The Architectural Review

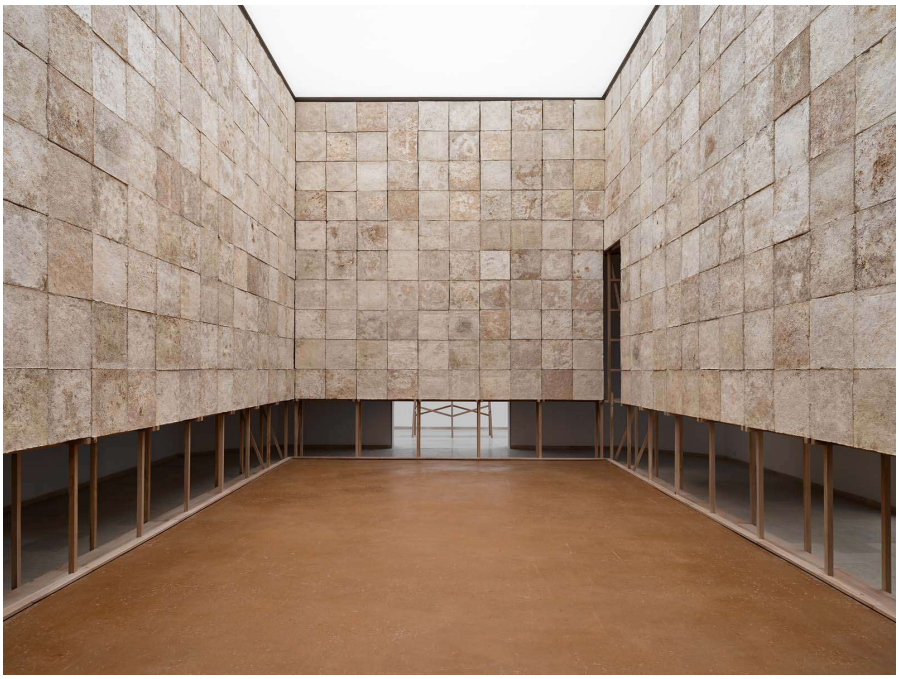
Planting a seed: bio-based building

15 JUNE 2023 | BY SUMMER ISLAM | KEYNOTE

As the construction industry embraces more plant-based materials, their cultivation must be scaled up in a responsible manner

Before the Industrial Revolution in Europe, and the widespread use of petrochemical energy sources and products, people used what they had to hand in the landscape around them to construct buildings: the clay, the stone and, of course, the plants. Following the process of industrialisation, building materials were turned into products, and a proprietary culture emerged that eroded the understanding of local building materials and construction techniques. Since then, modern globalised architectural practice has tended to keep plants at arm's length – as something to look at, as something to be controlled and maintained in gardens, or as raw material to turn into beautiful and soothing room linings.

This ideological separation of 'man' from 'nature' is, in many ways, at the root of the problems in the building industry today. The landscapes and raw materials used in shaping and building space were not formed for human use – they are a critical component of holistic ecosystems. The perception of humanity's role as manipulator and beneficiary of these ecosystems is represented very clearly in the language policy makers use to describe their roles: they provide 'ecosystem services', which society benefits from in the form of 'natural capital', represented in monetary units to be traded and exchanged. This term – 'ecosystem services' – was introduced in the 1980s to emphasise our reliance on the natural environment and aimed to appeal to a utilitarian agenda. It now dominates discourse and perpetuates a problematic anthropocentric attitude to human-nature relationships.



As argued in Belgium's pavilion at the 2023 Venice Architecture Biennale (above and below), future construction will rely on a mediation between animals and plants – and even fungi, a life form that possesses the properties of both
Credit:Ugo Carmeni 2023

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At a societal level, most people grasp the importance of plants to their lives and the ecosystems they inhabit. The success of humans as a species is inextricably interwoven with the success of plant life on Earth. Without the growth of ancient forests, the biosphere in which we live would not have enough oxygen-rich air for humans to have evolved. Without the cultivation of plants for food, humans could not have settled, built shelters and developed rich and diverse cultures. In practical terms, too, building with plants makes a lot of sense. They grow back and are relatively easy to cultivate, harvest and process into useful materials. Their inherent fibrous structures give our buildings integrity. Trees, processed into timber, work extremely well in both compression and tension. Hollow straws and grasses hold air within them, making them great insulators. The lignin in many different plants can act as a natural binder when heated, meaning that you can essentially squash them, heat them and they stick together into useful sheet materials. Mixed with different binders like clay and lime, they can be given resistance to fire, insects and mould. Bio-based materials are also hygroscopic – meaning that they hold and release moisture. The fact that they can absorb humidity from a room helps to regulate damp and prevent mould from growing. That they are moisture permeable means that water vapour trapped in walls, from rain ingress or generated through leaks, always has somewhere to go. Contemporary buildings, on the other hand, are essentially wrapped in plastic sheets, trapping in moisture and resulting in poor indoor air quality.

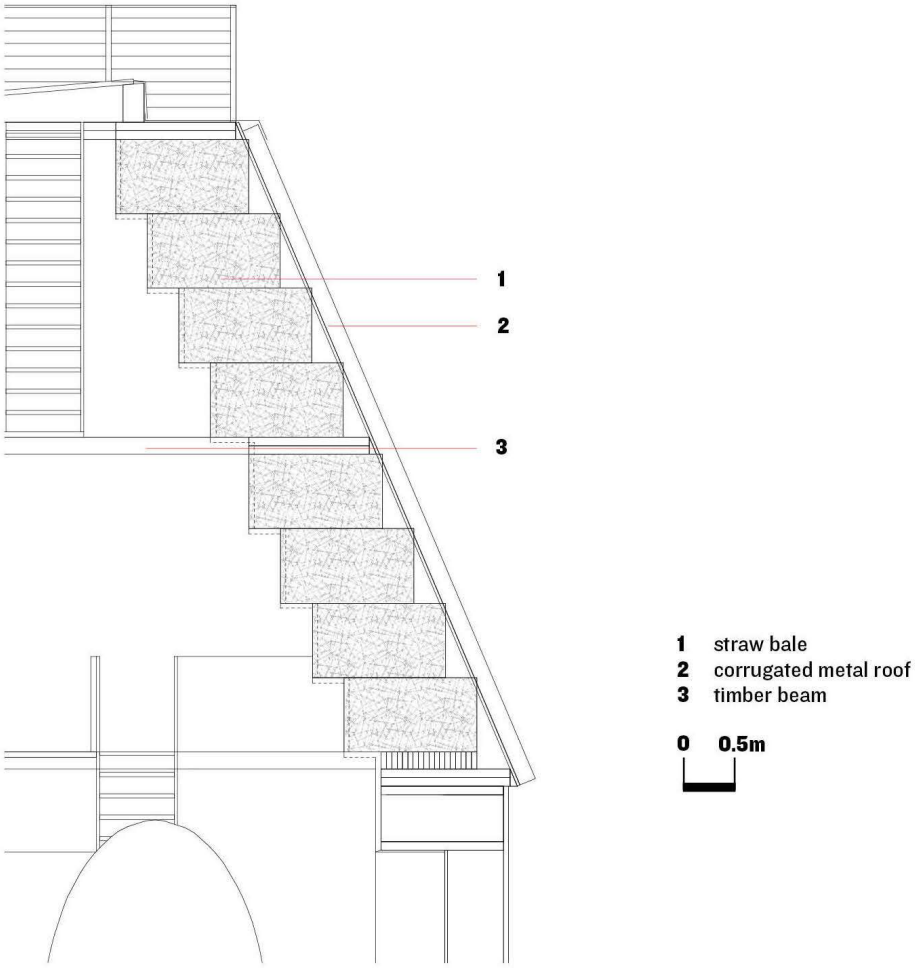
Some of the best examples of bio-based buildings are hiding in plain sight in villages, towns and cities across the globe, having withstood decades, sometimes centuries of wear and tear. Timber-framed barns, reinforced with hazel wattle and clay daub can be found dotted across the British countryside. The technique of cob building, using loadbearing clay and straw, was very commonly used in the south-west of England in the 19th century, and many of those cob buildings still stand in Devon and Cornwall today. They are finished in a lime render and look from the outside like any other stone or brick building.

> ‘In the modern construction industry, materials which have proven their efficacy over decades are considered risky, fringe and ultimately more costly’

That these techniques have not become more widespread is, at first glance, surprising. The local materials and skills used to build with them were relatively low cost, and when well maintained, extremely durable. The critical thing about these materials, however, is how they were intrinsically linked to land, and specific geographies or bioregions. Industrialisation brought with it a change in agricultural practices and land ownership. Bio-based materials were conventionally derived from agricultural waste; long wheat straw was for example used for thatching, until modern chemical fertilisers that help the wheat grow more quickly weakened the structure of the straw, making it too brittle. Water reed, also used in thatching and as a render substrate, was once abundant in wetlands, but these were drained over the course of the 19th century to develop more arable farmland, cutting by approximately 90 per cent the amount of land on which the reed could grow.

A 2020 project from Plymouth University explores contemporary applications of cob
Credit:The University of Plymouth / Photo: Lloyd Russell

Atelier Werner Schmidt's office building uses straw as a primary material
Credit:© Atelier Schmidt

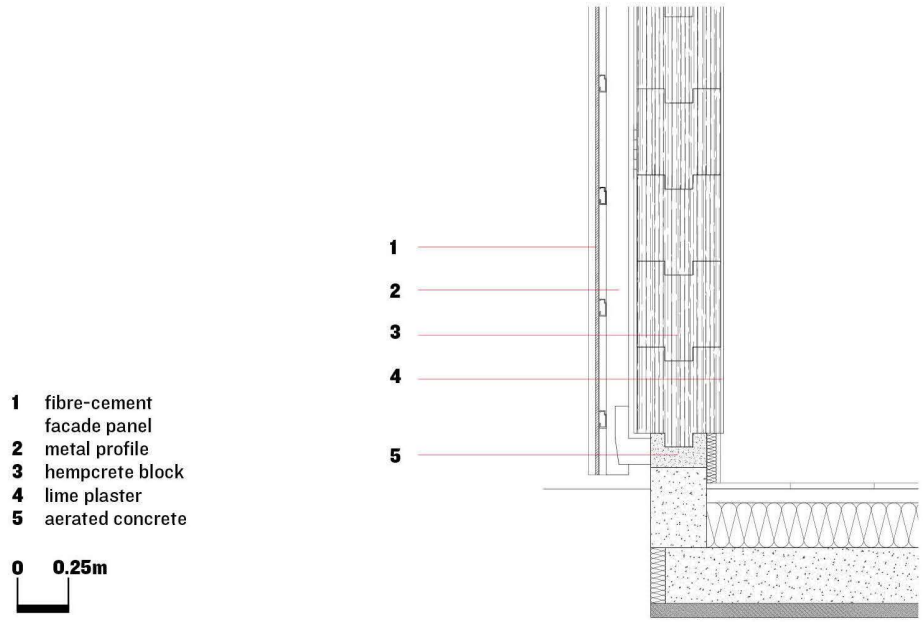


Industrialisation also brought about the development of contemporary insulations, designed initially to prevent energy loss from high-energy machinery and factory spaces. Materials such as concrete and steel, which enabled the quick assembly of spaces of production, ultimately sought markets in domestic construction too. These materials were produced at an unprecedented scale and advertised as technologically advanced, in need of little or no maintenance: symbols of a bright future in which being cold, damp and living with fire risk were a thing of the past. And as these materials became more and more popular, regulatory frameworks began to be designed around them, with lawmakers falling victim to aggressive lobbying and marketing campaigns. Today, testing and certification, mortgages and insurances in the UK and beyond are generally designed around contemporary building systems, and materials which have proven their efficacy over decades of service are considered risky, fringe and ultimately more costly.

The petrochemical and mineral materials we have been building with since the Industrial Revolution require an enormous amount of energy to be extracted and processed. The cement industry, for example, is responsible for about eight per cent of planet-warming carbon dioxide emissions – far more than global carbon emissions from aviation. We cannot continue to build using materials that generate enormous outflows of emissions and have to be shipped across great distances. We need to use materials that are lower in embodied carbon: bio-based materials, derived from plants which can regenerate sustainably and sequester carbon into our buildings.

Reed is used to create a thatched outer skin for the University of Stuttgart's Alpine hut
Credit:IBBTE / University of Stuttgart

Hempcrete, as seen at a recent French sports centre by Lemoal Lemoal, is often presented as a viable alternative to concrete
Credit:BCDF



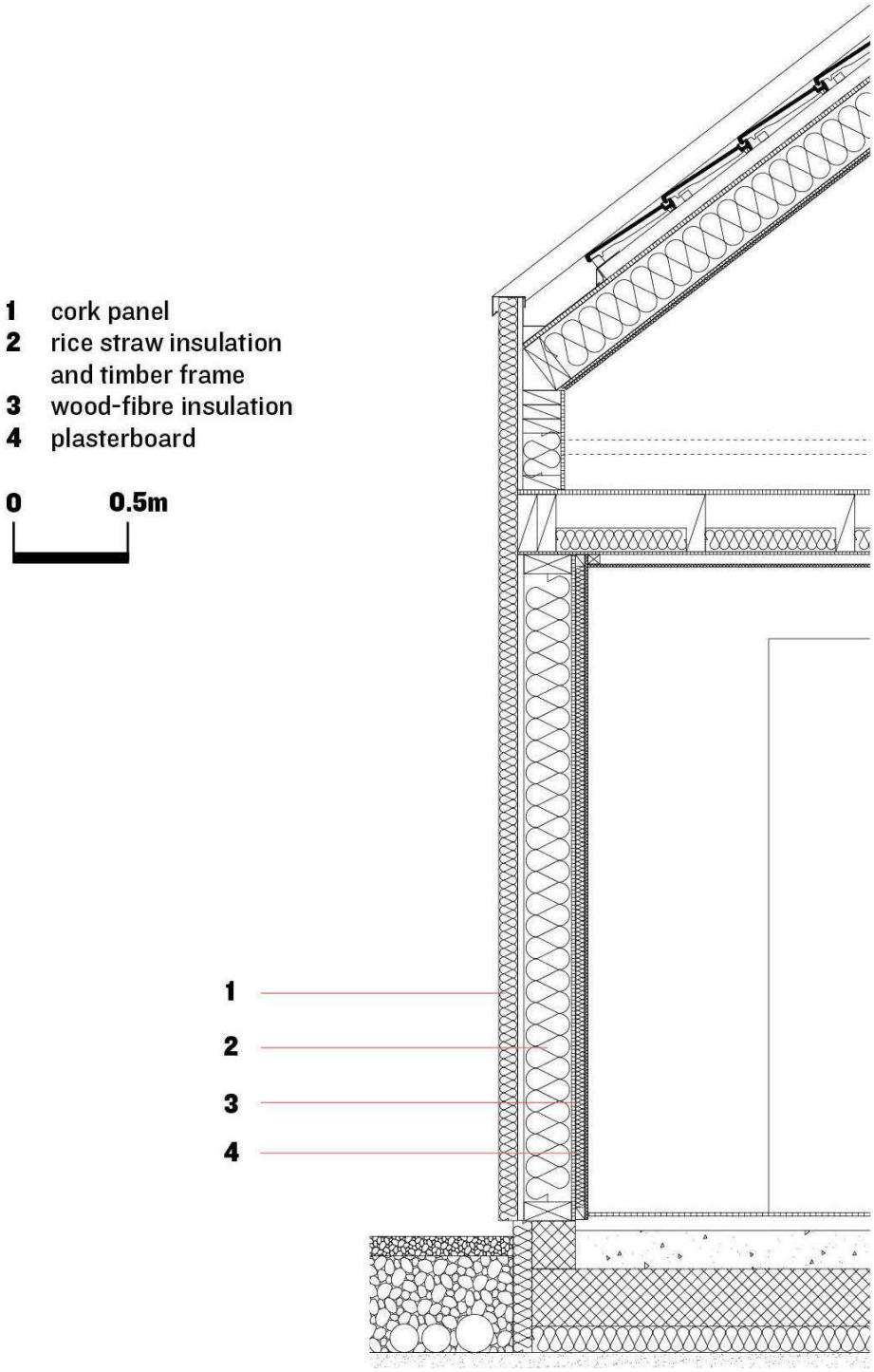
There are many plant-based building materials and technologies that we can use, from vernacular systems which bring together regionally specific materials, to contemporary technologies which are developing bio-based binders, making use of processing machinery to break down plant fibres at a microscopic level to help them bind together more tightly. Although these processed materials generally require more energy in their manufacture, they are much more familiar to our contemporary construction industry. Wood-fibre insulation, formed into batts, is applied in much the same way as popular mineral wool insulation. Corrugated cladding made using hemp fibre and bio-based resin looks and is applied like corrugated tin roofs, ubiquitous across the country. Many of these materials try to slot into existing skills and regulatory frameworks, coming in disguise into a market that is so extraordinarily risk averse that sometimes the materials do not even celebrate their bio-based credentials, preferring to build a customer base with contractors before they 'scare them off' with their plant-based reinforcing fibres. This is a real shame, and evidence that it is the cultures and practices of our industry that are the greatest barriers to real, transformative change.

The construction industry is looking for a silver bullet to enable it to carry on as normal, swapping in one material for another. Hans Joachim Schellnhuber has argued that if construction over the next couple of centuries substituted business-as-usual materials such as steel and concrete for engineered timber, the atmosphere could return to pre-industrial conditions. Engineered timber is now being heralded as the answer to all our industry's problems, without much careful interrogation or contextualisation. While a shift to bio-based materials is necessary, it is just as crucial to ask how these materials will be cultivated: where, on whose land, using what resources, and at what cost? The use of plants in buildings is necessarily intertwined with questions of sustainable cultivation, climate resilience, industrial agriculture, and the deployment of petrochemical-fuelled fertiliser and pesticide inputs. The world's ecosystems have shown us time and again that what landscapes need is diversity, and hectares and hectares of monocultural agriculture or woodland is neither resilient nor sustainable.

> 'A decarbonised construction industry needs to be integrated with forestry, agriculture, conservation and manufacturing'

This makes the question of how we scale up bio-based construction much more complex. The land on which we build is a finite and precious resource and, unsurprisingly, there is evidence that as we grow more softwood in monocultural plantations to meet engineered timber demand, biodiversity could decline at an almost proportionate rate. It has been easy to forget that plants are not just materials, providing us with services – they are habitats for a whole host of other species on whom we also depend. Cultivating plants at scale and using industrial agricultural practices have played a significant role in biodiversity decline – so, in asking ourselves how we can build more with plants, we also need to ask, how do we grow more of them without further damaging the ecosystems we have left?

The House of Wood, Straw and Cork by LCA Architetti in Magnago, Italy, tackles three plant-based materials in one project, taking advantage of the different properties of each. Timber performs well as a load-bearing material, straw is suitable for insulation, and cork can readily be used as cladding
Credit:Simone Bossi


1 cork panel
2 rice straw insulation and timber frame
3 wood-fibre insulation
4 plasterboard
0 0.5m
1
2
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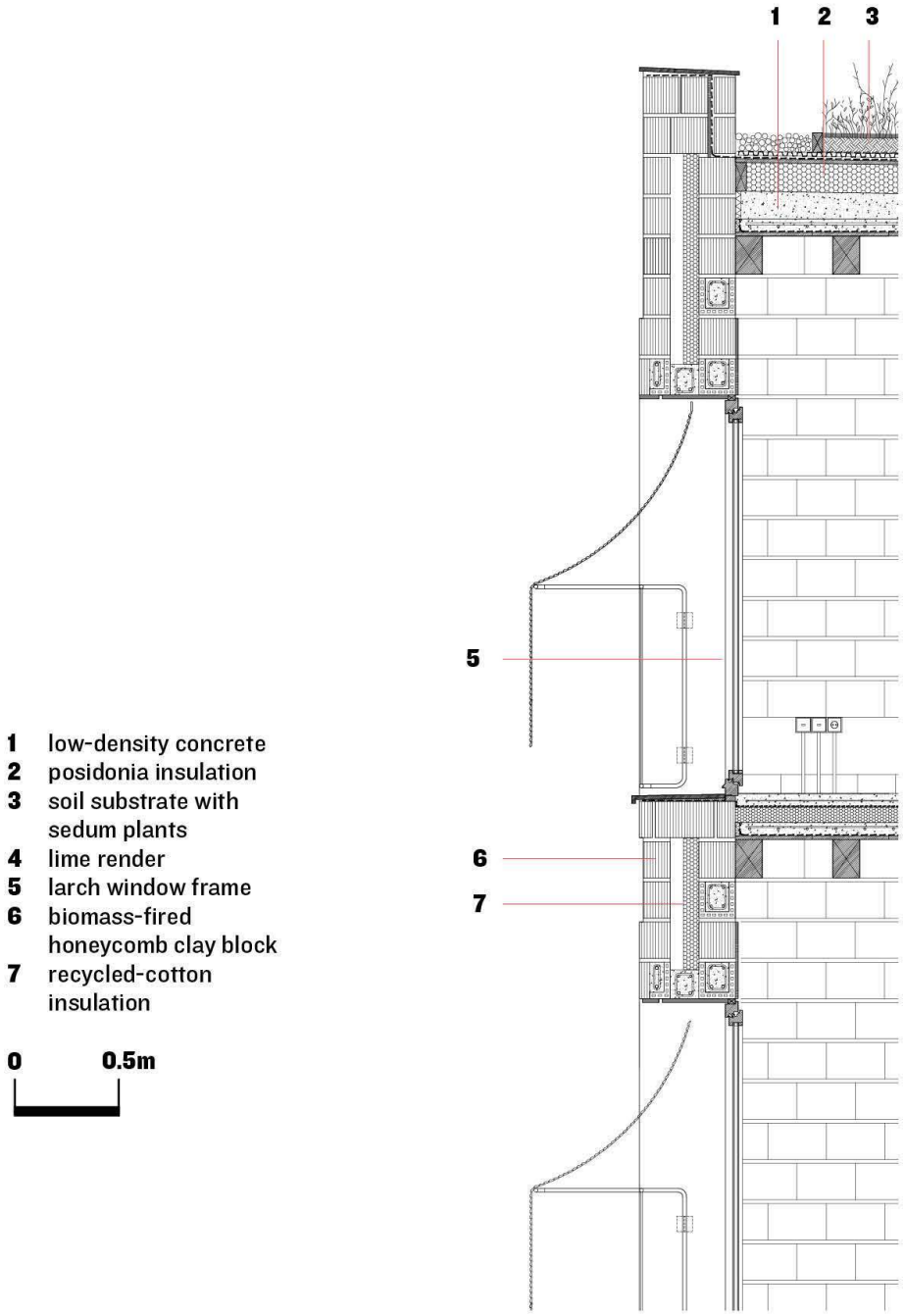
4

Seaweed is abundant in island locations such as Ibiza, where Estudi 08014 designed 24 public housing units in 2022, with the support of the Instituto Balear de la Vivienda (IBAVI)
Credit:Pol Viladoms

Adapting an ancient tradition of using posidonia as an insulation material, the scheme uses local seaweed on its roof
Credit:Estudi 08014



A decarbonised construction industry, then, needs to be integrated with forestry, agriculture, conservation and manufacturing to react in an agile way to the changing climate. This will necessitate regionally distributed manufacturing, local supply chains, and radical changes in the way we think about building. In a decarbonised future, the next big thing is many small things. What we choose to build, and where, will become so much more important. We need wholesale reform, to build less, to redistribute and refurbish the buildings we already have. Working with regenerative resources and bio-based construction also demands a different engagement with the seasons and time, a new way of thinking about building in which we recognise our place in an ecosystem where sometimes things take a bit longer to grow than anticipated. Between forestry and farming, the time it takes between harvests can oscillate between a matter of months and many decades. Thinking about working with the seasons in this way is what makes the idea of biodiverse and productive landscape systems so exciting. In a landscape in which arable crops are interwoven with softwood and hardwood trees, there are material outputs cultivated for the present alongside investments in ecosystems and materials for the generations to come.

Wetlands harbour great potential too. Conservationists in Brandenburg, Germany, are slowly beginning to re-saturate some of the farmland there, which had

previously been drained for farmers to access its fertile peat. As part of this effort, beavers have been left to do what they do best: build dams, allowing the ditches to slowly flood. As sediment and debris build up, stores of carbon do too, and these chemical changes alter the type of invertebrates on the land. The new water sources attract diverse species of birds, fish and amphibians. In flooding the former wetlands, the agricultural practices of the last decades have had to be replaced with other forms of production, supporting the tenant farmers who work the land in new ways. Growing vegetables and grazing sheep and cows are replaced with water buffalo, whose physiognomy is ideally suited to wetlands. The grazing buffalo keep back the growth of bushes and woody plants, maintaining the open wetland and conserving its biodiversity. Alongside the buffalo, water reed and canary grass can be cultivated, materials that regenerate the peat soils and are also valuable feedstocks for the construction industry. Local farmers have formed manufacturing co-operatives to make their own reed-based insulation products, and a skills-based industry will coalesce around their use. In landscapes with such diverse stakeholders, working with manufacturers, farmers and conservationists is critical to understanding how material supply chains can be supported to grow and scale sustainably, and how as architects we can promote new bio-based alternatives to plasterboard, OSB and foam-based insulations.

Fast-growing plants have been used structurally for millennia. Contemporary experimentation with such materials in the global north is developing ways of slotting them into an intransigent industry geared towards mineral materials. Below, EcoCocon, a manufacturer of straw and timber construction panels, prepare a shipment
Credit:EcoCocon®

It is in the woods, fields and wetlands that we will reap the rewards of material cultivation for the environment, the people who work the land, and the non-human species that depend on it. A sustainable construction industry is one in which we stop thinking of ourselves as outside the natural world and recognise our place as only a part stakeholder in the land. The landscape we need in the future is diverse and productive, in which we take an active role as custodians and cultivators of the lands we have already irrevocably transformed. The fact that the infrastructural change we need from industry will be slow to take hold is not a reason not to pursue it: activism, practice and lobbying are effective tools. As more of us advocate change, build differently and take responsibility, we can begin to repair the damage we have caused.

Lead image: A contemporary reading of the illuminated depiction of a mandrake from a 1474 version of Ibn Butlan of Baghdad's *Tacuinum Sanitatis*

might see in the root an image of the interconnectedness of human and plant life