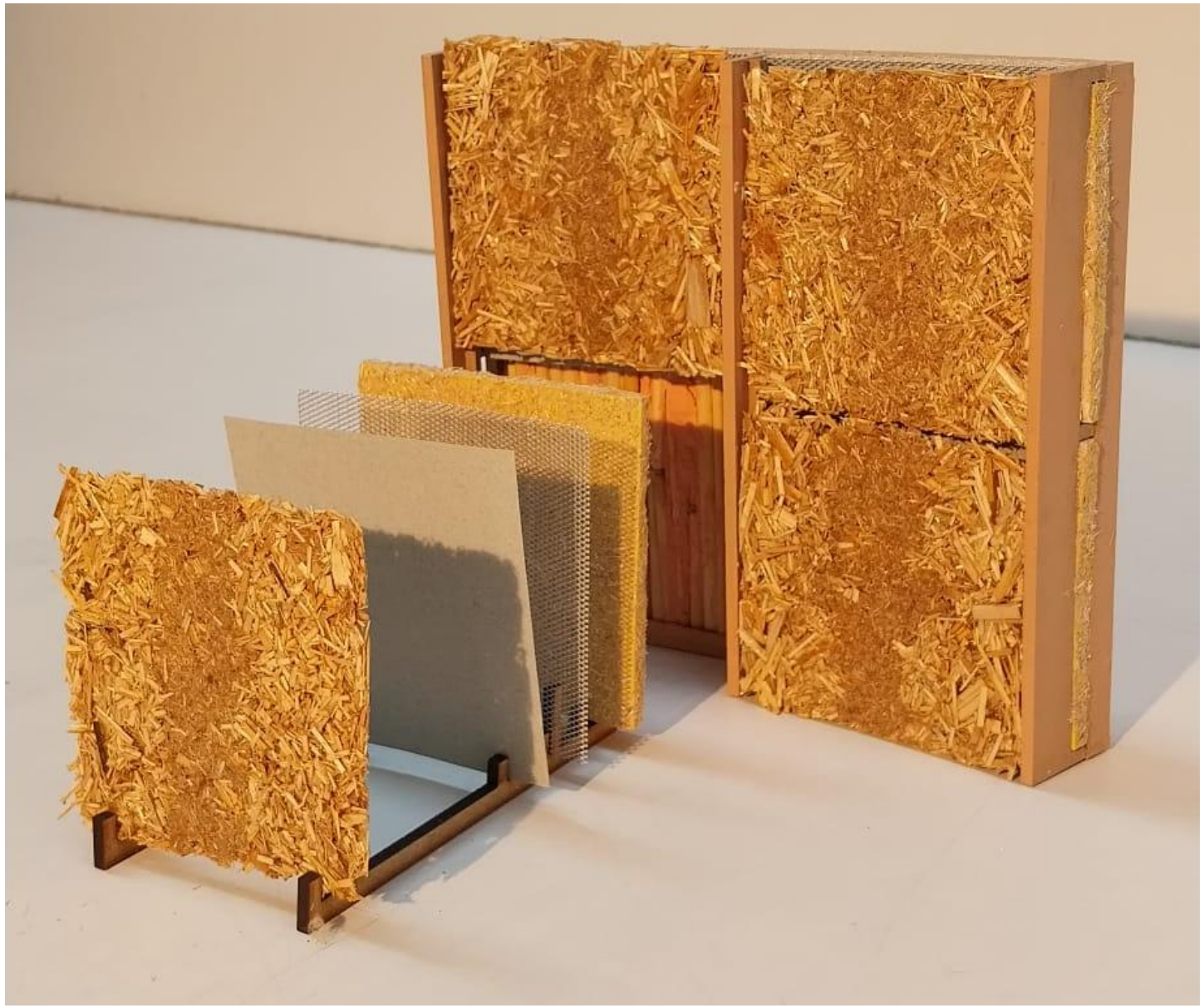
Durability ●●●●○
Excellent long-term stability

Fire resistance ●●●○○
Better than proteins but still combustible unless modified

Water resistance ●●●●○
Hydrophobic crosslinked network

Sustainability ●●●◐○
Partially bio-based; not biodegradable

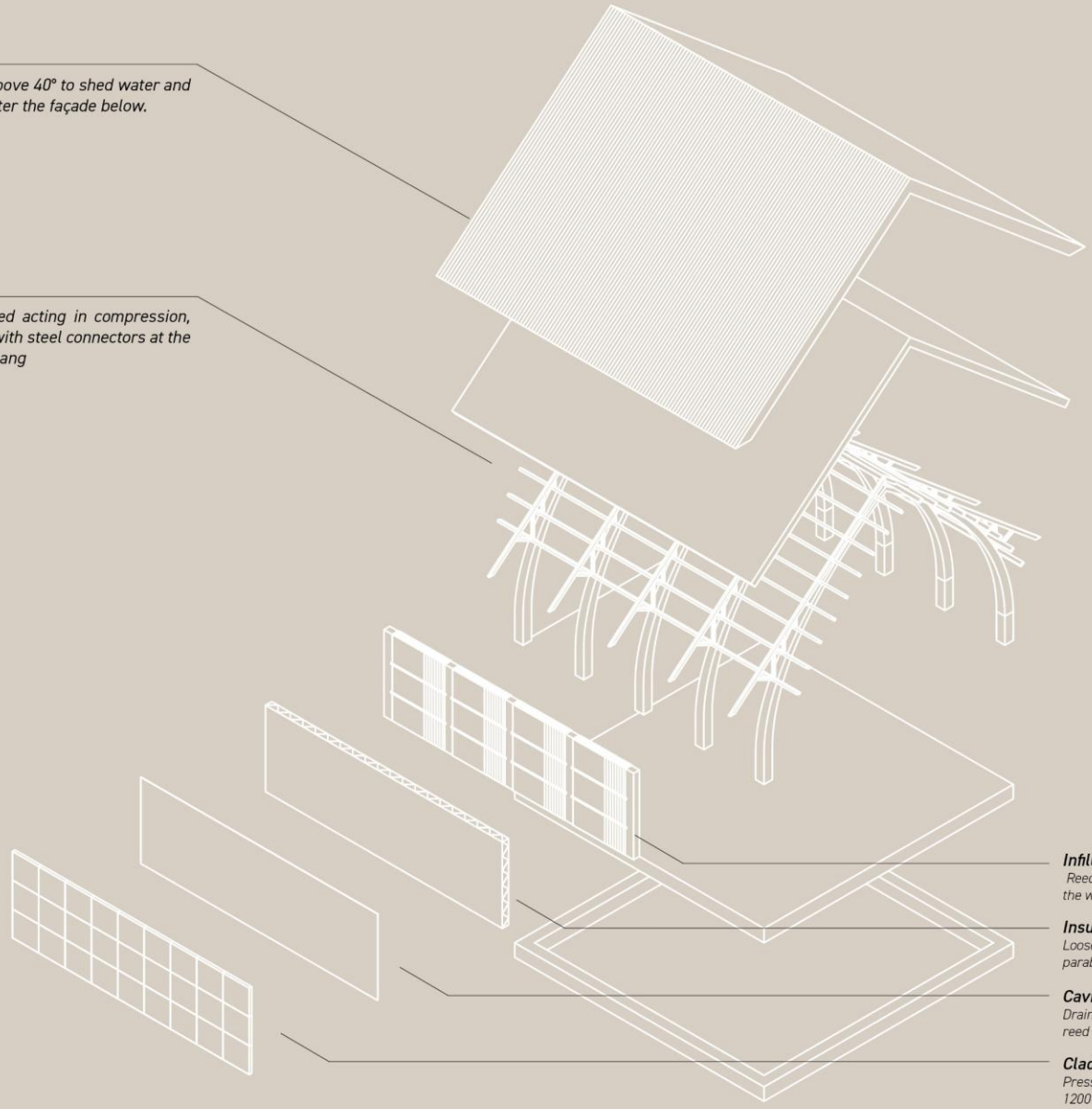




ONTWERP

Thatched roof
Thatch of whole reed stems, pitched above 40° to shed water and decay slowly with overhangs that shelter the façade below.

Bundled reed portal structure
Mudhif-derived arches of bundled reed acting in compression, spanning the long single-storey plan, with steel connectors at the binding points carrying roof and overhang

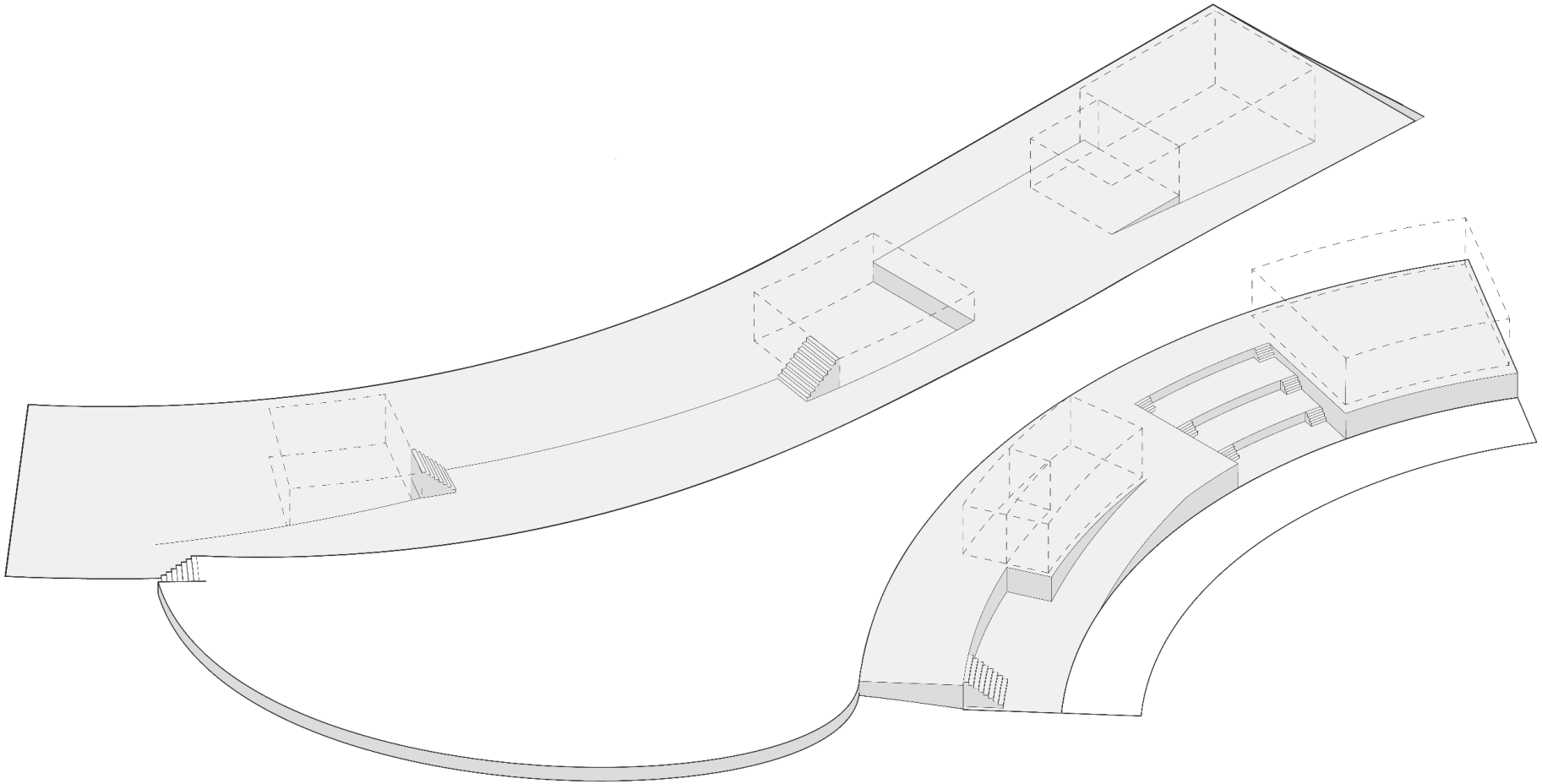


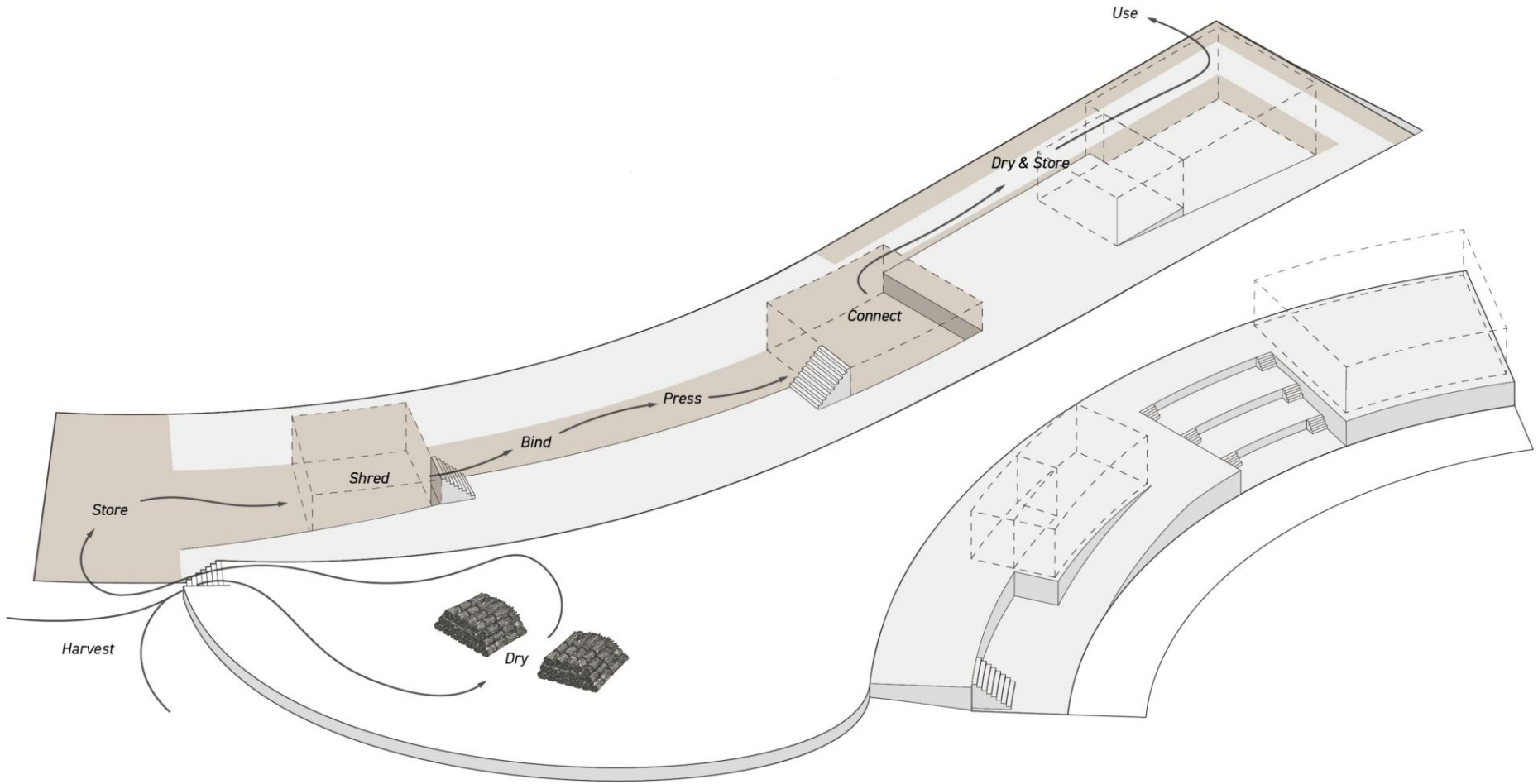
Infilll
Reed-clay thermal mass and moisture buffering on the warm side

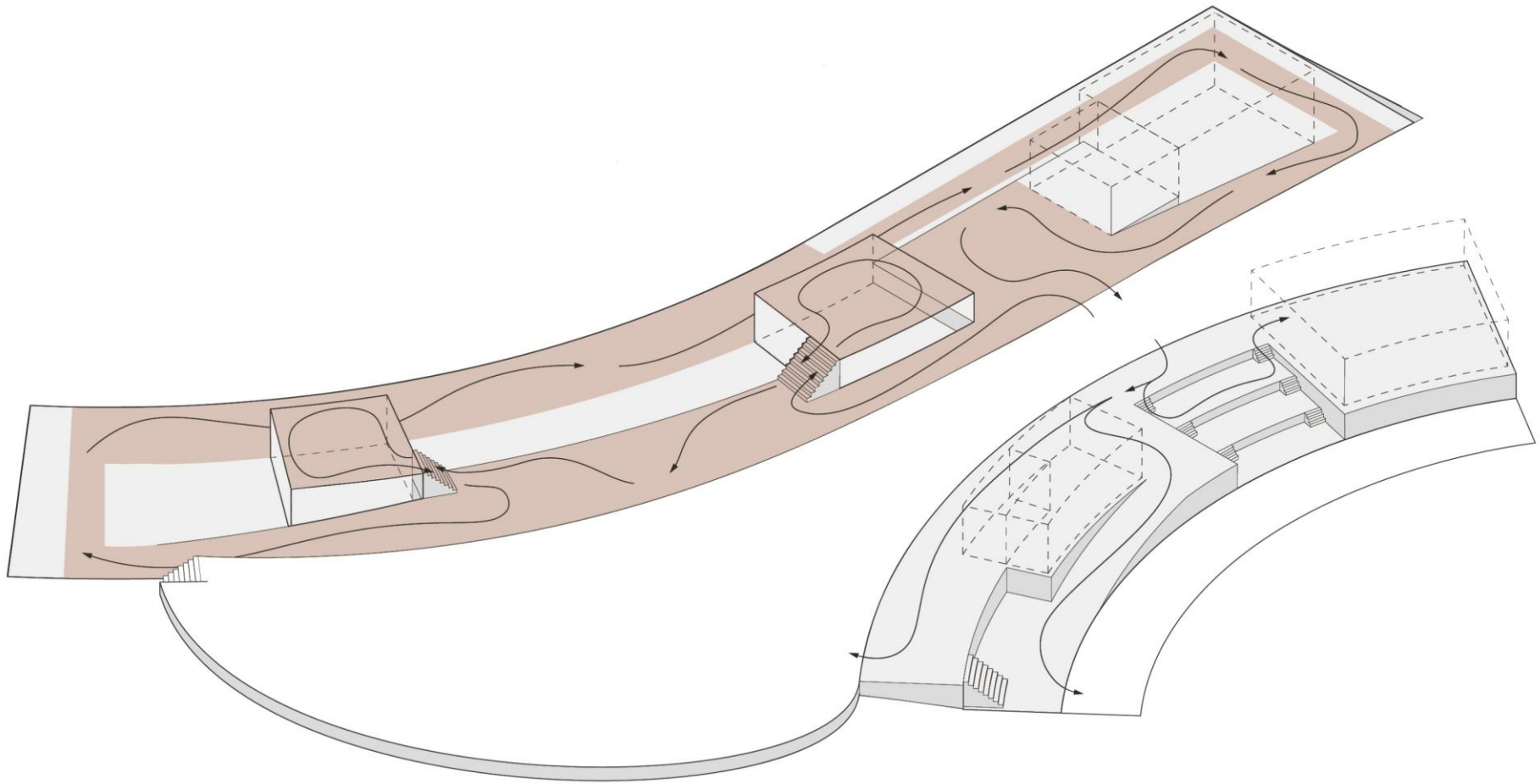
Insulation
Loose reed fibre traps air; ~0.06–0.08 W/m·K, comparable to bio-based insulation.

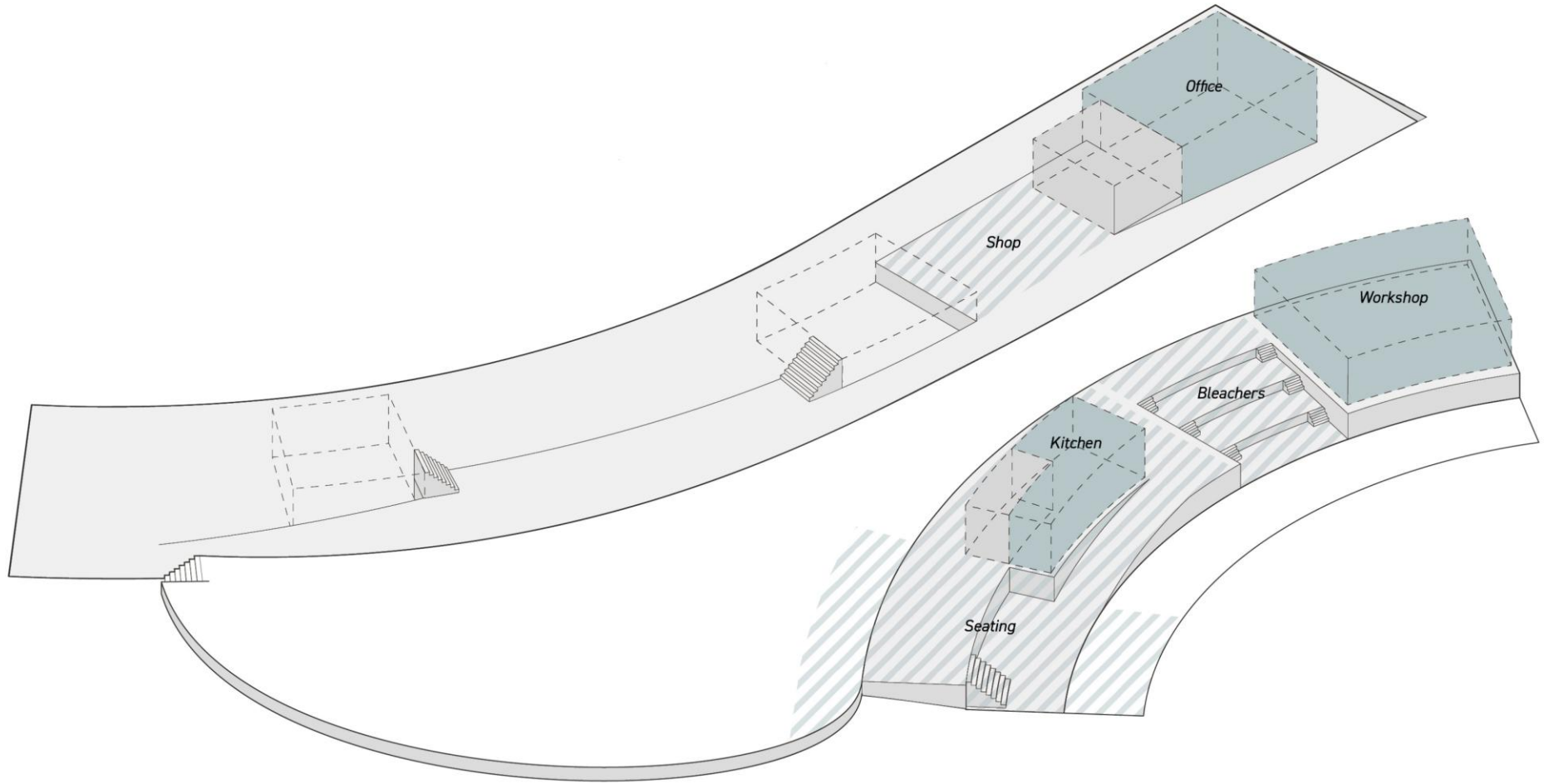
Cavity & water resistant layer
Drained, back-ventilated space keeping the visible reed dry; reconciles durability with exposure

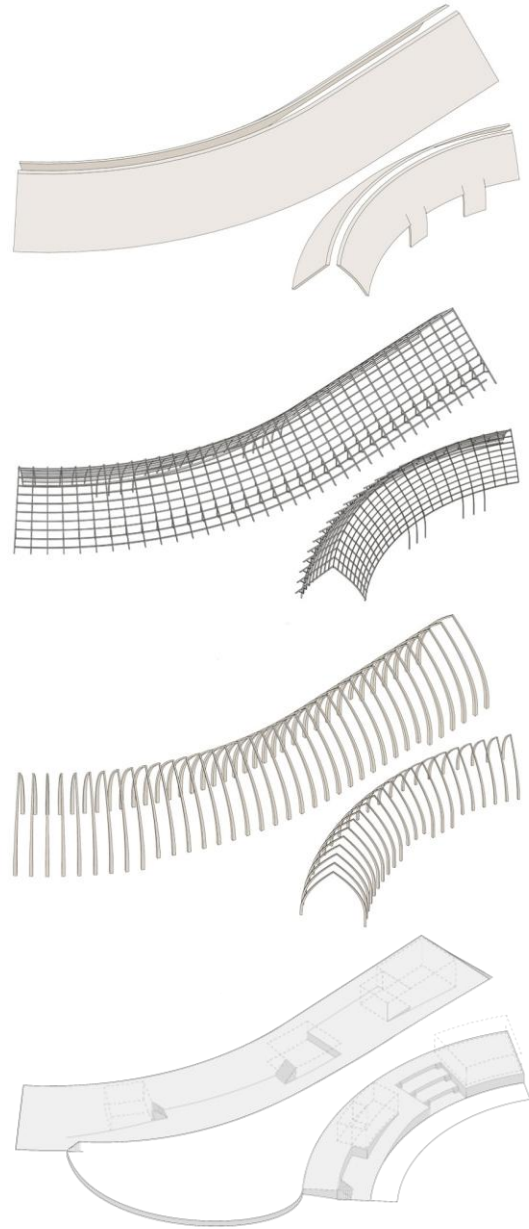
Cladding
Pressed reed-fibre panels (ventilated) Standardised 1200×1200 mm, mechanically fixed and fully removable; shows the material while being replaceable as it weathers.

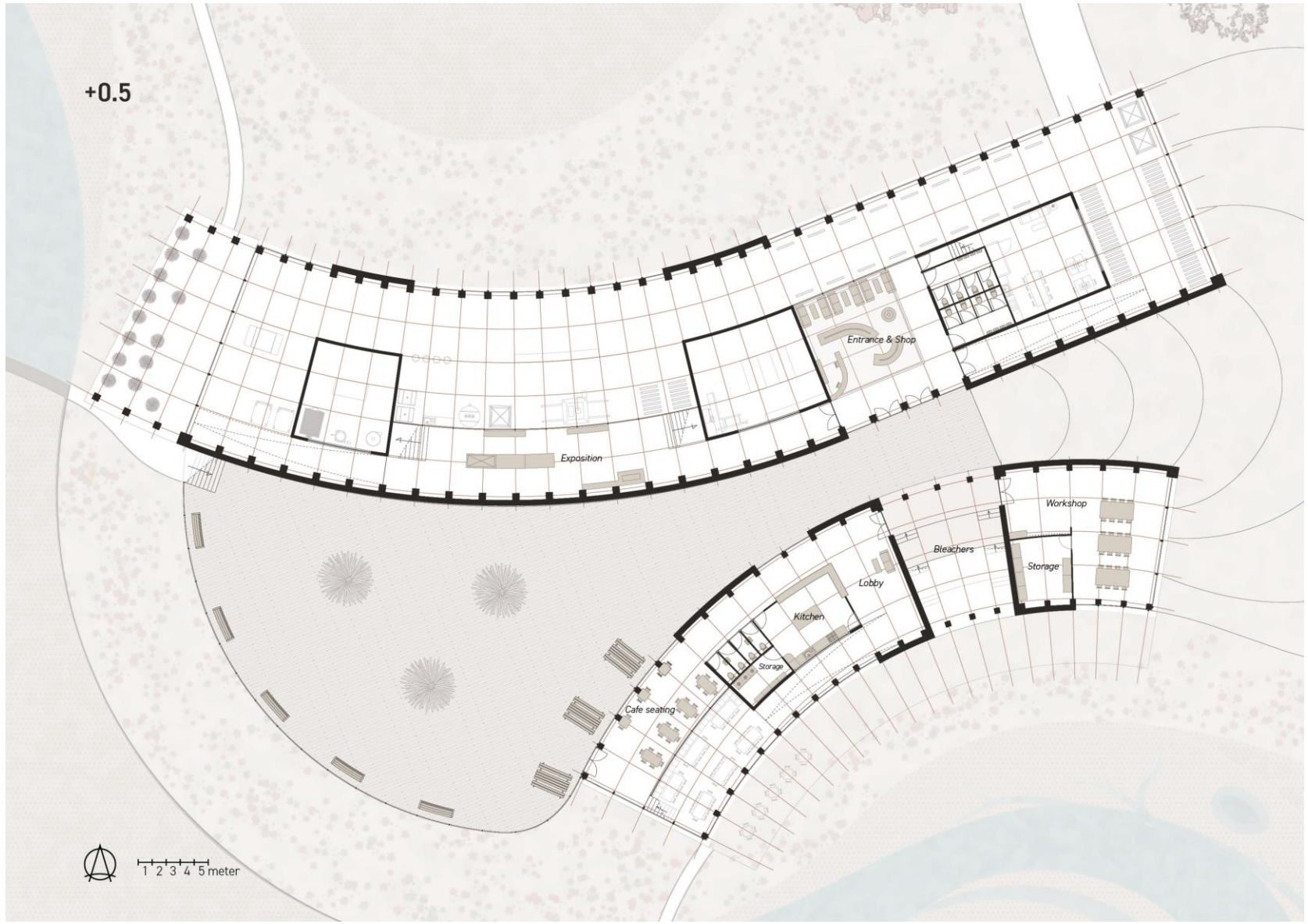


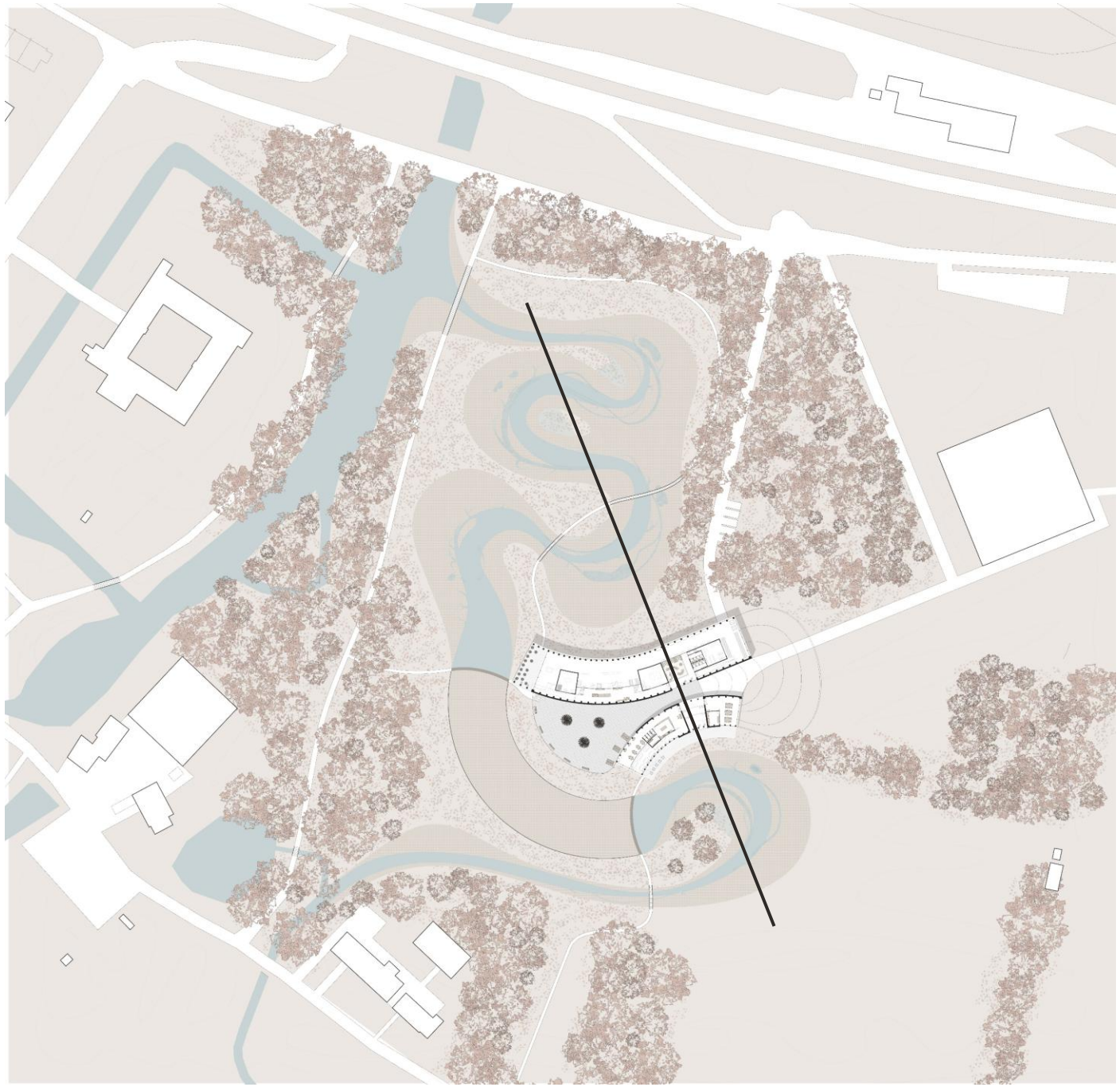

Use
Dry & Store
Connect
Press
Bind
Shred
Store
Harvest
Dry

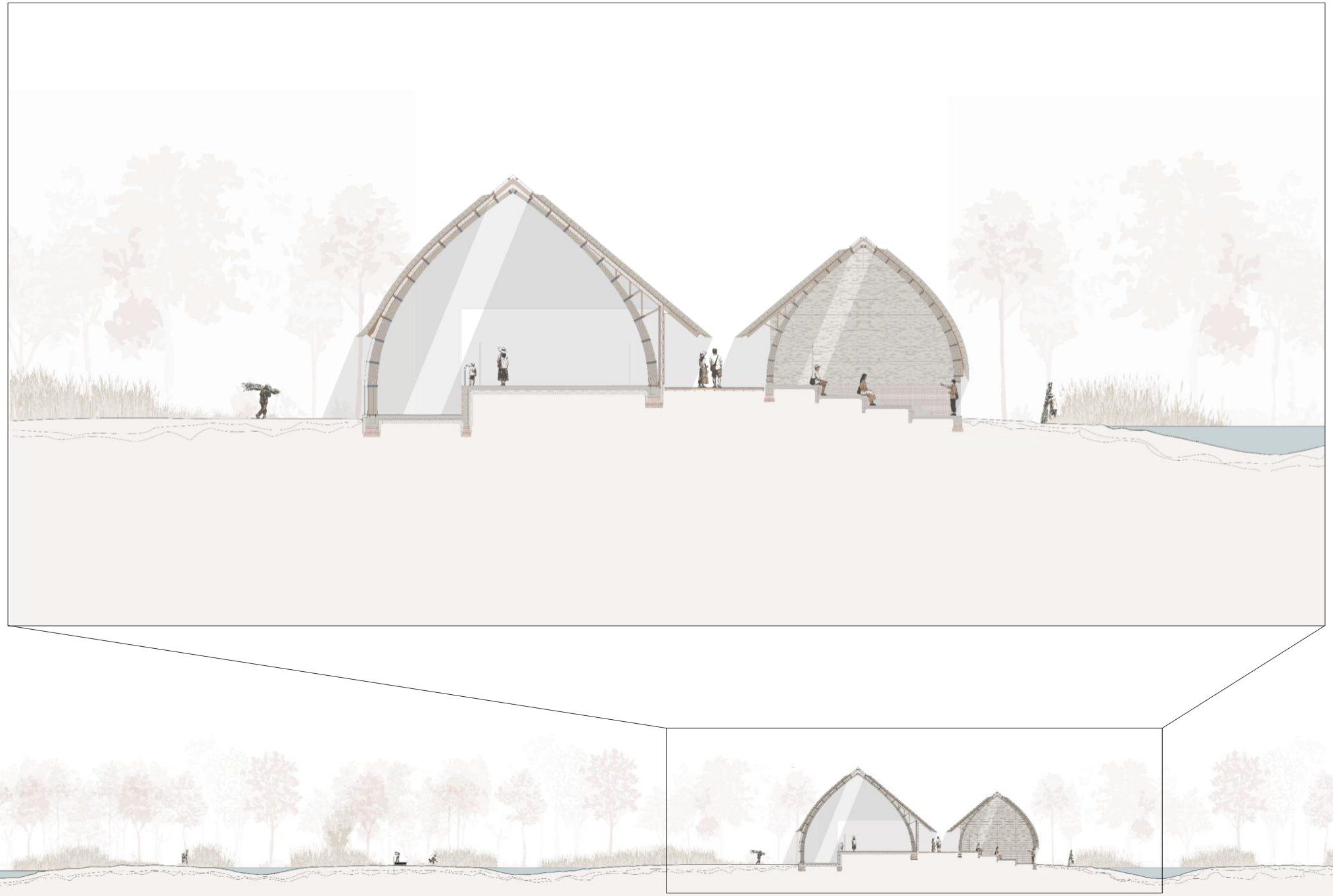



Office
Shop
Workshop
Bleachers
Kitchen
Seating

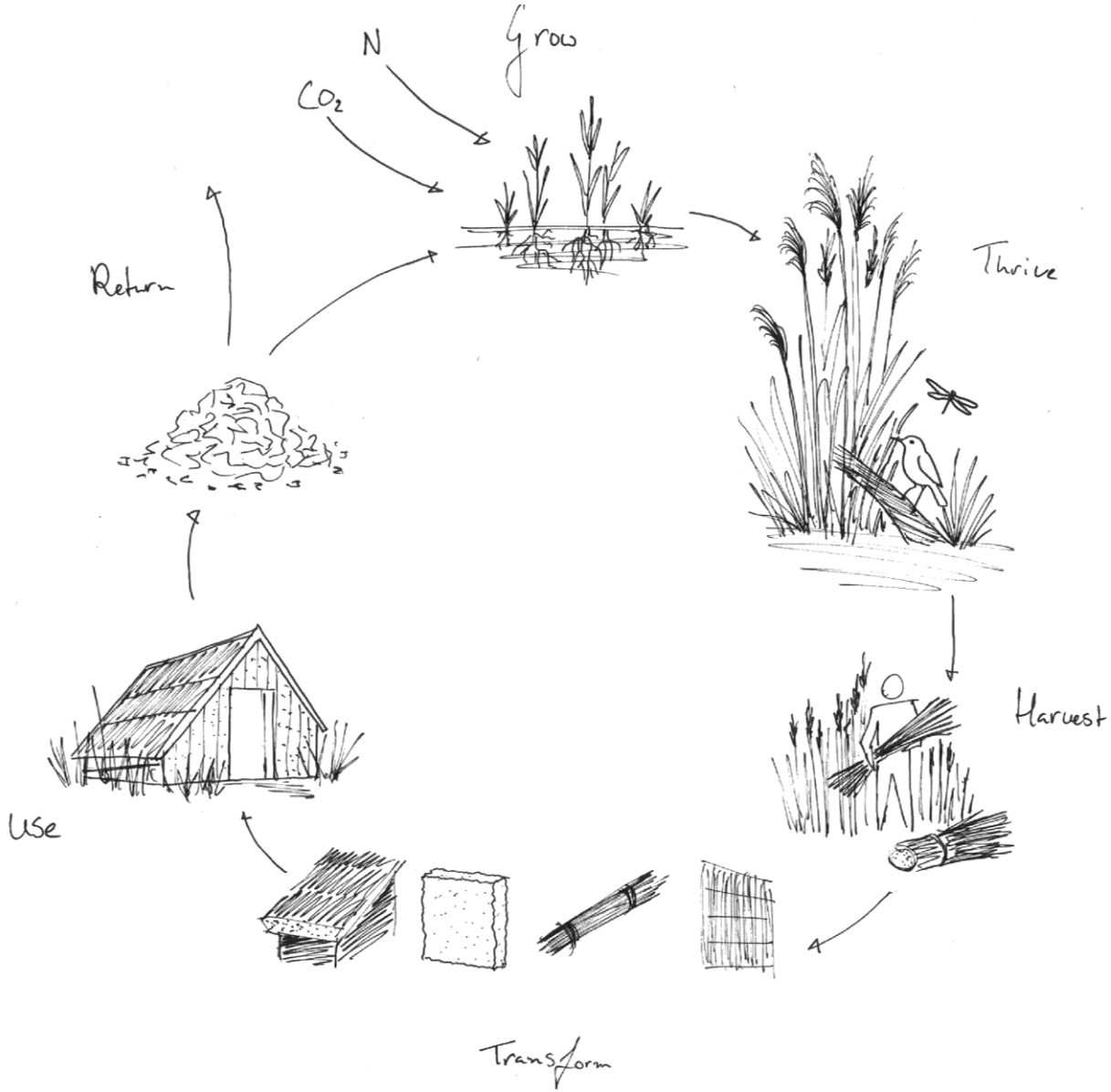



+0.5
Entrance & Shop
Exposition
Workshop
Bleachers
Storage
Lobby
Kitchen
Storage
Cafe seating
1 2 3 4 5 meter






REED PANELS
SUSTAINABLE BY NATURE


N
Grow
CO_2
Return
Thrive
Harvest
Use
Transform