REVOLVE

QUARTERLY INSIGHTS INTO A CHANGING WORLD

N°59 | Spring 2026



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Arctic Calling

There is widespread consensus in the world of climate communications that conflict metaphors should be avoided. There are several reasons behind this. If we are constantly "fighting" climate change, it means there will be a winner and a loser.

This kind of vocabulary perpetuates a constant sense of urgency and violence that can elicit fatigue in the audience (same happens with real wars). It also leaves little room for solution-focused approaches. REVOLVE helps fill this solutions gap.

That said, Svalbard is most certainly on the frontlines of climate change. This is not just a metaphorical statement, but also a geographical one. The over 2,000 permanent residents of Longyearbyen – the world's northernmost town – are having to adapt as their tap water becomes undrinkable due to minerals and metals released by permafrost thawing caused by general global warming.

It is climate change arriving through pipes, says Arctic climate expert and former International Director of the Norwegian Polar Institute Professor Kim Holmén in our Special Guest Editorial ('Change is a Verb', p.8).

On behalf of REVOLVE, I visited the archipelago in late winter (22–27 February 2026) to join a team of scientists dedicated to understanding the consequences of rapidly retreating glaciers, permafrost thaw, and new groundwater springs in one of the world's fastest warming regions. The Arctic is generally warming four times as fast as other regions of the globe. ('Svalbard – Canary in the Coal Mine', p. 10).

The trip took us from the factory floor of the local brewery, where, as well as beer, they now produce pure water, to the remote snow-covered valleys of Spitsbergen, and deep into the ice cave arteries of a sickly glacier. We found groundwater springs that continue to flow in the dead of winter and noted measurements of shocking annual snow cover decline.

Sentence all climate skeptics to a week in Svalbard. Here, the changes unfold before your very eyes.

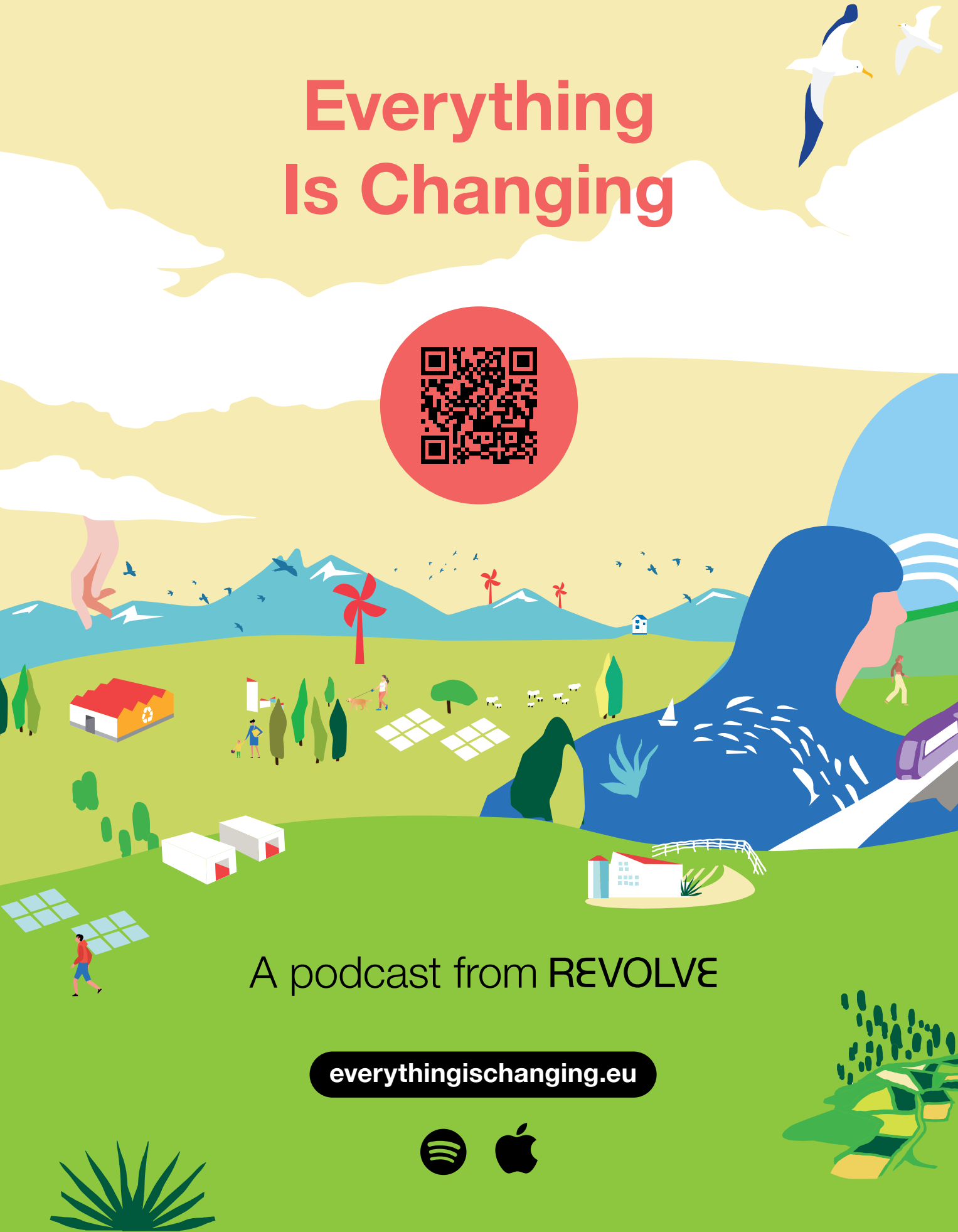
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Jake Threadgould

Editor-in-Chief

Everything Is Changing



A podcast from REVOLVE

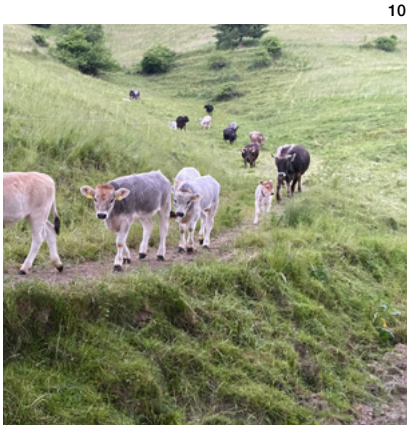
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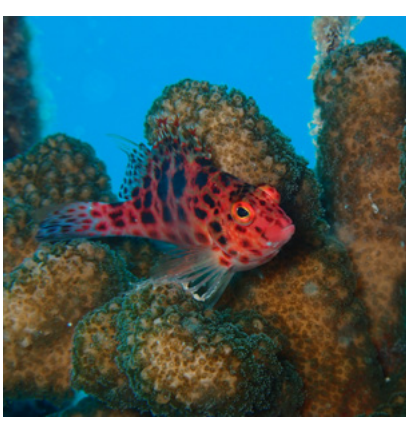
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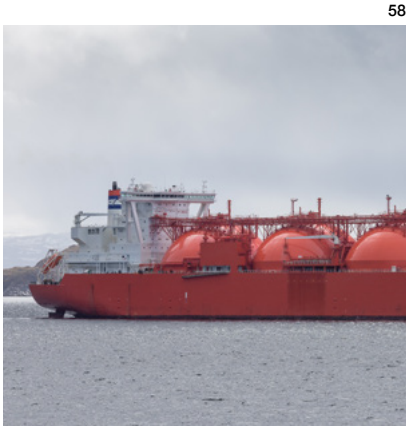
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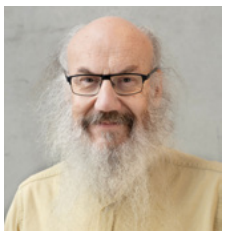
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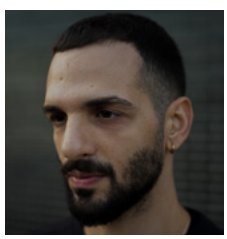
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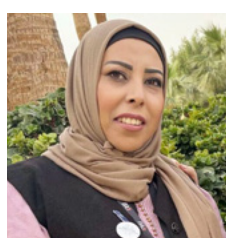
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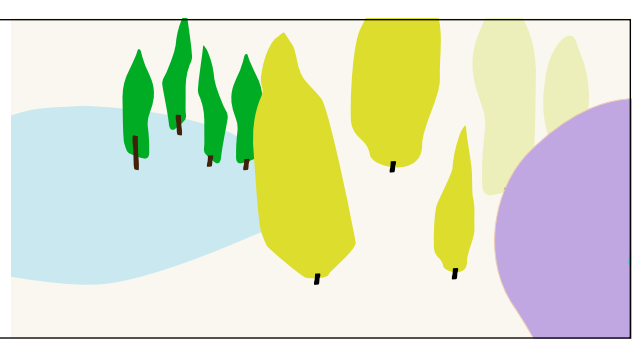
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Caption: Andrew Hodson, glaciology professor at UNIS, examines the wall of an ice cave in Svalbard. Photo: Jake Threadgould / REVOLVE

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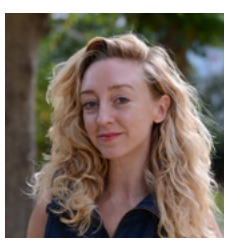
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Change is a Verb

PROFESSOR KIM HOLMÉN
CLIMATE & ARCTIC SPECIALIST

The Arctic's changing climate shows us that prudence and predictability are allies in future planning.

The planet has always changed. Over 4.5 billion years, Earth has never stood still: climates shift, coastlines move, species come and go, and nothing truly "returns." Change is not a one-off; it is a permanent state – a verb.

What is different today is the scale of the human footprint. Humankind has become a geophysical force, accelerating change in the climate system and in ecosystems. The larger the perturbation, the larger the response – and the less predictable the outcome. Predictability is not a luxury. It is what allows societies to plan, invest, cooperate, and create a basic feeling of security for one another. That is why prudence matters: keeping our perturbation as low as possible is, at its core, practical risk management.

The Arctic is often described as warming several times faster than the global average. Recent analyses suggest the region has warmed around four times faster than the planet as a whole since the late 1970s. In the high north, this is not abstract. Svalbard sits close to where warm Atlantic water meets the ice edge. Because most excess heat is stored in the ocean, shifts in ocean heat transport can rapidly change sea-ice conditions, which in turn alters heat exchange between ocean and atmosphere.

I have seen this firsthand. Fjords that once froze reliably now often remain open through winter. Winters have warmed far more than summers. Globally, we debate 1.5°C, framed in the Paris Agreement as a guard-rail against "dangerous" change. On Svalbard, however, winter warming has been measured in many degrees: assessments report roughly 7°C winter warming since the early 1970s, and some recent reporting describes winter temperature increases approaching 10°C in parts of the archipelago over recent decades.

This is the context for the elevated manganese levels recently detected in Longyearbyen's drinking water. It is a vivid example of how rapid change produces surprises. We have warned



Illustration by Dariana Guevara / REVOLVE

for decades about climate impacts on weather, biodiversity, economies, and health – but few people predicted that a trace metal would become a household concern, with measured values at times far above recommended limits and advice issued to avoid long-term consumption. The manganese story is not "just" a technical issue: it is climate change arriving through pipes, treatment plants, catchments, and daily routines.

Nature can still surprise us in the other direction, too. Just this week, a long-term study led by the Norwegian Polar Institute reported that polar bears around Svalbard have maintained – or even improved – body condition over the last few decades, despite dramatic sea-ice loss. It is cautiously encouraging. But time scales are tricky. Short-term resilience can coexist with long-term risk, and "good news" can be temporary in a system still being pushed.

The long view helps. Willem Barentsz reached these waters in 1596 – about 430 years ago – and named Vogelhoek ("bird corner" or "bird nook") on Prins Karls Forland for its dense bird life. It remains an exquisite bird cliff. Yet the centuries that followed also brought industrial whaling that collapsed local bowhead whale stocks. Choices made hundreds of years ago shaped what we see today.

So, what will people see 430 years from now? The Arctic matters not only because it is unique, but because it is woven into the planet's climate engine. The more we perturb it, the less predictable the future becomes – for Svalbard, for the wider Arctic, and for societies everywhere trying to plan and adapt. The manganese lesson belongs in that frame. Svalbard is a forewarning of what rapid, human-driven change looks like when it reaches into the infrastructure of daily life.

Change is permanent. Losing control is not inevitable. Prudence is simply the most realistic form of optimism we have.





Climate Canary in the Arctic

WRITER: **JAKE THREADGOULD**



1

Svalbard's contaminated drinking water saga is the tip of the iceberg, and a climate warning to the rest of the world.

Inside the world's northernmost supermarket, among the imported fruit and vegetables, a steady stream of people collect water from two large tanks – free of charge. Most customers come armed with 5-litre plastic bottles that they will then carry back to their homes in Longyearbyen, where the tap water is becoming too dangerous to drink.

This relatively minor inconvenience for residents of Svalbard is due to high levels of manganese in the local water supply, which scientists believe is being released by thawing permafrost and the emergence of new groundwater springs that percolate long-frozen material up to the surface.

Bitter taste

The water saga began in earnest in September 2025, when Svalbard's authorities issued a general advisory against consuming tap water after they detected manganese levels as high as 1,000 micrograms per litre (µg/l), far above the World Health Organization's recommended maximum rate of 80 µg/l.

Prolonged exposure to high levels of manganese can cause neurological disorders and is particularly dangerous for infants and children whose brains are in development. Tap water guidelines for youngsters were applied in Svalbard as early as February 2025.

The situation has prompted a blizzard of solution seeking. The water available at the supermarket comes from the Svalbard brewery (you guessed it, the world's northernmost) as part of a deal with the local council.

The brewery's output of purified water, which also goes to some of the bars and restaurants in Longyearbyen, is set to increase thanks to the delivery of a new reverse osmosis machine, freshly unveiled when REVOLVE visited the installations on 24 February 2026 **(see: Brewing Change)**.

Far from being a local issue, the changes detected in the drinking water form part of a much larger picture of a rapidly shifting climate in the Arctic.

Svalbard is warming as much as seven times faster than the global average, according to numerous studies. Glaciers, which cover 57% of the archipelago, are retreating at dizzying speed, permafrost thaw is altering the landscape, and sea ice loss is affecting weather patterns.

The free water at the supermarket is merely a symptom of these unbridled shifts in climate.

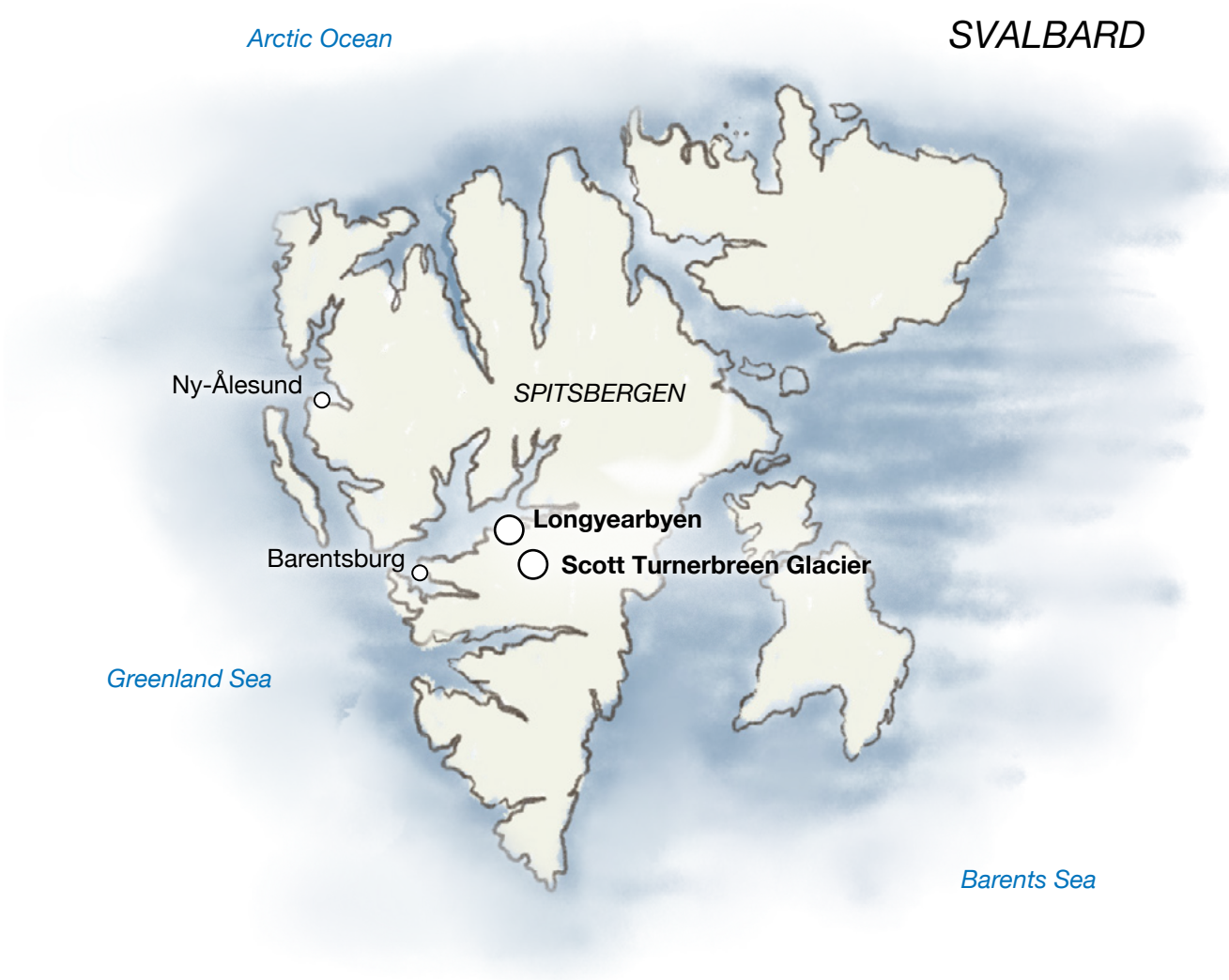
To get a better understanding of these new climate interactions, scientists from the University Centre in Svalbard (UNIS) turned their attention underground. Rather fitting for a region that is steeped in coal mining history.



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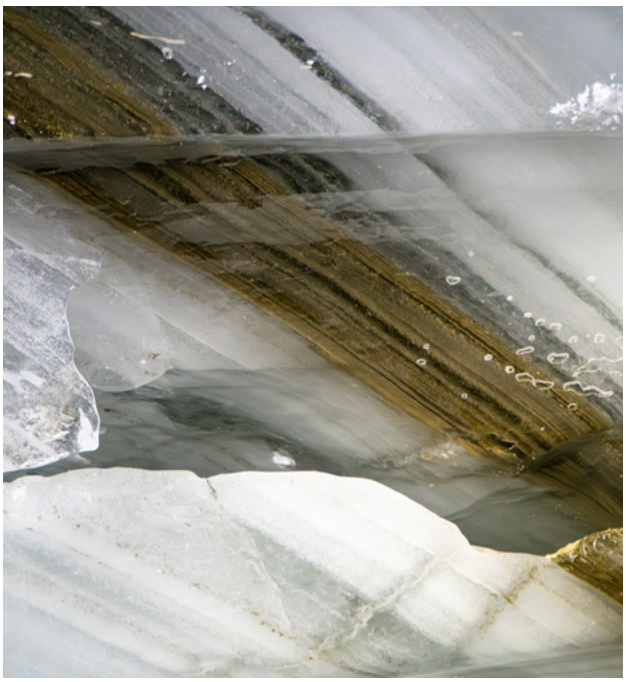
Probing the permafrost

UNIS glaciology professor Andrew Hodson is at the wheel of the double-cabin belt wagon with post-doctoral researcher and permafrost expert Marjolaine Verret by his side. With a handful of visiting researchers and some state-of-the-art geophysics gizmos in tow, the diesel-powered wagon chugs up the Bolterdalen Valley towards the Scott Turnerbreen Glacier.

There is no asphalted road up to the field site, only some red poles marking out tracks for snowmobiles and dog sleds that haul tourists up to ice caves in the glacier. Strong winds have blown the snow into deceptively deep drifts, and the belt wagon gets stuck going over a ridge. Everyone piles out to dig a path through.

The group is armed with two rifles and a flare gun in case a polar bear turns up, an obligatory and diligently observed measure for anyone who travels outside the town Longyearbyen. You can bump into a polar bear anywhere in Svalbard, although the odds are low this high up in the valley.

The UNIS researchers are focused on the area of newly exposed land in the shadow of the Scott Turnerbreen



5



6

Glacier, which is indiscernible in the snow-covered valley. Here, they have set up a field observatory to collect data on the weather and monitor permafrost formation and water flows.

These studies are being carried out as part of the CryoSCOPE project, an EU initiative with Swiss and Indian involvement that is researching the cryosphere – the frozen parts of our globe – with case studies in the Himalayas, northern Scandinavia, Finland, the Alps, and Iceland.

A rapidly retreating glacier

Like many glaciers in Svalbard, Scott Turnerbreen is dwindling fast. According to Hodson, it has lost 90% of its volume in the last 100 years. It is precisely because of this rapid deglaciation that the UNIS scientists chose the site, as it offers unique insights into the changing interaction between the cryosphere, the atmosphere, and hydrology.

"We've just driven to Scott Turnerbreen through three moraine ridges, so we know there's been quite a history of advances and now a major retreat," Hodson says, referring to the rocky rubble lines that mark out the stages of a retreating glacier. "Some of those advances were climatically driven a few hundred years ago, at least one of them was due to a very harmful surge, a sudden unstable advance which was probably linked to warming around the turn of the last century."

To the untrained eye, a glacier that has surged might appear to be large and healthy given its apparent reach down the valley. But that's an illusion. In Svalbard, scientists think glaciers are surging due to warming temperatures and changes in the waterways below the glacier itself, which cause them to slip down the valley as they continue to melt.

"Scott Turnerbreen is quite interesting because it kind of tried to kill itself with one of these advances," Hodson adds.

Professor Hodson guides REVOLVE into the belly of the glacier through a tight crawl space in the snow. Inside, the channel opens up into an ice cave carved out by flowing meltwater in the warmer summer months. Hodson can read the ribbed walls, gravel deposits, and trapped bubbles embedded in the meandering cavern like rings in a tree.

Cake layers of ice tell the story of freeze-thaw cycles over time. In the winter, the walls of the dormant river illuminate in frozen shades of blue, green, and white by the light of a head torch. Streaks of gravel and mineral deposits twinkle like jewels suspended in time.

These river paths, obscured by snow and ice on the surface of the glacier, are getting larger each year due to increased snow melt and meltwater from the retreating glacier.

"Every year it gets deeper and deeper, and it migrates in three dimensions, meandering and eventually cutting all the way to the bottom," Hodson says, adding that the growing flows during the summer are "changing the way that water drains this landscape."

Running water in the Arctic winter

Back out on the glacial forefield, Marjolaine Verret, the permafrost expert, crouches down over two dark patches where the snow has been melted away by running water. This is unusual for late February in Svalbard, where temperatures the week prior dipped as low as –20C (-4F).

"You can actually see there's liquid water right here in the middle of winter at -5C," Verret tells REVOLVE. This water is not coming from inside the glacier, but rather from the ground below. What this tells Verret is that permafrost – ground that is frozen for two or more consecutive years – has not yet formed in this area of rapid deglaciation. This gives groundwater below an opportunity to punch through what would normally be impermeable ice, establishing a channel of liquid water that flows year-round.

"We don't yet have permafrost closing the cryospheric cap at this location," Verret says. "So, it (the water) manages to emerge through these gravels into the forefield."

The water that emerges at these springs brings with it a cocktail of minerals and metals, including manganese, the same mineral that is contaminating Longyearbyen's taps. It also brings up nutrients that are influencing change in the local ecosystems, Verret adds.

"These groundwaters are also rich in nitrates, which is basically what you find in farmland fertiliser. These nutrients are being used by opportunistic species like algae to colonise these waterways. It's not all negative but it's definitely a change to the environment."

Permafrost is found under much of Svalbard, and ranges from around 100 to 500 metres deep, depending on where you probe. Seasonal thawing is creeping deeper into the ground each year at the expense of permafrost as temperatures rise. Permafrost thaw and glacier melt lead to the release of large quantities of greenhouse gases like methane and carbon dioxide that were previously sealed beneath the ice.

These greenhouse gas emissions are of global relevance as the onus of offsetting the consequences lies with policymakers further south.



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8

Keeping cool

"There's an old adage that what happens in the Arctic doesn't stay in the Arctic," says Hodson. "It's well known that warming here is having an effect in mid-latitude areas and it is proving costly."

Snow and ice play a fundamental role in keeping the Arctic region cool by reflecting between 50-70% and 90% of incoming solar radiation, respectively. When sea ice, ice caps, glaciers, and snow cover melt over time, it increases the warming of the exposed sea and land, which warms the atmosphere and increases melting. This spiral of heating is known as ice-albedo feedback.

A visible example of this is the melting of sea ice, which in the Arctic has reduced by nearly 50% since 2000, according to the US National Oceanic and Atmospheric Administration.

This warming affects polar weather systems in a way that dominos down to southern latitudes, increasing the chances of frigid cold snaps and extreme weather like heavy rain.

"Our role in CryoSCOPE is not to catastrophise but quietly reveal these unstoppable changes that are happening here and make people realise that lifestyle adjustments are necessary," Hodson tells REVOLVE. "Given what we are seeing here, we're trying to get the message across to the relevant policy-making authorities that more multilateral action is needed."

Canary in a coal mine

Back in Longyearbyen, the easing of the polar night heralds an influx of tourists. They come to get a taste of the Arctic, to see the alluring aurora borealis (northern lights), to pose with the polar bear signs, and often just to tick it off the bucket list.

The tourism industry has replaced coal mining as a major cog in the local economy. Old coal mining lodges have been converted into hotels and the town's bars and restaurants are brimming with a medley of languages.

At this rate of climate change, Svalbard might have to start planning for a post-tourist future, too. The water collection points at the supermarket are here to stay for the time being, a minor but very real annoyance that is symptomatic of a rapid change afoot.

It's cliché but undeniably fitting to call Svalbard a canary in a coal mine when it comes to climate. What is happening here is a warning to those of us who live further south. It is important that those in charge listen in, as the canary might be on its last few chirps.

This feature is the result of a field trip for the CryoSCOPE project to Svalbard during the week of 23-27 February 2026. For more details, visit: cryoscope-project.eu



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1. UNIS researchers dig a path through the snow below the Scott Turnerbreen Glacier. Photo: Jake Threadgould / REVOLVE
2. A client fills up a bottle of water at the supermarket in Longyearbyen. Photo: Jake Threadgould / REVOLVE
3. A sign marks out the reservoir to the east of Longyearbyen. Photo: Jake Threadgould / REVOLVE
4. Map of Svalbard archipelago. Illustration by Dariana Guevara / REVOLVE
5. Material deposited in the walls of the Scott Turnebreen Glacier, Svalbard. Photo: Jake Threadgould / REVOLVE
6. Marjolaine Verret crouches by running water in the glacial forefield. Photo: Jake Threadgould / REVOLVE
7. Professor Andrew Hodson examines the inner walls of the Scott Turnerbreen Glacier. Photo: Jake Threadgould / REVOLVE
8. A hillside above Longyearbyen. Photo: Jake Threadgould / REVOLVE
9. A reindeer huddles for warmth in the wind. Photo: Jake Threadgould / REVOLVE
10. Robert Johansen poses on the factory floor. Photo: Jake Threadgould / REVOLVE

Brewing Change

The Svalbard Bryggeri (“Svalbard Brewery”) is no longer just a purveyor of fine beer but has had to make extra room on the factory floor for a new reverse osmosis (RO) machine delivered in February 2026, which it will use to boost its production of purified drinking water for Longyearbyen residents.

The brewery has been providing the water available for free at the Svalbardbutikken department store since September 2025 as well as to some of the bars and restaurants in Longyearbyen, according to Bryggeri owner Robert Johansen. The cost of production is covered by the local council, which pays three krone (0.27 euros as of February 2026) per litre of water.

The brewery was already purifying water with ionised electrolysis as part of its beer production to remove manganese and sulphates as well as chlorine, which is used to kill bacteria like legionella that can live and propagate in Svalbard's heated pipe system.

Johansen, who came to Svalbard in the early 1980s to work in coal mine 3 (now home to the Arctic World Archive data bank), tells REVOLVE he wouldn’t feel comfortable trying to turn a profit for the provision of water.

“We’re not that kind of business,” he says.



10



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Where the Water Dies

WORDS: **MARTA SAIZ**
PHOTOGRAPHY: **GIANNI ESPOSITO**

Export-oriented shrimp farms cast shadow over struggling Guatemala fishing communities.

The Laguna Grande and El Muerto lagoons near Champerico on Guatemala's southern Pacific coast are tainted by years of contamination that local fishing communities blame on wastewater discharge from intensive shrimp farms. The lagoons – once connected to the sea but now blocked – are showing signs of biodiversity loss and sea lice outbreaks that harm fish stocks.

"The shrimp industry has destroyed the mangroves," local fisherwoman Doris Ramírez told the United Nations Human Rights Council in Geneva in March 2025. Her statement to the UN body came three years after she joined the Champerico Fishers' Association.

Six months later, in a conversation outside her home on the outskirts of Champerico, Ramírez adds: "I used to go out with a sack and catch whatever there was: blue crab, shrimp (...) whatever was along the estuary shore, we collected it by hand. But as time went by, the fish started to disappear."

Nearby, the main road leading inland passes by the headquarters of Novaguatemala SA, a subsidiary of the Spanish-owned Nueva Pescanova Group that since 2008 has farmed, processed, and exported shrimp from its installations in the area.

In addition to wastewater discharged from shrimp ponds, which contain chlorine and sulfites according to the Fishers' Association, the lagoons have witnessed the spread of sea lice, small crustaceans that feed on fish and disrupt the ecological balance of the habitat.

Local fishers and researchers argue that the farm's discharge in combination with decreasing water levels has transformed the lagoons into a perfect breeding ground for the outbreak, accusations backed by Virginia Tech's Nicholas Copeland and Marco de León who in their paper Sea lice or subsistence? Peasant multispecies justice in the Plantationocene.

Cover: Víctor Arcadio López navigating Laguna Grande estuary.

Above: Doris Ramírez with her daughter and granddaughters. Doris is a community leader advocating for marine biodiversity and fisher's rights in international forums.
Below: View of Nueva Pescanova's facilities in Champerico, where thousands of families depend on shrimp farming and exports.



Above: Doña Marina, 73, at home drying her children's fishing nets, preparing them for use in the nearby lagoons.
Below: Fishermen pulling fish from their nets, the last remaining artisanal activity amid youth migration from Champerico.



Aerial view of the Laguna Grande estuary.





Fishermen helping boats leave Champerico port, navigating shallow waters caused by neglected maintenance after operations moved to Puerto Quetzal.





Freshly collected shrimp in Laguna Grande, where declining biodiversity forces fishermen to spend days in the water for each catch.

One of the few community leaders who publicly accompanied the researchers is Pedro Liceo Vázquez, who spent more than 30 years engaged in subsistence fishing in the estuaries of Champerico. That changed in 2016, when the Subsistence Fishers' Association – of which he is vice president – organised a protest against NovaGuatemala, accusing the company of polluting the estuaries, causing biodiversity loss, and increasingly degraded waters.

NovaGuatemala responded by accusing six protesters of coercion. Four years later, all were acquitted for lack of evidence. Since then, no further protests have taken place. Fear of criminalisation, ongoing anonymous threats against community leaders such as Vázquez, and the influence of drug trafficking in the region have severely weakened the already fragile social fabric.

Asked about the environmental allegations, NovaGuatemala claimed that its two operations in the vicinity of the Laguna Grande and El Muerto estuaries had been inactive since 2018 and 2022 respectively. According to NovaGuatemala it never received environmental sanctions or notifications related to pollution or pest outbreaks during the years both farms were operational.

Shrimp produced by NovaGuatemala is exported mainly to Europe, with Spain the primary destination. One of the main shipping points is Puerto Quetzal, located about 200 kilometers from Champerico. According to World Integrated Trade Solution, Spain imported approximately 735,158 kilograms of frozen shrimp from Guatemala in 2024, with an estimated value of $7.05 million.

These figures place Spain among the leading European destinations for Guatemalan shrimp, although other countries – such as the Netherlands and France – also receive significant volumes.

This piece is part of a broader investigation by Víctor Cabo, Gianni Esposito, and Marta Saiz with the Catalan Commission for Refugee Aid, through Lafede.cat's Connect for Global Change fellowship.



Fish with sea lice in the estuaries of Champerico, a parasite that has multiplied with aquaculture expansion.





Pedro Liceo Vásquez at his home. He was among the fishers who protested against NovaGuatemala in 2016 later to be acquitted.

Above: Víctor Arcadio López's parents in front of their home.
Below: Traditional fisherfolk preparing their small catches from offshore trips to sell at Champerico's local market and surrounding areas.



Export vessels at Puerto Quetzal, from where Guatemala's fishing industry sends products to international markets.



Aerial view of Champerico.

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Women and Youth Can Drive Sustainable Agriculture in Senegal

WRITER: **GABRIELLA VENTALORO**



1

In Senegal, the seeds of the future are in the hands of its women and youth.

The West African nation of Senegal is highly vulnerable to climate change, caught between coastal exposure and a heavy reliance on natural resources. According to United Nation figures from 2024, approximately 60% of Senegal's population lives in rural areas, and over half of those rural dwellers rely on agriculture for their survival. In a country where livelihoods are deeply intertwined with the land, environmental shifts quickly translate into economic and social instability.

Senegal's geography creates a perfect storm of climate challenges. In northern and central regions, desertification is thinning topsoil, while areas in the delta and coastal regions face threats from rising sea levels and saltwater intrusion. For the millions of rural dwellers who rely on rainfed agriculture this is not an environmental statistic but a threat to their way of life. Soil degradation and salinisation make it harder for crops to take root, while shifting weather patterns make the traditional planting calendars that were passed down over generations unreliable. Rains arrive later than expected, end sooner, or fall in intense events that wash away fragile topsoil, leaving farmers struggling to adapt season after season.

Within this complex context, women are the backbone of rural food security, comprising nearly 70% of Senegal's agricultural workforce and producing 80% of the nation's food. Despite these contributions, women continue to face systemic barriers, ranging from discriminatory social norms to legal frameworks, limiting their access to land ownership, financial services, and agricultural extension services. While a male farmer may own the land he farms, women often gain access via traditional grazing rights, or family permission, making their long-term investment in the soil a riskier endeavour.

The distinction between customary land usage rights and formal land ownership is critical. Traditional usage rights may grant women the ability to cultivate a plot, but these rights are often informal or contingent on family relationships. However, these rights do not provide the legal security to use the land as collateral to access credit or invest in long term soil restoration. Many agroecological practices that improve conditions and support climate resilience require time before results are visible. Without guaranteed tenure, the incentive to invest in measures that may only yield returns after several seasons is significantly reduced. In this way, insecure land



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access not only undermines farmers decision-making, but also broader efforts to build climate resilience and restore degraded ecosystems.

At the same time, Senegal is home to a large and growing youth population. According to an analysis of UN population data from PopulationPyramids, over half of the country's population is under 21 years old. Without adequate support systems, however, this demographic opportunity might be missed and Senegal's youth risk being excluded from shaping the future of the country's agricultural sector. Investing in sustainable agricultural education and entrepreneurship is essential not only for securing rural livelihoods, but also for addressing long-term challenges such as climate adaptation and food system resilience.

One of the biggest challenges to youth participation in agriculture is insufficient access to knowledge, information, and education. In many rural areas, agricultural training remains limited, and young people are incentivised to pursue urban opportunities rather than farming careers. It is therefore important to improve young people's access to these resources and to incorporate agricultural skills into rural education, in order to ensure rural youth have the skills to take part in the emerging green economy.

Another challenge is the limited access to financial services, as most providers are hesitant to support rural youth due to factors like insufficient collateral, low financial literacy, and other barriers. Developing and promoting financial products tailored to youth, strengthening mentorship programmes, and expanding start-up funding opportunities could help remedy this issue and unlock hidden entrepreneurial potential. By expanding financial inclusion, Senegal can help transform agriculture from a subsistence activity into a dynamic and innovative sector.

From agricultural workers to decision-makers

Addressing these challenges to empower women and youth is not only a matter of equity, but an economic and environmental imperative that strengthens food security, fosters inclusive economic growth, and creates a more resilient food system. To build a sustainable system in Senegal, these groups must move from being viewed solely as farm workers to being recognised and supported as decision-makers, innovators, and leaders.

Creating an enabling environment is essential if women and youth are to truly thrive in agriculture. This means advocating for the effective implementation of existing laws that grant land access, alongside ensuring the rehabilitation and fair distribution of agricultural plots. Policy alone, however, is not enough: training



4

programmes tailored to their specific needs are fundamental to success, and strengthening coordination between local authorities, research institutions, and farmer organisations can further ensure these policies translate into tangible improvements on the ground.

This success is rooted in agroecology, a farming approach that works with nature rather than against it. Activities such as workshops focused on practices like composting, seed selection, and water management can help to equip women and young farmers with the practical tools needed to restore soil health while navigating climate risks.

To truly empower these communities, training centres must embrace a holistic curriculum tailored to the specific needs of women and youth. This means integrating leadership and entrepreneurial training alongside field-based skills. While workshops provide the immediate means to survive a changing climate, the addition of digital tools and sustainable business models ensures that the next generation sees agriculture not just as a viable career, but as an innovative and exciting one.

Success stories

Across Senegal, change is already taking root. In May 2025, the country officially launched the second phase of the PAVIE project (*Projet d'appui et de valorisation des initiatives entrepreneuriales des femmes et des jeunes*) at the Grand Théâtre National in Dakar. Building on the first phase that created 93,000 jobs, this new chapter focuses on introducing key improvements, including the complete digitalisation of all business processes, enhanced territorial support through localised mechanisms, and focused economic empowerment in underserved areas. In doing so, PAVIE aims to strengthen the agricultural, livestock, and fisheries sectors while fostering innovation.

Complementing this is the CIRAWA project, an EU-funded initiative dedicated to developing new agroecological-based practices that build on existing local and scientific knowledge to help create more resilient food supply chains in West Africa. The project prioritises the inclusion of women and youth, and has been conducting targeted awareness-raising campaigns since its launch in 2022.

In April 2025, CIRAWA hosted a week-long event in Saint-Louis to raise awareness about agroecology, giving students the opportunity to get hands-on experience with sustainable farming techniques that support soil health. The project also organised a visit to meet and learn from members of the *Femmes Battantes de Mbane*, a women-led farming initiative in the area that is demonstrating that strength lies in numbers.

Women farmer networks

Fatou Thiaw, a member of Femmes Battantes de Mbane, spoke more about the initiative from her farmland on the banks of the Lac de Guiers, a major source of freshwater in Senegal. Like many farmers on the banks of the lake, Thiaw relies on flood irrigation. During the rainy season, the lake's water fills the plots, which are then planted when the water subsides.

"We women work in agriculture. Each of us has a few plots to cultivate," Thiaw explained to REVOLVE. "We work with CIRAWA, which helps us a lot. We are also seeking help from relevant authorities to combat soil salinity… (because) salinity makes production difficult."

CIRAWA

CIRAWA: Agroecological Strategies for Resilient Farming in West Africa

CIRAWA is an EU-funded project working with small-holder farmers in West Africa to improve food nutrition, local livelihoods, and ecosystem health. Bringing together 16 partners from 9 countries, CIRAWA is developing new agroecological-based practices that build on existing local and scientific knowledge to help create more resilient food supply chains in 8 regions across Cape Verde, Ghana, Senegal, and The Gambia.

CIRAWA aims to demonstrate how working with nature can enhance ecosystem health and biodiversity, while improving local livelihoods and climate resilience using four key agroecological approaches.



Agro-waste valorisation



Pythoremediation



Quality seeds



Land placement practices

"I have hope. They are aware that they need to change their farming methods."

Dr. Mame Farma Ndiaye, Research Lead, ISRA-Saint-Louis.

The Femmes Battantes de Mbane collective, which has around 50 members, is more than just a farming group, it is a vital support network. By organising as a collective, the group offers stronger representation and bargaining power to advocate for their needs in the face of climate change and structural inequalities.

Alongside environmental challenges, Thiaw and her colleagues face distribution and infrastructural challenges. "We don't yet have complete control over compost production, and it's not easy to produce it on our own... in addition, we have product distribution problems: sometimes crops rot due to lack of preservation and they are fed to animals."

An appetite for knowledge

Further south, near the town of Mboro, Binta Ba's farm emerges from the arid plain like a green oasis where rows of cabbages are watered under the shade of an iconic boabab tree. Farming is in her blood, and she endeavours to employ agroecological practices like compost but points out that there is a lack of regulatory support, training, and finance.

"If we had training in seed production, we wouldn't have to buy them," she told REVOVLE in an interview. "Or if the government guaranteed the purchase of our crops, and provided cold storage facilities, it could fill market gaps without resorting to imports. This would be truly beneficial for us, the producers."

Ba works closely with the CIRAWA project's regional partner, the Senegalese Agricultural Research Institute (ISRA), to implement socially minded agroecological practices in the country. Dr Mame Farma Ndiaye, research head at ISRA-Saint-Louis told REVOLVE she was optimistic about the future.

"I have hope. With 15 years of experience at ISRA, when we started working only on organic material, with the same producers, in the same areas, we realise that the farmers themselves are aware of this: they're aware of the dangers of the excessive use of chemical fertilisers on their health, they see for themselves the degradation of the soil," she said.

"They are aware that they need to change their farming methods."

Women and youth at the heart of change

Women and youth need to be at the centre of a sustainable agriculture sector in Senegal. Given Senegal's climate vulnerability, climate-resilient agricultural practices need to be increasingly employed.

As Senegal continues to stimulate entrepreneurial growth, ensuring that women and youth have access to tools and resources to support locally adapted sustainable agricultural practices will have far-reaching impacts across the country. In doing so, the country can build resilience to climate change while strengthening rural livelihoods and domestic food systems.

In this context, training and education that offer practical experience in implementing climate-resilient farming techniques are essential not only to safeguard the sector but to enable it to thrive despite growing environmental challenges.

1. Fatou Thiaw on her plot near Mbane, Senegal.
   Photo: Jake Threadgould /REVOLVE
2. A farmer's shed on land outside Dakar, Senegal.
   Photo: Jake Threadgould / REVOLVE
3. Binta Ba holds up some onions from her plot near Mboro, Senegal.
   Photo: Jake Threadgould / REVOLVE
4. Youngsters prepare to move seedlings into their school garden in northern Senegal.
   Photo: Jake Threadgould / REVOLVE



CIRAWA

Agroecological Solutions for
Resilient Farming in West Africa



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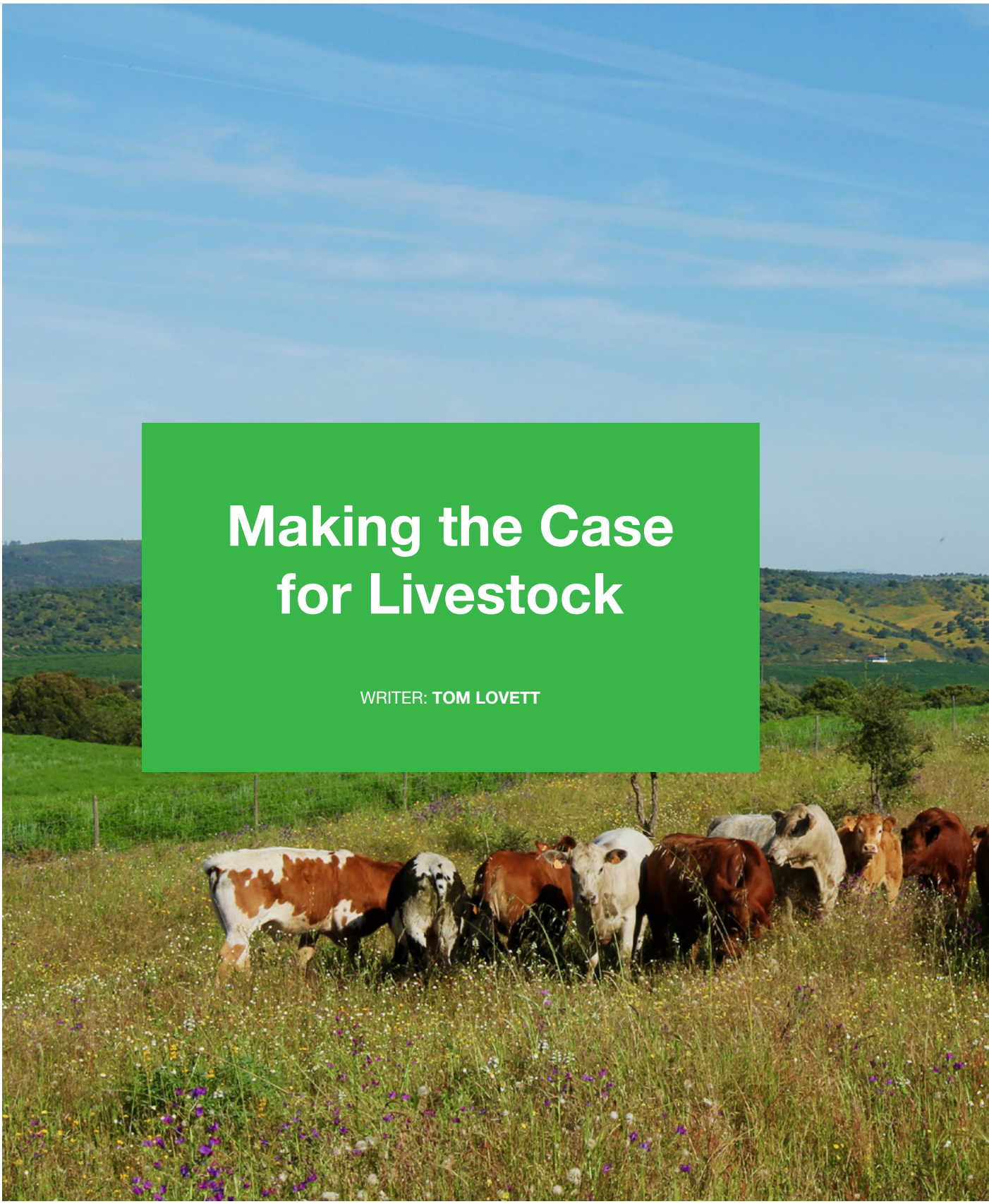


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Making the Case for Livestock

WRITER: **TOM LOVETT**



1

As Europe confronts soil degradation, grazing animals are being reimagined as tools for regeneration, not extraction.

Wildflower meadows stretch beneath scattered cork and holm oaks. A tawny pipit flits through the pasture to hunt among the hum of insects. Griffon vultures circle high above, riding spring's warm currents. A herd of cows moves slowly between the trees, grazing on abundant pasture. Beneath it all, unseen, rich soil teems with underground life.

This is a *montado* system. Covering more than a million hectares in Portugal, it is one of the country's most iconic landscapes. Across the border in Spain, where it is known as dehesa, it extends another 3.5 million hectares. These open woodlands and pastures did not emerge by accident. They evolved over centuries through the interaction of trees, grasslands, people, and grazing animals. The result is a biodiversity hotspot – a landscape rich in life because of livestock, not in spite of it.

"Animals and plants live together. Animals depend on plants, and plants depend on animals," says Diogo Pinho, Research and Development lead at Monte Silveira, a 700-hectare farm in Portugal's Castelo Branco region, where around 500 hectares are managed as *montado*. "If animals are always in movement and at high density," he adds, "we mimic what happens in nature."

This scene feels far removed from the dominant narrative of sustainable food production, where eliminating livestock is often framed not only as necessary, but as a moral act: fewer animals, fewer emissions, fewer hectares devoted to feed and pasture, fewer forests cleared for soy.

But this story is incomplete. It treats livestock as inherently extractive and rarely asks a harder question: what role can animals play within mixed farming systems – like a *montado* – when they are managed not as isolated units of production, but as part of living landscapes?

In Europe, that question is arising as another crisis becomes impossible to ignore – soil degradation.

The real front line of climate change

Soil is the foundation of landscapes as we know them. It is one of the planet's largest carbon stores, the most scalable water reservoir, and the basis of our food system. According to the Food and Agriculture Organisation of the United Nations (FAO), around 95% of global food production depends on soil. Grasslands, forests, and farms are all rooted in it. Yet this living resource, built slowly over centuries, is routinely treated as expendable.

Across Europe, the scale of the problem is stark. The European Commission estimates that 70% of soils in the EU are degraded, resulting in annual losses of around €50 billion due to declining soil health. This is part of a global pattern: the World Atlas of Desertification finds that more than 75% of land worldwide is already degraded. A 2025 global review identifies unsustainable agriculture as the main driver, with tillage, heavy machinery, overgrazing, and simplified crop systems disrupting soil-building processes.

As soils degrade, they lose their ability to absorb water, store carbon, and support plant growth. The result is a dangerous feedback loop: drought intensifies as soils shed moisture, while floods worsen as rainfall turns rapidly into runoff. When heavy rains arrive, bare or compacted soils erode, stripping away fertile topsoil and leaving landscapes more vulnerable with each event.

The frequent flooding in southern Europe is the result of changing rainfall patterns, but also soils that can no longer hold water. Soil erosion has also been identified as a driver of what the UN describes as "water bankruptcy" in a 2026 report.

"If animals are always in movement and at high density, we mimic what happens in nature."

Diogo Pinho, Research and Development lead at Monte Silveira.



2

"Now we're facing not just erosion driven by climate change," says Maria Anastasi, coordinator of the EU-funded project Groundwork, "but soils that are losing their basic ability to function."

Groundwork, led by the Cyprus Research and Innovation Centre, is part of a growing wave of initiatives attempting to reverse this trajectory – not by treating soil as inert, but as a living system that must be rebuilt through changes in farming practices and land management. At the EU level, strategies such as Farm to Fork and the EU Mission A Soil Deal for Europe set ambitious goals to reduce agriculture's environmental footprint and restore soil health – goals that Groundwork aims to translate into on-the-ground practice.

Working through five Living Labs across Portugal, Germany, Sweden, Belgium, and Serbia, Groundwork tracks how different farming approaches influence soil health over time under real climatic, ecological, and economic conditions.

Livestock as a keystone species for soil health

"For me, farming was only crops – annual or permanent – until I started to measure what animals were doing to soil life," explains Diogo Pinho Research and Development lead at Monte Silveira, one of Groundwork's Living Labs.

Trained as a biotechnologist, Pinho later completed a PhD in soil microbiology. His early research focused solely on plant–soil systems. That changed when he joined Monte Silveira, a former conventional tobacco farm that converted to an integrated organic system in 1999 and now brings together five livestock species – cattle, black pigs, sheep, goats and horses –across a mosaic of *montado*, olive and almond groves, and arable cropland.

Pinho and his team began on-farm trials to understand what happens below ground after animals move through a field. Sampling soils before and after grazing, they measured microbial diversity and activity. "The animals had a strong impact on the soil," he observes, "and over time, microbial activity increased – soil life recovered."

By 2023, longer-term data confirmed the trend. "In five years, we increased soil organic matter by 50%," he notes, adding there were clear signs of rising biological activity. "That's when I realised that animals are key to speeding up soil regeneration."

Next to this, field assessments at Monte Silveira show exceptionally high biodiversity, with more than 100 plant species across *montado* pastures and around 300 animal species – from insects to birds and mammals – suggesting that carefully managed grazing can enhance ecological complexity.



3

Regenerative Grazing Livestock Practices

These findings align with the principles of Regenerative Grazing Livestock Practices (RGLPs), which use grazing animals as part integrated farm management. By controlling grazing intensity, timing, and recovery, these practices rebuild soil organic matter, stimulate soil life, improve water infiltration, and regenerate landscapes – with livestock acting as biological catalysts rather than extractive pressure.

Popularised by Allan Savory, the approach draws on the behaviour of wild herbivore herds grazing intensively, moving quickly and allowing grasslands time to recover. “In nature, wild herds have two main concerns,” Pinho describes. “To eat as much grass as possible – and to frequently move to avoid predators.”

Grazing shapes which plants thrive and how they grow. What animals leave behind – dung, urine, and even saliva – returns organic matter and nutrients to the soil. Grazing also affects root growth and the release of carbon-rich exudates that feed soil microbes and the many organisms that make up the soil food web. Improving structure and water retention, reducing erosion, and locking carbon into the ground.

Several thousand kilometres east, the same hypothesis is being tested under different conditions. In the Allgäu Alps of Germany, Christine Bajohr and her husband Martin Wiedemann-Bajohr, part of another Groundwork Living Lab, manage KugelSüdhangHof, a mixed meat and dairy system exposed to increasingly extreme weather. Scorching summers, winters dropping to –20°C, and rainfall arriving in longer, more intense bursts.

Their shift toward regenerative grazing began in 2003, after successive droughts exposed the limits of their system. Searching for ways to adapt, they focused on soil health, drawing on research, experimenting with composting, and rethinking how animals, plants and soils interact. “We started to look much more closely at what our herd is actually doing,” Bajohr explains.

Changes in grazing management helped stabilise pastures and extend the time animals could remain outdoors. The system has not become immune to climate extremes, but it has become more resilient: more grass in dry years, better recovery after heavy rain, and a farm that responds rather than collapses under pressure.

Rest and recover

Central to this approach is rest and recovery. "More important than how long animals stay in one place is how long you let the pasture and soil recover," Pinho describes. "You have to let the system breathe – recover, recycle nutrients, regrow – and only then bring the animals back."

This is as much about energy balance as it is about grazing pressure – not just for animals, but for plants and soil life. "You have to leave enough energy in the system," Bajohr elaborates. On her mountain pastures, that shapes herd decisions. "I can't afford a cow that produces 10,000 litres of milk. I can't feed her. She takes too much energy out of the system."

Animals, she argues, must be matched to the landscape's capacity, ensuring enough biomass remains to regenerate plants and sustain soil organisms.

For Maria Anastasi, this emphasis on observation, context, and recovery exposes a deeper flaw in modern agriculture. "People came up with solutions to produce faster and more," she argues. "Instead of slowing down and looking at the source – the soil – production just became more intense."

The great simplification – and the way forward

At the turn of the 20th century, a European farm rarely existed without livestock. Sheep passed through fallow fields. Cattle grazed meadows after harvest. Pigs rootled beneath orchards. Animals moved across landscapes that mixed crops, trees and pasture, cycling nutrients back into the soil that fed them.

"Animals have always been part of farming systems – most farms were mixed until the mid-20th century," says Anastasi. "When animals graze land and return organic matter through manure, they tend to regenerate soils rather than degrade them."

Over the course of the 20th century, that complexity was steadily dismantled. As agriculture industrialised, animals were separated from the land that sustained them. Feed was grown in one place, animals raised in another. Manure accumulated as waste rather than returning to fields as fertility. Cropping systems became dependent on synthetic fertilisers; tillage intensified; soil cover declined. Landscapes were simplified – and with them, ecological relationships unravelled. Animals no longer cycled nutrients; they disrupted them.

"Because we don't understand complexity, we try to split nature into parts to control it and make it efficient," says Pinho. "And we end up with something completely artificial."

Within industrial food systems, livestock impacts appear overwhelmingly negative. When feed production, fertiliser use, transport and land-use change are included, livestock accounted for over 85% of agricultural greenhouse gas emissions in the EU in 2017, according to the report Future of EU livestock: how to contribute to a sustainable agricultural sector.

For Bajohr, the emissions story of livestock is told within narrow boundaries. "Climate balance is only measuring the cow in an artificial system," she argues. "But what happens when cows are working a grassland ecosystem? You need to track the bugs and flies and birds and plant species, which are only there because the cow is there."

Industrial livestock production has also driven biodiversity loss, water pollution, and deforestation, alongside severe animal welfare impacts. But in regenerative grazing systems – such as in the high Alps or the *montado* landscapes of Monte Silveira – animals operate within a different logic: a partnership between people, soil health, and ecosystems, shaped through long-term management and holistic principles.

This is the space Groundwork operates in. Working across the five Living Labs in Europe, the initiative works to understand how regenerative livestock grazing

"Animals have always been part of farming systems – most farms were mixed until the mid-20th century."

Maria Anastasi, Coordinator of Groundwork.

can restore soil health and ecological function while keeping farmers at the centre of decision-making. “We’re not another project where researchers tell farmers what to do,” Maria says. “We co-create with them.”

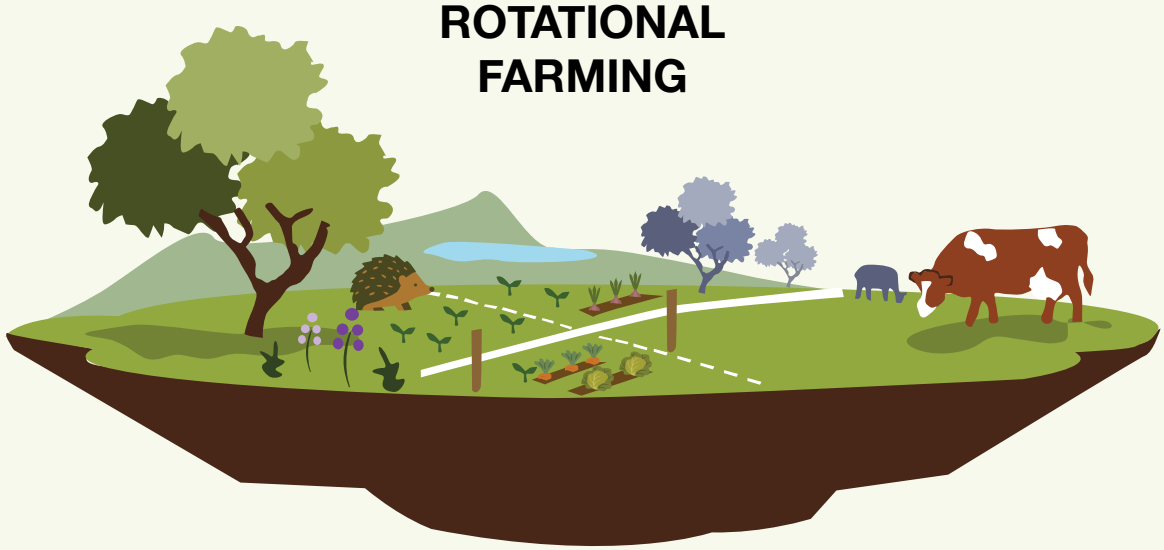
Seen in this light, the transition to a sustainable food system built on healthy soils should not be about choosing sides. It should be about redesigning agriculture around what land can sustain. That will likely mean fewer animals overall in Europe – particularly fewer animals fed on imported grain and confined in systems that sever nutrient cycles and externalise damage.

But it also means recognising where grazing animals still belong: on permanent grasslands, in semi-natural landscapes, and within mixed systems where their presence supports soil structure, water retention, biodiversity, and long-term fertility.

The question, ultimately, is not whether livestock are good or bad, but where, how and in what numbers they function as part of a living food system.

1. Cows graze in a meadow in Monte Silviera Farm, Portugal. Photo: Monte Silviera
2. Soil erosion in Southern Spain. Photo: Jake Threadgould / REVOLVE
3. Scientists measure biodiversity in a montado system at Monte Silviera Farm, Portugal. Photo: Monte Silviera
4. The rotation of livestock between paddocks over time supports soil health, plant regrowth, and biodiversity. Visual: Samia Singh / REVOLVE

ROTATIONAL FARMING



Regenerative Grazing

Cattle graze in one area and move on to the next, allowing the full regrowth cycle essential for grassland ecosystems.

DIVERSE HABITAT

Regenerative grazing enhances habitat diversity, which benefits birds, pollinators, and other wildlife.

CARBON SEQUESTRIATION

Plants capture atmospheric carbon most efficiently during the regrowth process.

CLIMATE RESILIENCE

Healthy soils with deep roots hold more water and can better withstand droughts.

GroundWork

Regenerating Soils, Rethinking Livestock

5 Living Labs

24 partners

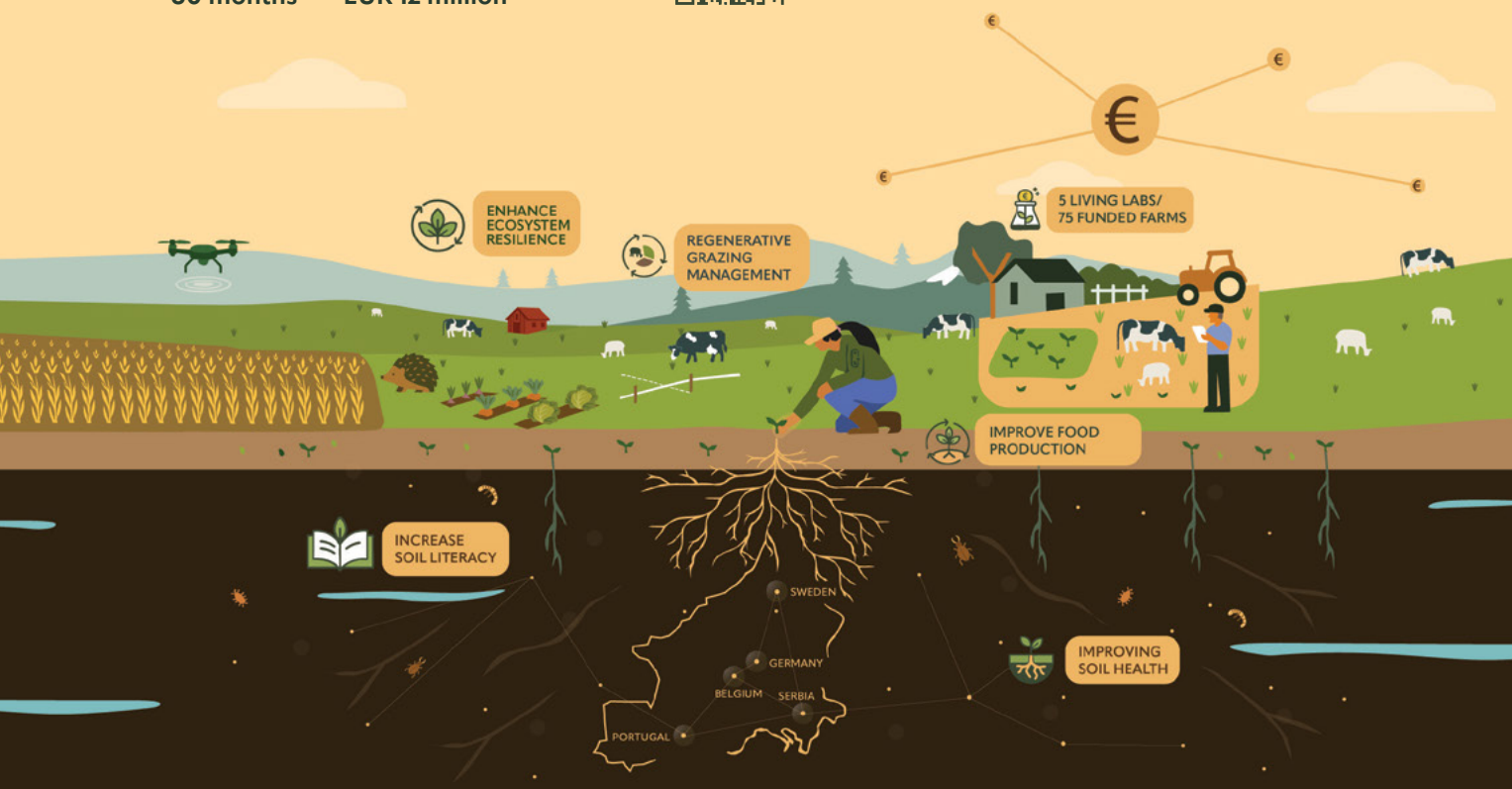
60 months

EUR 12 million

GroundWork is an EU-funded Soil Mission project bringing together farmers, scientists, and communities to **regenerate soils** and advance **sustainable agriculture**. Through **region-specific grazing practices**, the project restores **soil health**, **reduces pollution**, and **supports climate action**, proving that **nature-friendly farming** can be **productive**, **resilient**, and **sustainable**.

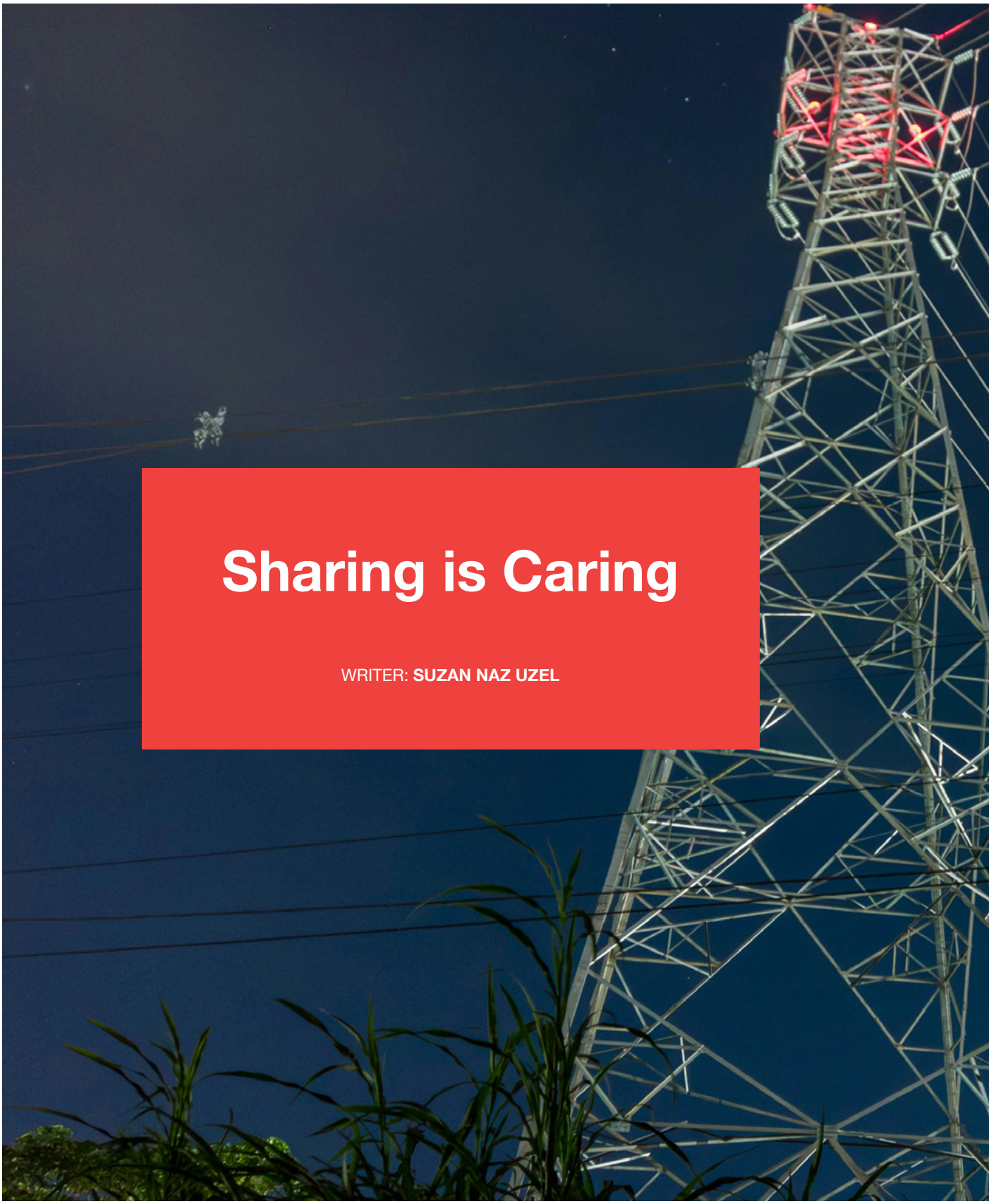
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Sharing is Caring

WRITER: **SUZAN NAZ UZEL**



1

Energy sharing's potential hinges on political, regulatory will.

We use electricity every day without thinking too much about how it reaches our homes. Somehow the energy flows, our lights turn on, and we are able to watch our favorite show on TV. Yet behind that everyday convenience sits one of the most complex systems Europe has ever built – and one now under pressure to change faster than ever before.

As the European Union accelerates its clean energy transition, the electricity system is being asked to do more than simply deliver power. It must integrate vast amounts of variable renewable energy, remain affordable during geopolitical shocks, and actively involve consumers in keeping the grid stable. One emerging idea promises to address all three at once: energy sharing.

Peer-to-peer (P2P) energy sharing offers a more democratic and potentially more decarbonised approach to electricity systems. However, turning this vision into reality will require thoughtful market design, transparent pricing mechanisms, and clear rules that ensure fairness and equitable participation for all stakeholders.

What is peer-to-peer energy sharing?

Peer-to-peer energy sharing/electricity trading is a decentralised market arrangement in which electricity is exchanged directly between participants through a digital platform, rather than being supplied exclusively by a traditional utility. The platform facilitates matching between those who have surplus electricity and those who wish to purchase it, enabling transactions based on mutually agreed prices.

Under the conventional electricity model, consumers buy power from retailers at regulated or contract-based tariffs, while small-scale generators typically sell excess production back to the grid at administratively defined compensation rates.

P2P trading seeks to create a more flexible framework in which participants can alternate between buying and selling electricity. By allowing direct exchange, it aims to improve price signals and generate more favourable outcomes for both sides compared to standard retail tariffs and feed-in compensation schemes.

Such arrangements can operate at different scales, from local community-based systems to wider interconnected networks. However, their viability depends on having a sufficient number of active participants and clear operational rules.

When trading occurs within the public distribution network, coordination with system operators remains necessary. Electricity flows must be managed to preserve grid stability, infrastructure costs must be covered, and any net imbalances must be settled with the broader market.

"Energy sharing has big potential and can empower consumers and support local renewables," Cillian O'Donoghue, Policy Director of Eurelectric, tells REVOLVE. "However, for it to work, national rules need to clearly define responsibilities, costs allocation, consumer protection, and grid stability. Without that we are just shifting risks onto suppliers or vulnerable customers and not capitalising on its major potential."

"Energy sharing has big potential and can empower consumers and support local renewables. However, for it to work, national rules need to clearly define responsibilities, costs allocation, consumer protection, and grid stability."

Cillian O'Donoghue, Policy Director, Eurelectric.



2

P2P energy sharing and conventional energy distribution

In conventional energy distribution systems, electricity flows in a one-directional manner – from large, centralised power plants through transmission and distribution networks to end consumers. Generation and grid management are controlled by utilities and grid operators, who are responsible for balancing supply and demand. In this model, end users are passive consumers who purchase electricity at regulated tariffs determined by utilities or regulatory authorities. Consumers typically have limited ability to choose their energy source or negotiate prices.

By contrast, P2P energy sharing operates on a decentralised structure. Individuals who both produce and consume electricity, commonly referred to as prosumers, can trade surplus energy directly with other participants through a shared digital platform. Energy flows can occur in multiple directions at the local level, for example from one household to another. These systems are often enabled by smart metres and digital platforms that facilitate measurement, verification, and settlement of transactions, reducing reliance on a central intermediary.

Economically, traditional systems rely on fixed or regulated pricing structures. Customers pay standardised tariffs, and pricing is largely disconnected from real-time local supply and demand conditions. In contrast, P2P energy markets often use more dynamic pricing mechanisms. Prices can reflect local generation and consumption patterns, frequently allowing buyers to pay less than retail electricity rates while enabling sellers to earn more than standard feed-in tariffs. By reducing or redefining the role of traditional utilities, transaction structures and cost allocations may change.



3

From a technical perspective, conventional energy systems involve long-distance transmission of electricity across extensive grid infrastructure. This can result in transmission and distribution losses, and centralised systems may be vulnerable to large-scale disruptions if major generation facilities fail. P2P energy sharing, on the other hand, promotes local energy trading, which can reduce transmission losses and alleviate grid congestion. By supporting distributed generation and localised balancing, P2P systems may enhance resilience and reduce dependence on single centralised sources.

Traditional energy models have historically been slower to integrate and reward small-scale renewable generations. P2P energy sharing frameworks actively encourage distributed renewable energy sources, such as rooftop solar, by allowing prosumers to sell excess electricity within their community. These arrangements can also support the development of community microgrids capable of operating semi-independently while maximising the use of local renewable resources.

Positive vibes

The appeal of energy sharing lies in its multiple benefits – economic, environmental, and systemic. Financially, prosumers can earn more than they would through low feed-in tariffs, while consumers often pay less than retail electricity prices. For households facing high energy bills, this can make a tangible difference.

From a system perspective, consuming electricity locally reduces strain on the grid. When energy is generated and used close to where it is produced, transmission losses fall, congestion eases, and peak demand can be reduced. A study from 2023 on peer-to-peer energy sharing and trading of renewable energy in smart communities by Yuekuan Zhou and Peter D. Lund found that well-designed P2P trading can improve self-consumption rates, lower primary energy use, and reduce the need for expensive grid reinforcement.

Environmentally, energy sharing encourages greater uptake of renewables by making small-scale solar and storage more economically attractive. This matters in a system where wind and solar already account for nearly half of the EU's electricity consumption – and are only expected to grow.

Compared with other energy management strategies, such as large-scale storage or power-to-X conversion,

When energy is generated and used close to where it is produced, transmission losses fall, congestion eases, and peak demand can be reduced.

P2P energy sharing can avoid energy losses linked to battery charging and discharging. It also offers flexibility without relying solely on centralised infrastructure.

What's the catch?

Despite its promise, energy sharing still sits uneasily within Europe's existing Electricity Market Design. Today's market largely fails to account for several real costs associated with decentralised energy systems including the degradation of solar panels and batteries, electricity losses across networks, and the expenses of maintaining grids, meters, and digital infrastructure. Many P2P pricing models implicitly treat electricity as if it can be generated and transported without cost.

This omission has significant implications. When prices fail to reflect underlying system costs, investment signals may become distorted, cross-subsidies can emerge, and non-participants may ultimately bear rising costs. Clear rules on pricing, grid cost allocation, and consumer protection are therefore essential to ensure that energy sharing complements rather than fragments the integrated EU energy market.

There is also a deeper issue of fairness. Most cost-benefit analyses of P2P trading focus on overall system efficiency while paying limited attention to how gains and risks are distributed. Some participants may consistently benefit more than others, and if the system is perceived as inequitable, engagement will decline. Academic research shows that while well-designed P2P systems can generate win-win outcomes for prosumers, consumers, retailers, and aggregators, models that explicitly address the fair distribution of costs and benefits remain rare.

Cooperation and governance add further complexity. Effective P2P markets require dynamic pricing that responds to supply, demand and weather conditions, as well as participants who understand how to organise and manage energy communities. Yet much of the literature still assumes self-interested individual behaviour, with limited exploration of collaborative decision-making or long-term cooperative arrangements. Questions therefore remain about how communities can reach stable and socially accepted pricing structures over time.

Regulation is a decisive factor in addressing these issues. The 2023 reform of the Electricity Market Design, in force since July 2024, together with revisions to the Renewable Energy Directive and related policy guidance, offers an opportunity to clarify how energy sharing operates within the internal market. The challenge now is to ensure that active customers and energy communities can engage in production, supply and sharing without facing legal uncertainty or disproportionate administrative burdens.

Ultimately, participation is the critical bottleneck. Energy sharing is as much a social innovation as a technical one: its success depends on trust, transparency, and perceived shared benefit.

A shared future

Energy sharing is unlikely to replace large-scale renewables, cross-border interconnections, or other backbone elements of the European power system. But it could become a complementary layer within it – one that strengthens local participation, improves system efficiency, and supports renewable integration where it makes economic sense.



4



5

Energy sharing is expected to stimulate additional investment in renewable energy while broadening access to its benefits. By enabling electricity generated in one location to be shared among multiple users, it can open up participation to consumers who cannot install their own systems – for example, low-income households in social housing who could access more affordable renewable electricity produced on public or community buildings.

If designed carefully, energy sharing can reinforce – rather than undermine – the internal energy market. It can provide flexibility without distorting price signals, empower consumers without shifting hidden costs, and contribute to decarbonisation without fragmenting the grid.

Ultimately, the question is not whether energy sharing is technically feasible, but whether it can be integrated into Europe's electricity system in a way that preserves stability, fairness, and trust. That will depend less on technology and more on regulatory clarity and political choices made in the coming years.

1. Power line, Brazil.
   Photo: Thalysson Santos / Unsplash
2. Wind turbines, Portugal.
   Photo: Bruno Vieira / Unsplash
3. Rooftop solar panels in a Sidney residential neighbourhood, Australia.
   Photo: Shanjir H. / Unsplash
4. Electrical boxes, Japan.
   Photo: Jonas Gerlach / Unsplash
5. Solar panels on the roof of a house, USA.
   Photo: Wiseman Mabasa / Unsplash

Ultimately, participation is the critical bottleneck. Energy sharing is as much a social innovation as a technical one: its success depends on trust, transparency, and perceived shared benefit.

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Feeling the Heat

WRITER: **HUDA ALHANAIEFAH**



1

Jordan's rain-fed olive groves face water scarcity and intense heat.

Agricultural engineer and pruning expert Ziad Al-Atoum stands among his olive trees on his farm in the Jerash Governorate in northwest Jordan. He takes stock of the trees that failed to blossom this year.

"Thank God for everything," he says.

In bumper years, Jordan can rank among the top 10 olive oil producers globally and the sector provides a source of income for more than 80,000 rural families, according to the country's National Agricultural Research Centre (NARC). However, many farmers describe the 2025 season as the most difficult in years.

Al-Atoum owns several rain-fed farms covering 30, 60, and 100 dunams (10 dunams is around 1 hectare), and also supervises pruning work for expatriate landowners in the area. "The trees did not flower at all; despite all the care I gave them. My production this year is zero, because there was not enough rain to meet the trees' needs," he says.

For Al-Atoum, the past two years were also disappointing. Last year, production did not exceed 40% of normal levels and in 2023 it fell to less than a quarter. A widespread lack of rain has affected farmers across Jerash. "Many trees were completely scorched, and I estimate the damage to be between 70 and 90%," he says, adding that these conditions also contributed to the spread of pests and diseases such as cotton bollworm. "If it had rained, the diseases would not have stayed on the trees."

Rain-fed farming under climate pressure

In the Karak Governorate, to the southwest of Amman, farmer Nayef Al-Majali faces the same hardship. He owns 500 trees spread across 30 dunams, yet they produced very little fruit in 2025. "This year's rainy season was weak. If we get seven tanks of water, it's a blessing," he says.

Last year, he harvested two tons of olives from his farm, producing 24 jerrycans of oil. In the 2023 season, he produced only 11 jerrycans. He recalls how the season was lost: "The trees began to flower and set fruit, and I was optimistic and took pictures of it. But at the beginning of May, we were surprised by heavy rains that destroyed



2

all the blossoms." Al-Majali does not expect this year's production to cover the cost of ploughing the land and buying fertiliser.

In the town of Kafrsum, northern Jordan, Omar Obeidat says his production was badly affected by high temperatures and low rainfall during the rainy season, despite his regular care for the trees. "My family has been growing olives for a hundred years. Today, I own 20 dunams of rain-fed land. I grow several varieties, including Mahras, Nabali, Spanish Grosadi, and improved Nabali," Obeidat says. Last year, his farm produced 13,500 kilograms of olives, yielding about 200 jerrycans of oil, each weighing 16 kilograms.

According to the Ministry of Agriculture, the northwestern governorates of Irbid, Jerash, and Ajloun as well as parts of the southern governorates Karak and Tafila, which rely heavily on rain-fed agriculture systems, are the most affected by climate change. It is precisely this dependence on rainfall that makes them highly sensitive to climate shifts amid decreasing and increasingly irregular precipitation and rising temperatures, which combine to increase soil evaporation and reduce productivity.

An estimated three quarters of Jordan's olive groves are rain-fed, equating to a total land coverage of around 130,000 hectares. Climate pressures on irrigated agricultural systems manifest in the form of groundwater and reservoir supply challenges.

Irregular rainfall and shrinking harvest

With the agricultural sector consuming roughly 52-60% of Jordan's total water supply, the industry remains particularly exposed to escalating drought and heat, as noted in a 2022 Agronomy study. This pressure is only set to intensify. Research in the International Journal of Water Resources Development forecasts that demand for irrigation will climb by 14% by 2030 and 28% by 2050.

Recent climate shifts have exacerbated the natural alternate bearing pattern of Jordanian olive cultivation, according to agricultural expert and engineer Mazen Abu Qumra, who explains that, normally, "a year of high production is naturally followed by a weaker year." This indicates that low rainfall along with fluctuations in its timing and intensity has increased surface runoff and reduced the soil's ability to retain moisture, especially in areas that depend entirely on rainfall.

Abu Qumra also points to other extreme climatic conditions that damage the flowering period, such as dry winds and sandstorms, which hinder fruit set and cause the fruits to fall before ripening. He adds that declining rainfall has also contributed to the spread of agricultural pests and diseases, further weakening the trees' ability to produce.

For this reason, Abu Qumra calls for the adoption of supplemental irrigation, along with sound agricultural practices such as regular pruning, pest control, and proper fertilisation to maintain productivity and oil quality.

The statistical report of the Ministry of Agriculture for the period between 2019 and 2023 (see graph) indicates notable fluctuations in rainfall in Irbid, with levels dropping down by about a quarter for several seasons. Jerash's rainfall decline was even more dramatic.

This was reflected in olive production: in Irbid, output fell about a quarter between 2021 and 2023, dropping from

> "The trees began to flower and set fruit, and I was optimistic and took pictures of it. But at the beginning of May, we were surprised by heavy rains that destroyed all the blossoms."
>
> Nayef Al-Majali, Farmer.

70,578 to 54,616 tons, despite a slight increase in cultivated area of around 5%. In Ajloun, production fluctuated, while in Karak it declined by about 14%, alongside a reduction in cultivated area of roughly 4%.

The results reinforce the conclusions of a study published in August 2024 titled Mapping the Future of Green Gold: GIS-Based Insights to Identify the Best Olive-Growing Areas in Jordan under Climate Change. The study stressed the importance of matching rainfall levels with suitable crop varieties, noting that areas receiving 400–600 mm annually, such as northwestern Jordan, are suitable for rain-fed agriculture. Areas receiving less than 400 mm, however, require supplemental irrigation, improved varieties, and the use of Geographic Information System (GIS) to support agricultural decision-making.

According to the Meteorological Department, olive trees need about one cubic meter of water per dunam to meet their water needs during key growth stages: from early March to mid-May (the flowering period), from May to July, and from July to October. In a previous statement, the head of the Olive Research Department at the National Centre for Agricultural Research explained that the period of oil formation in the fruit, after the pit hardens, extends from August to October. However, in August, Jordan experienced a heat wave lasting 13 days, which negatively affected this process.

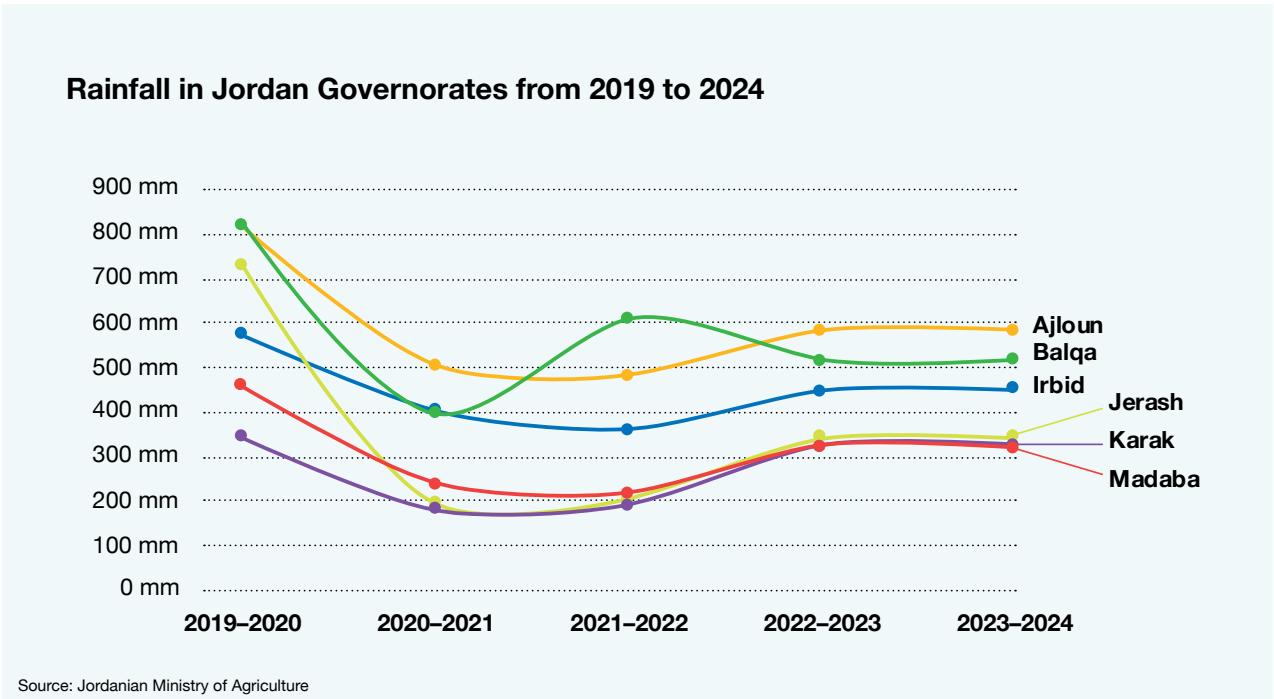
Adapting olive farming to a changing climate

Putting solutions into practice on farms is complex as farmers face real constraints related to water availability, crop varieties, and irrigation and maintenance methods, says Ziad Al-Atoum. “If we talk about supplemental irrigation, in Jerash there are no wells that can meet these needs like in the south or in Mafraq. There, an artesian well can pump 300 cubic meters per hour and cover the trees’ needs.”

Al-Atoum grows Nabali and Syrian Baladi olive varieties, and says both were affected this year. However, he explains that the Syrian variety planted



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Source: Jordanian Ministry of Agriculture

4

in high-altitude areas does not give the same yield as in its native environment, and the opposite is true for the Nabali variety. He adds that many people are now turning to olive farming without checking the type of seedlings they buy. They rely on the honesty of nursery sellers who claim the seedlings are suitable for the region, only to discover later that this is sometimes not the case.

Al-Atoum, as a pruning and grafting expert, has converted some olive varieties in Jerash and Zarqa into types that are more resilient to climate change. He notes that the success of the grafting process depends on the engineer's experience and the age of the trees, and that a weak rainy season can delay or even prevent successful grafting.

As for Majali, he cultivates the Rumi variety, which he considers the best in Karak, yet it has not produced a harvest for two years. He says he contacted the Directorate of Agriculture and Agricultural Extension, which provided him with a fungicide spray tank at a symbolic price, but he has not heard of any unconventional solutions to protect the flowering season. He tried all the available methods, relying mainly on what he reads and exchanges with other farmers on social media.

Al-Majali says there is no real possibility of supplemental irrigation: "My farm needs 3 to 4 water tanks per season, each load costs 35 dinars and covers 30 metres."

For his part, expert Abu Qumra emphasises that olive trees need integrated care in order to continue producing under changing climatic conditions. Al-Atoum, meanwhile, calls on the Ministry of Agriculture to intensify its extension visits to farmers and closely monitor the season on the ground to mitigate losses.

In response to inquiries about efforts to help farmers adapt to climate change and reduce its impacts, the Ministry said that it was working with partners to implement packages of climate change adaptation measures. These include awareness campaigns, training on climate-smart agriculture, introducing more efficient irrigation techniques, and improving cultivated varieties to make them more resistant to drought and heat. The measures also focus on managing the critical stages of flowering and production, to ensure the sustainability of the season and the quality of the crop. ●

1. Olive plantation, Jordan. Photo: Merlijn Hoek / Flickr
2. Woman removing leaves from olive harvest, Saham, Jordan. Photo: Hadeel Tawalbeh / Pexels
3. Olive trees in the spring, Jerash, Jordan. Photo: Hisham Zayadneh / Unsplash
4. Rainfall in Jordan Governorates from 2019 to 2024. Source: Analysis of data from the Ministry of Agriculture's annual report 2023

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VIEWS

The Corals of Zanzibar

WORDS: **CHARIS BRICE** IN CONVERSATION WITH **FRANK MOLLEL**
PHOTOGRAPHY: **FRANK MOLLEL** & **MALOU ANDERSEN**

A Masai warrior from the mountains of Tanzania blends coral conservation and community wellbeing.

Frank Mollel is a proud Masai who found his calling on the island of Zanzibar, which lies off the east coast of Tanzania in the Western Indian Ocean. Here, coral reefs protect coastlines, support fishers, and sustain communities who have long been connected to the sea. But warming waters, overfishing, pollution, and coastal development are pushing these reefs towards decline.

“Corals are not just grey rocks or colourful plants; they are living animals, and come in all sizes, textures, and colours. They can camouflage themselves with their surroundings and work in harmony with one another, communicating without ever speaking,” Mollel tells REVOLVE. “Corals play a vital role in ocean life, housing 25% of marine life despite covering less than 0.1% of the ocean floor.”

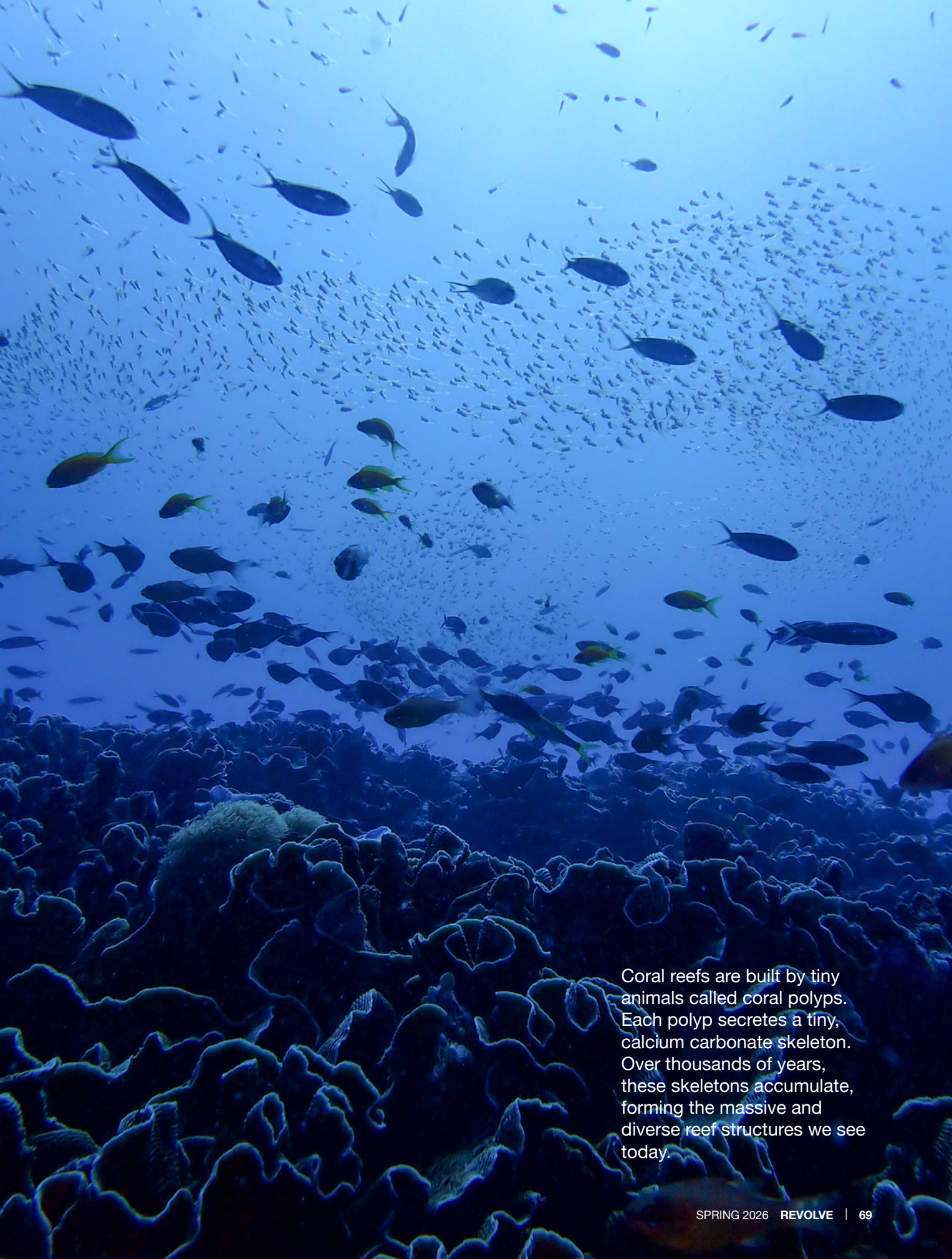
“I love them because they provide food, shelter, and medicine; they support the ecosystems above and below them, and they act as a barrier to protect us from the wrath of the sea, breaking those massive waves into gentle, calm swells."

In response to the challenges faced by coral reefs, Mollel founded the Linda Bahari Zanzibar initiative in 2019. By growing coral fragments (known as nubbins) back to health in nurseries and outplanting them onto damaged reefs, the project helps restore reef structure, buying time in a rapidly warming ocean.

Equally important is the initiative’s work above water. It teaches children to swim and dive, organises beach cleanups, and demonstrate to local fishers how reefs function, why certain species are important, and explains the significance of sustainable fishing practices in protecting both marine life and human livelihoods.

In Zanzibar, conservation is inseparable from community.

Cover: Anemonefish and anemone, bound by mutual survival in a reef system increasingly stressed by warming seas.



Coral reefs are built by tiny animals called coral polyps. Each polyp secretes a tiny, calcium carbonate skeleton. Over thousands of years, these skeletons accumulate, forming the massive and diverse reef structures we see today.



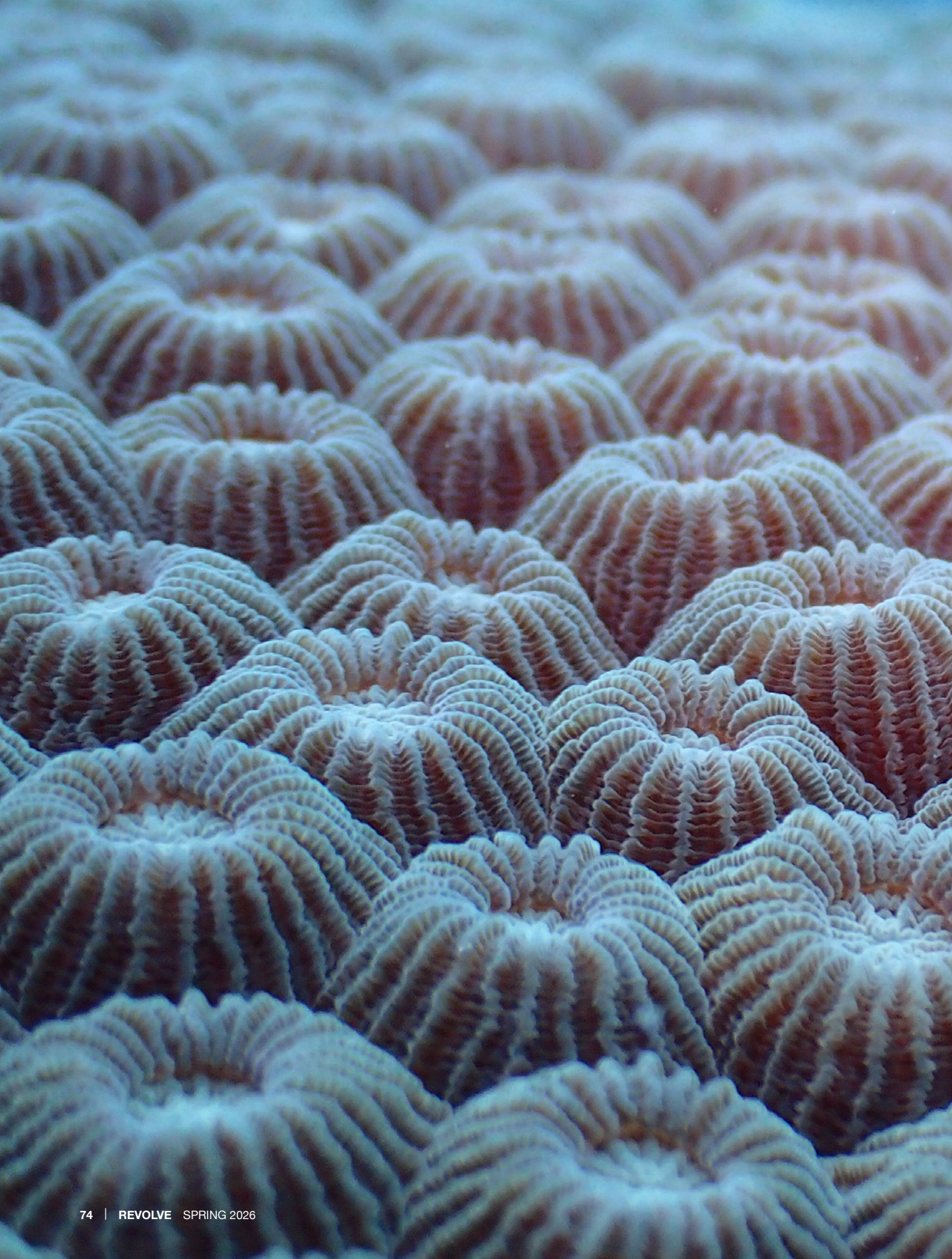
Moray eels are important reef predators, helping regulate fish and invertebrate populations. They rely on complex reef structure for shelter. Reef degradation reduces hiding spaces, making species like morays more vulnerable.

Above: A small coral goby hovers near the surface of a brain/maze coral, identified by the meandering ridges and valleys. Small fish like this depend on live coral structure; when corals bleach or die, these fish are among the first to disappear. **Below:** A longnose hawkfish perches on living hard coral. It is dependent on the reef's three-dimensional structure for shelter and hunting.



Following the rain, a traditional sail boat is photographed in Zanzibar on Matemwe beach.







Close-up view of a Boulder coral, known for its tendency to grow into big boulder-shaped structures. In this photo, each polyp is approximately 3mm in size.

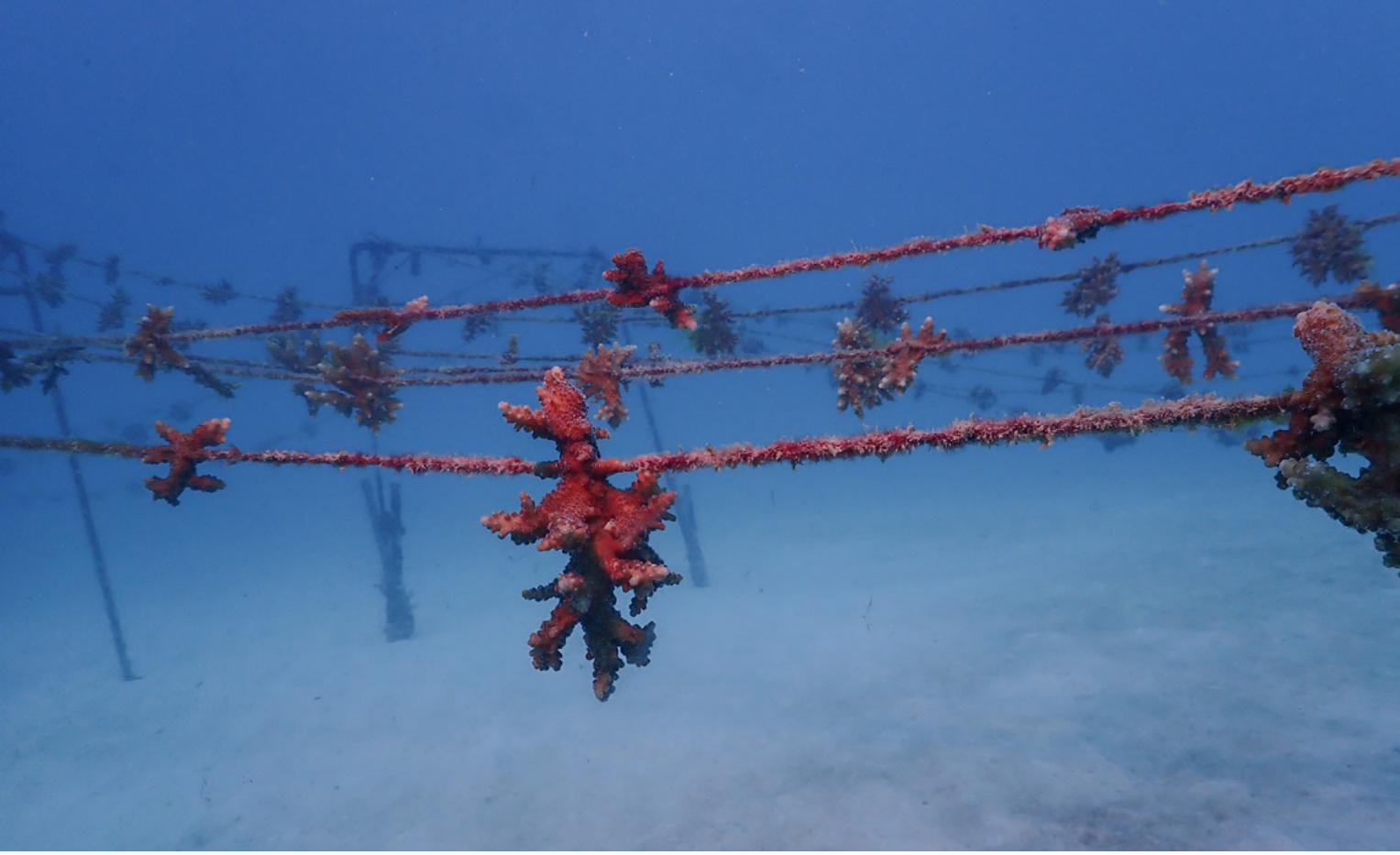


A colour guide is used by the divers to determine the health of different corals. When bleaching or damage is detected, the reef is placed on a watch, potentially being flagged for intervention.



Frank preps a coral fragment to be attached to a rope nursery, allowing it to grow and strengthen before being re-attached to a reef. On rope nurseries, coral fragments are free to grow in all directions and to absorb nutrients from the moving currents, with less attacks from predators and algae.

Above: Coral reefs thrive only within a narrow temperature range and in stable tropical waters. Unlike fish and other marine life, corals cannot relocate to cooler or calmer water; they are stuck, exposed to their environments.
Below: A sign of health: a “baby” acropora coral has grown and attached itself to the block beneath it, showing it is strong and growing quickly.



Above: A rope nursery holding dozens of coral fragments as they absorb nutrients from the sea and heal, preparing for outplanting. Corals rely on microscopic algae, sunlight, and photosynthesis for most of their energy.
Below: Two coral rangers prepare tables that will serve as a coral nursery, designed to hold fragments of living coral above the seabed. These fragments, known as coral nubbins, are typically grown from broken but living pieces of coral collected after storms or bleaching events.



Above: Anemonefish and anemone, bound by mutual survival in a reef system increasingly stressed by warming seas.
Below: During restoration visits a technique using coral clips is used to attach coral to the reef.





In Matemwe, Zanzibar, community members gather discarded plastic from the coastline, a response to the endless pollution that threatens nearby coral reefs and marine life.

Taken after a devastating Tropical storm (Hidaya) in 2024, this photo shows the tenacity of the reef and of the sea to keep living despite all odds.



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Ships Are Ready for New Fuels, Are Ports?

WRITER: **AHMETCAN UZLAŞIK**


TERMINAL BURCHARDKAI
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TERMINAL BURCHARDKAI
TAMPA TRIUMPH
PANAMA

1

Hundreds of new vessels are being ordered to run on alternative fuels, but infrastructure is lagging.

Shipping is in the midst of a radical fuel transition. In 2024 alone, shipowners ordered 515 vessels capable of running on alternative fuels, a 38% increase from the year before, according to risk management provider DNV. Liquified Natural Gas (LNG) was the preferred fuel choice for those orders, with methanol and ammonia close behind. International Maritime Organization data shows that more than 230 new LNG carriers are due to enter service between 2026 and 2030, with 2026 set to become the busiest delivery year on record.

What stands out is not just the scale of the shift, but its speed. Container ships and car carriers accounted for nearly two-thirds of all alternative-fuel orders, driven by cargo owner pressure, tightening climate regulation, and long-term fleet renewal needs.

Yet behind the surge in newbuilds sits a quieter, more difficult question: will ports and fuel suppliers be ready when these ships arrive?

Why infrastructure now matters more than engines

For decades, shipping's decarbonisation debate focused on ship technology: engines, fuels, hull efficiency. Today, that focus is shifting toward infrastructure.

The International Renewable Energy Agency (IRENA) estimates that global shipping consumed nearly 11 exajoules of energy in 2018, producing around 1 billion tonnes of CO_2, roughly 3% of global greenhouse gas emissions, almost the same as Germany. International shipping enables up to 90% of global trade and accounts for about 70% of shipping's energy emissions, making it one of the hardest sectors to decarbonise.

IRENA's modelling is clear: meeting climate targets means replacing fossil fuels with renewable alternatives, primarily advanced biofuels in the short term, and e-fuels such as methanol and ammonia in the medium to long term.

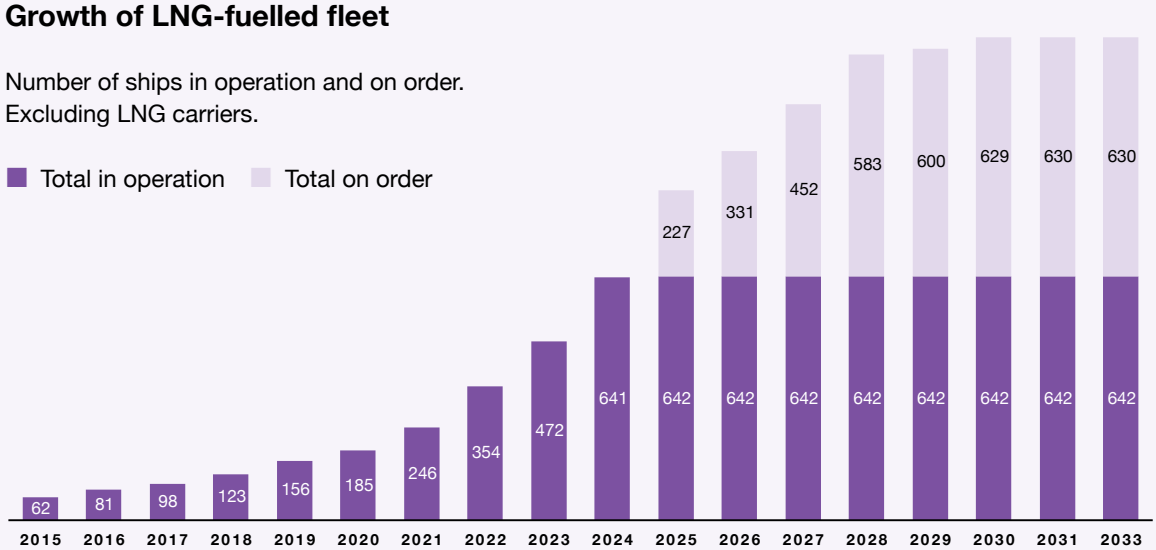
Engines alone cannot deliver that. Transition fuel availability, bunkering systems, safety approvals, and port investment will determine which fuels actually scale.

LNG's head start

LNG currently enjoys a significant infrastructure advantage. The number of LNG-fuelled vessels in operation doubled between 2021 and 2024, reaching more than 640 ships worldwide. According to the Bunker Index, bunkering networks for LNG are expanding across major ports, supported by decades of experience in gas handling and existing investments in storage, safety systems, and supply chains.

Growth of LNG-fuelled fleet

Number of ships in operation and on order.
Excluding LNG carriers.



Source: DNV

That level of preparedness is the factor that is shaping fleet decisions. LNG accounted for roughly two-thirds of alternative-fuel container ship orders in 2024, making it the dominant transitional choice for large operators. For many shipowners, LNG offers a practical bridge in cutting CO_2 emissions. According to SEA-LNG's 2024 report: LNG, and its pathway, "is the most viable current and practical solution for decarbonisation of the maritime space."

Jesper Soerensen, Global Head of Alternative Fuels & Carbon Markets at KPI OceanConnect, says bottlenecks now span the entire value chain.

"Fuel supply, bunkering capacity, port readiness, and regulatory approvals all feature in the lamentable slow pace of infrastructure developments for alternative fuel," he says. "LNG itself is a globally traded commodity, but access to molecules, bunkering capacity, and port readiness are limited even at some of the biggest ports in the world."

Climate credibility under scrutiny

LNG's long-term climate credibility is increasingly under scrutiny. A key challenge is methane slip, which is unburned methane that is released during combustion and fuel handling. Because methane has a global warming potential 25 times – or as much as 28 times according to some sources – higher than CO_2, even small leakage rates can significantly erode LNG's emissions advantage. According to DNV, methane slip can account for up to 24% of GHG emissions from an LNG-fuelled vessel.

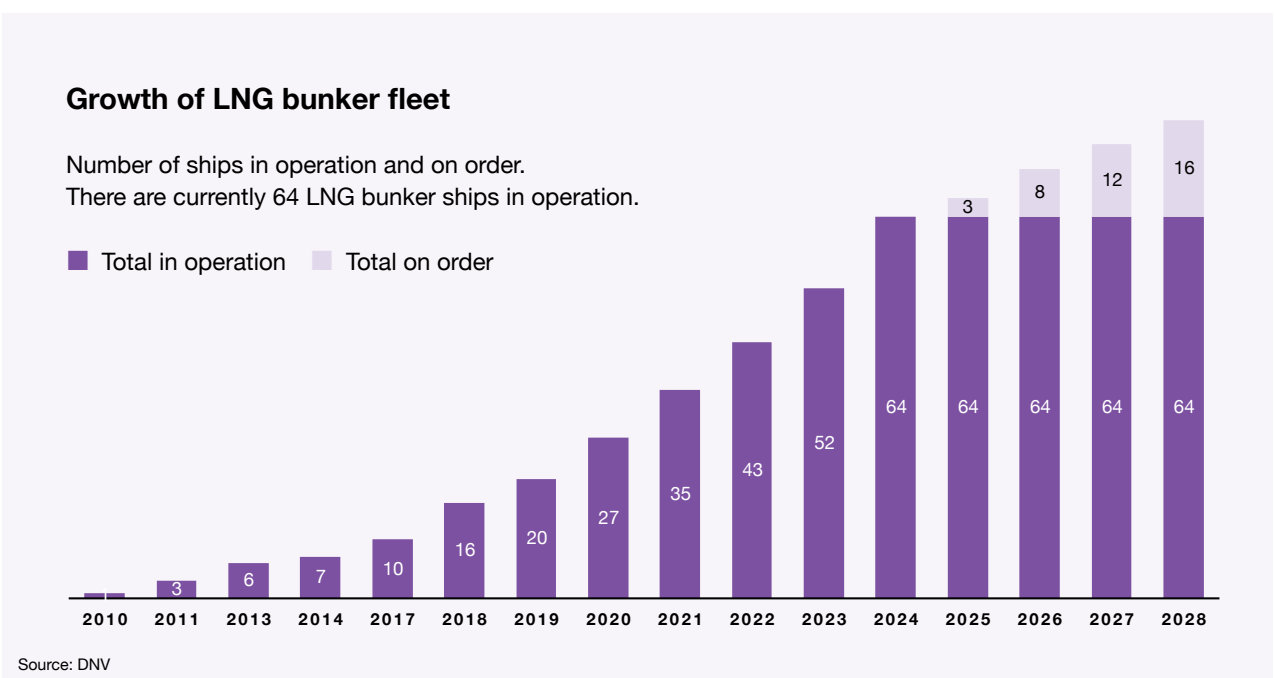
This is where targeted technology efforts are emerging. The EU-backed GREEN RAY project, for example, is developing engine upgrades and exhaust aftertreatment systems designed specifically to reduce methane slip in LNG vessels. By improving combustion efficiency and converting residual methane in exhaust gases, the project aims to preserve LNG's short-term climate benefits while remaining compatible with future renewable methane fuels.

Moreover, recent onboard trials by Japanese outfits including Mitsui O.S.K. Lines and Yanmar have already demonstrated methane slip reductions of up to 98%, showing that near-elimination of leakage is technically achievable.

Regulation makes infrastructure decisive

At the same time, policy pressure is also intensifying. Since January 2024, the EU Emissions Trading System has applied to maritime transport, covering CO_2 emissions from all large vessels calling at European ports, including 100% of emissions on intra-EU voyages, 50% on routes between the EU and the rest of the world, and all emissions produced while ships are at berth.

Crucially for LNG, the system expanded again in January 2026 to include methane and nitrous oxide on a CO_2-equivalent basis. Shipping companies will be required to monitor and pay for these emissions through annual



Source: DNV



allowance purchases, with compliance rising from 40% of emissions in 2025 to full coverage by 2027.

That shift will directly link infrastructure performance to operating costs.

"What we have consistently seen is that fuel choice is informed by infrastructure and supply availability," Soerensen says. "For alternative fuels, however, fuel choice is mainly driven by regulation. Without a regulatory requirement, shipping will stick with the most cost-effective solution."

That shift means methane leakage will no longer be a hidden climate cost. For LNG operators, methane slip will translate directly into higher operating expenses, potentially narrowing or eliminating LNG's economic advantage compared with genuinely zero-carbon fuels such as green methanol and ammonia.

The infrastructure squeeze behind LNG's boom

Aside from methane slip, infrastructure itself is becoming a growing constraint on LNG's expansion.

While LNG-fuelled ships have surged past 640 vessels in operation, with the fleet expected to double again by the end of the decade, the bunkering systems that supply those ships are scaling far more slowly. According to DNV data, LNG consumption by shipping increased by more than 500% between 2020 and 2024, a pace that far outstrips the growth of bunkering capacity.

In early 2025, there were some 64 LNG bunkering vessels in operation worldwide, with only 16 additional vessels on order through 2028, according to an article by DNV Maritime's Global Business Director for Gas Carriers and FSRUs, Martin Cartwright. These ships, which act as floating fuel stations transferring LNG directly to vessels in port, form the backbone of today's LNG supply chain. But their numbers are not keeping pace with fleet growth, creating a widening gap between fuel demand and bunkering supply.

The port picture tells a similar story, Cartwright argues. In 2024, only 191 ports globally had active LNG bunkering facilities, such as dedicated storage tanks, transfer systems, and approved safety infrastructure. Another 81 ports were under construction, but even if all are completed on schedule, the expansion remains modest compared with the scale of LNG vessel orders now in the pipeline.

Regionally speaking, the LNG bunkering capacity is uneven. According to DNV, around 42% of bunkering vessels

operate in Europe, 28% in Asia, and 18% across the Americas, leaving large parts of the global trading system with little to no access to LNG refuelling. For shipowners running global liner networks, this uneven coverage complicates route planning and increases reliance on a small number of equipped hubs.

Soerensen says that the gap is less about LNG production and more about access.

"The growing supply-demand gap is less about global LNG availability and more about terminal accessibility, including bunker slot availability, port coverage, and logistical readiness across global trading routes," he says. "Where supply remains concentrated in a limited number of hubs, shipowners face operational and commercial risk if vessels cannot reliably bunker LNG when required."

"This challenge is probably best reflected in Southeast Asia," he explains, where Singapore's LNG bunkering system is approaching full capacity, prompting authorities to invite new operators to expand supply.

Ports entering a multi-fuel reality

If LNG infrastructure is strained, methanol and ammonia are even further behind.

"Ports around the world are doing their best to meet the demands of clients in an emerging multi-fuel world," Soerensen says. "But decision making is very challenging, for ports and for fuel buyers, who need to understand the infrastructure landscape, the demand for a specific product, and where it is available to confidently meet their operational and regulatory obligations."

Methanol bunkering remains limited to a small number of early-adopter ports. Ammonia infrastructure, outside pilot projects, is largely non-existent.

Solutions for ammonia

As the fleet shifts rapidly toward alternative fuels, early infrastructure projects are beginning to move from planning to construction, particularly around ammonia, which many long-term decarbonisation models identify as a major future marine fuel but which as of 2026 lacks dedicated bunkering networks.

In Norway, several of the most advanced efforts are focused on building the first commercial-scale ammonia fuelling systems. Azane Fuel Solutions has created a separate infrastructure company to develop and operate bunkering terminals designed specifically for ammonia-powered vessels. In late 2025, the group secured public funding of NOK 442 million (approximately €38–40 million) to support construction of three terminals along the Norwegian coast, in Florø, Stavanger, and Mongstad, with operations targeted before the end of the decade. and Mongstad, with operations targeted before the end of the decade.

"Fuel supply, bunkering capacity, port readiness and regulatory approvals all feature in the lamentable slow pace of infrastructure developments for alternative fuel."

Jesper Soerensen, Global Head of Alternative Fuels & Carbon Markets at KPI OceanConnect

The projects aims to provide refrigerated ammonia storage, transfer systems, and fuel logistics for early ammonia-fuelled ships, infrastructure that currently does not exist at scale in most ports worldwide.

Alongside fixed terminals, partners involved in the Ammonia Fuel Bunkering Network are developing floating bunkering barges that can deliver ammonia directly to vessels. Designed to be relocatable, the units are intended to allow ports to begin supplying ammonia without committing immediately to large permanent facilities, reflecting uncertainty around how quickly demand will grow.

The infrastructure build-out is being paired with early vessel deployment. Norwegian operators are preparing ammonia-capable bulk carriers and container vessels intended to run initially on dual-fuel systems before transitioning toward higher ammonia shares as supply becomes available. Fuel producers, including Yara Clean Ammonia, have announced plans to support early bunkering hubs with low-carbon ammonia.

Even in these frontrunner markets, challenges remain. Permitting processes for hazardous fuel handling are complex, safety standards are still evolving, and early demand volumes are expected to be too small to fully utilise infrastructure in the short term. Research modelling by research organisation SINTEF suggests that ammonia consumption in maritime transport will grow slowly through the 2020s before accelerating in later decades.

The pattern echoes the early days of LNG bunkering, which began with mobile fuelling solutions before expanding into large shore-based terminals as vessel numbers increased. Today, LNG benefits from nearly 200 active bunkering ports globally, a scale that alternative fuels have yet to approach.



Infrastructure as the real fuel selector

As emissions regulation tightens, infrastructure availability is likely to become one of the most decisive forces shaping which fuels ultimately scale.

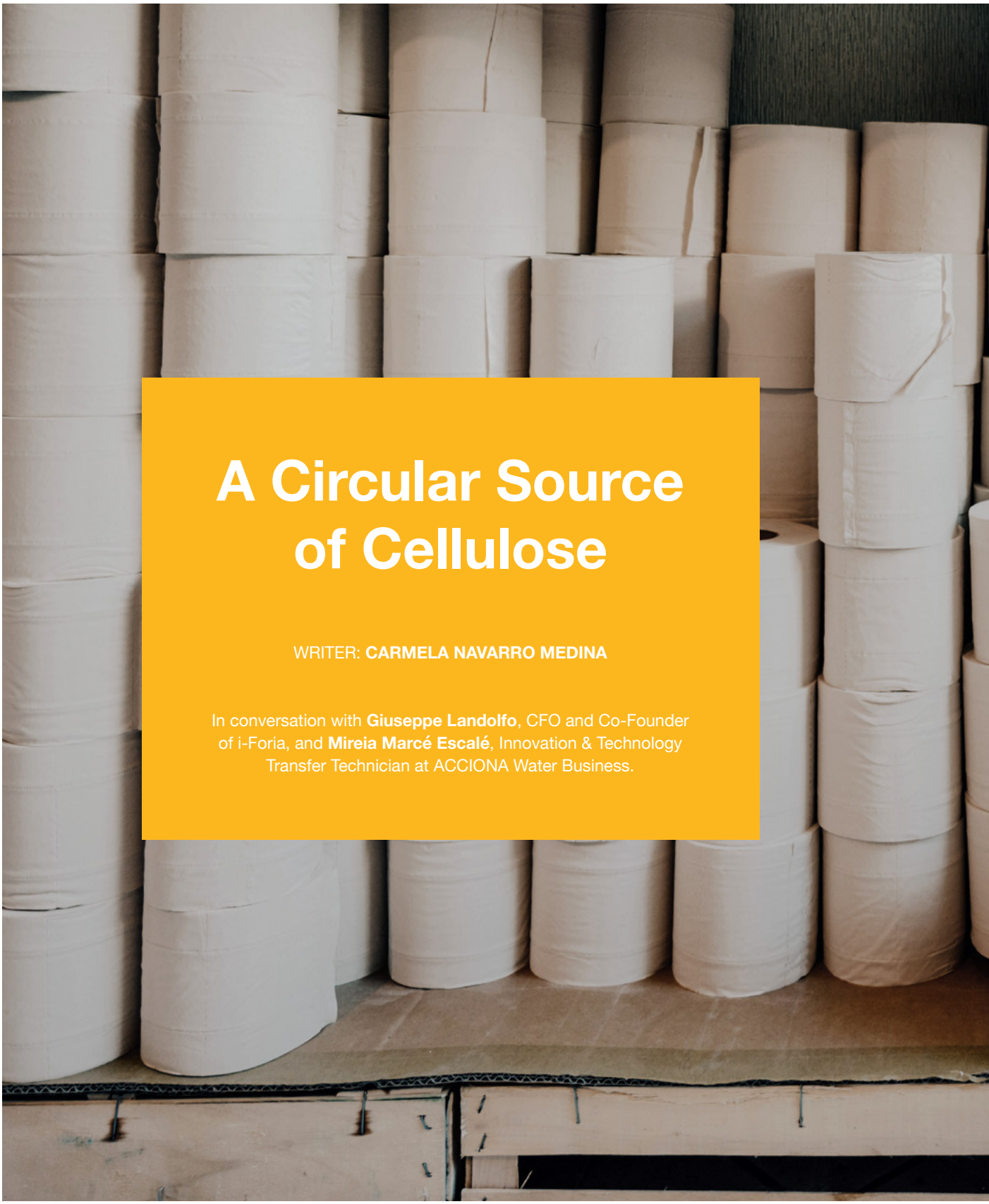
“What we have consistently seen is that fuel choice is informed by infrastructure and supply availability,” Soerensen explains. “For alternative fuels, fuel choice is mainly driven by regulation, but without regulatory requirements, shipping will stick with the most cost-effective solution.”

Looking ahead, he argues that collaboration across the value chain will determine whether the industry can move fast enough to meet climate targets.

“The industry needs active collaboration to develop pathways and infrastructure, from feedstock supply to fuel production and offtake,” he adds. “Ensuring coordinated investment, strong partnerships and knowledge sharing will be critical to enabling a commercially viable energy transition.”

1. Cargo ships in the port of Hamburg, Germany. Photo: Wolfgang Weiser / Unsplash
2. Growth of the global LNG-fuelled vessel fleet and orders, 2015–2033. Source: DNV Alternative Fuels Insights
3. Growth of the global LNG bunkering vessel fleet in operation and on order, 2010–2028. Source: DNV
4. LNG tanker ‘Arctic Princess’ at anchor on the coast of Hammerfest, Norway. Photo: Joachim Kohler Bremen / Wikimedia
5. LNG tanker ‘Gulf Energy’ at anchor beside Bukkøy Island, Norway. Photo: Gordon Leggett / Wikimedia





A Circular Source of Cellulose

WRITER: **CARMELA NAVARRO MEDINA**

In conversation with **Giuseppe Landolfo**, CFO and Co-Founder of i-Foria, and **Mireia Marcé Escalé**, Innovation & Technology Transfer Technician at ACCIONA Water Business.



1

Breakthroughs in cellulose recovery are creating an alternative forest to meet rising resource demand.

Historically, cellulose production has been synonymous with the logging of forests but as Europe seeks to strengthen its resource independence and protect natural ecosystems, the search is on for alternative sources. The EU-funded ICARUS project brings partners together in the search for circular cellulose solutions within the construction sector.

ICARUS partners are working together to validate an efficient system to recover cellulose from urban wastewater (WWTP) and absorbent hygiene products (AHP) through two pilots in Italy and Spain, led by i-Foria and ACCIONA Water Business.

REVOLVE spoke with i-Foria CFO and Co-Founder Giuseppe Landolfo and ACCIONA Water Business' Innovation & Technology Transfer Technician Mireia Marcé Escalé to find out more.

We often overlook the sheer volume of cellulose that ends up in our waste systems. AHPs are a good example of this – what makes this waste stream more challenging than others?

Giuseppe Landolfo: (AHPs) include items like baby nappies, sanitary pads, and incontinence products. These are highly complex products made of mixed materials – plastics, cellulose, and superabsorbent polymers – bonded together in multilayer structures. Their contamination with biological waste and the difficulty in separating the materials made them historically "impossible to recycle."

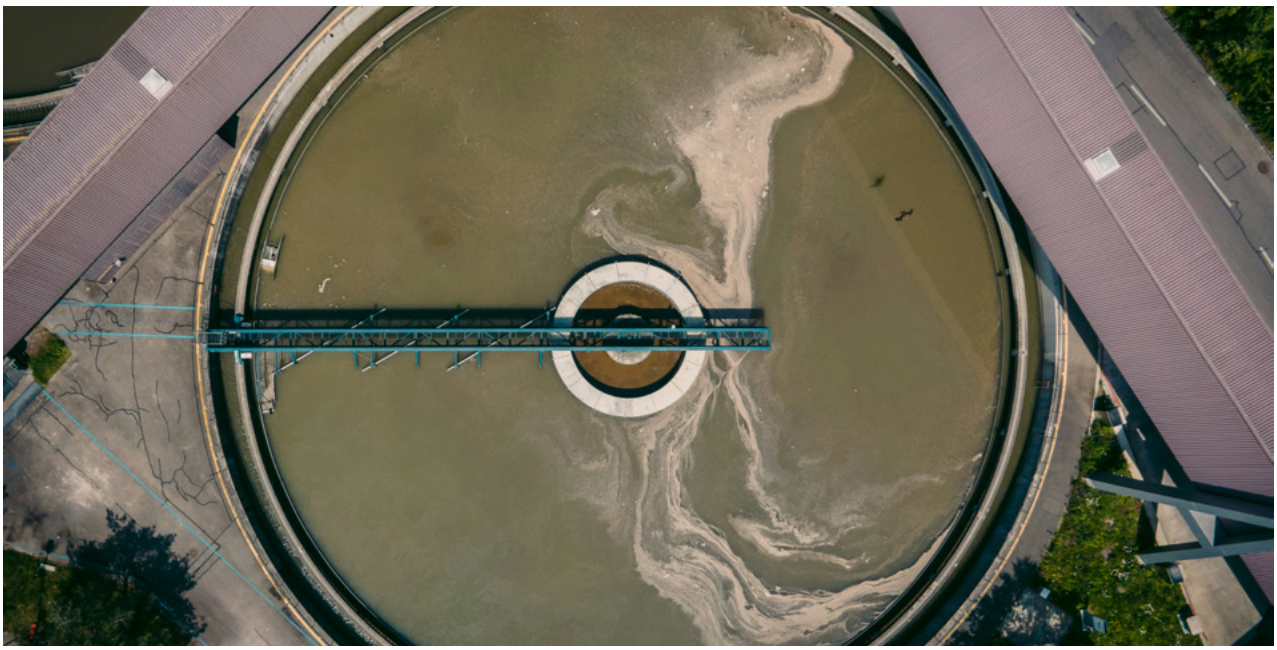
In Europe, over 8 million tonnes of AHP waste are generated every year. In Italy alone, it's estimated that AHPs account for around 900,000 tonnes per year, which represents over 4.4% of the total municipal solid waste – more than the textile sector (4.1%).

We often think of wastewater treatment as just cleaning water, but at ACCIONA Water Business, you are essentially mining it. What makes cellulose from wastewater a viable resource?

Mireia Marcé Escalé: Cellulose is the primary component of toilet paper, and depending on the manufacturer, its content can reach up to 85% of the paper's overall composition. Considering that each European citizen uses between 10 and 50 grams of toilet paper per day, the resulting generation of cellulosic waste across the European Union is substantial and estimated at around 4.3 million tonnes per day.

"In Italy alone, it's estimated that AHPs account for around 900,000 tonnes per year, which represents over 4.4% of the total municipal solid waste – more than the textile sector (4.1%)."

Giuseppe Landolfo, CFO and Co-Founder, i-Foria.



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Beyond the volume of waste, what are the environmental costs of letting these materials go to waste?

MME: Within wastewater treatment, one of the most significant environmental impacts associated with cellulose is the high energy demand required for aeration, which entails energy consumption and an important carbon footprint. Aeration is essential for sustaining the biological processes responsible for degrading organic matter, including the cellulose present in the wastewater influent. Because aeration accounts for the largest share of energy consumption in most wastewater treatment plants, any reduction in organic load becomes crucial for improving sustainability and operational efficiency.

GL: AHPs that aren't landfilled are often incinerated, leading to greenhouse gas emissions and loss of recoverable materials. Moreover, when mismanaged, they can contaminate organic waste streams—particularly in composting facilities—adding costs and inefficiencies to treatment processes. In many regions, especially in the Global South, used nappies are visibly dumped in the environment, contributing to pollution and health risks.

What is a breakthrough or key element in ACCIONA Water Business's process that makes it possible to recover cellulose?

MME: ACCIONA Water Business is using a Rotary Belt Filter (RBF) to retain the small solid fraction present in the wastewater stream. This retained material is particularly cellulose-rich, as cellulose represents a substantial portion of the solid fraction. After the RBF, the retained solids undergo a dewatering step, achieving a dryness level of approximately 25-30% (kilograms of dry solids per kg of wet sample). However, this fraction is also mixed with a significant quantity of other debris, which must be further handled downstream by i-Foria.

Although RBFs are conventionally installed at the end of the wastewater treatment to dewater the sludge, ACCIONA Water Business is investigating a novel application of this technology. In this case, the RBF has a mesh size capable of effectively sieving and retaining cellulose fibres present in the wastewater effluent.

GL: For i-Foria, the breakthrough lies in a mechanical process. Our technology gently separates each material without degrading its properties, recovering cellulose, superabsorbent polymers and plastic in clean, reusable forms. The i-Foria technology is the only one capable of removing drug residuals while complying with the EU's end of waste (EoW) criteria (which determines when waste becomes a secondary raw material) – all through a low-energy process.

How has the close relationship between ACCIONA Water Business and i-Foria helped streamline the objectives of the ICARUS project?

MME: The integration of our process with i-Foria's cellulose recovery technology is essential to revalorise the





3

cellulosic sludge generated at the WWTP. Our process generates a cellulose-rich sludge, but this material cannot be directly used in construction applications. Similar to the absorbent hygiene product feedstocks that i-Foria is using as initial feedstock, too, the cellulosic sludge first requires proper hygienisation and purification to remove contaminants and ensure that the resulting secondary cellulose meets the quality standards necessary for applications such as pavements, cement, and concrete.

By working closely with i-Foria, we can evaluate how operational adjustments in the RBF process influence the downstream purification and polishing steps and ultimately affect the quality of the recovered cellulose.

What are some real-world applications for recovered cellulose?

GL: Recovered cellulose can be reused in insulation panels, agricultural substrates, or as a raw material for biochemicals. Plastics are suitable for producing construction components, packaging, or urban furniture. Each tonne of recycled AHPs saves virgin pulp and plastic production, significantly reducing carbon footprint and dependency on fossil-based or forest-derived materials.

MME: By recovering cellulose, we are unlocking a new material to be added to construction formulas such as the concrete used in pavements. The properties of cellulose will contribute to diminishing the risk of cracking of this type of pavement due to drying shrinkage. Currently, polypropylene microfibers are used for this purpose, therefore, with the ICARUS initiative we are reducing the reliance of the sector in fossil fuel-based materials, and therefore, also reducing its carbon footprint.

Both of your companies are in pilot phases as of early 2025, what are the next steps to scale the technology up?

MME: The next phase will involve a technoeconomic analysis to evaluate the costs and benefits associated with scaling up this technology. The outcomes will help validate the feasibility of scaling up the technology and provide insight into the potential profitability of the initiative, thereby paving the way for its future integration into a full-scale wastewater treatment plant.

GL: We have a pilot that has a capacity of 100kg per batch. With this pilot, we have successfully demonstrated and validated the technology at a meaningful pre-industrial scale. We are now able to produce representative samples compliant to the EoW criteria that allow us to test and validate real downstream applications with our industry partners.

The next step for i-Foria is to license this innovative technology for the construction of the first industrial-scale plant in Tuscany, where there was already a Public Tender last year, and they selected i-Foria technology. This installation in Tuscany is supported by funding from the PNRR (National Recovery Plan) programme, which is enabling the development of 15 recycling facilities across Italy.

What are some of the main hurdles you face when trying to scale up to wider deployment?

MME: On one hand, this particular technology is typically applied to the sludge stream, at the end of the treatment, for its dewatering before its following processing. This stream can be up to one hundred times smaller than the WWTP's influent flow, the stream

targeted in our initiative. For this reason, scaling up the process requires addressing not only an increase in the number of RBF units but also improvements in their efficiency and processing capacity. The separation step must be capable of handling substantially higher flow rates, making technical optimisation essential for full-scale deployment.

GL: AHP collection requires dedicated bins and separate logistics that have already been implemented in many Italian cities. Public cooperation is needed. The success of municipal pilot programs shows that people are willing to separate AHPs when given the infrastructure. Today in Italy, 20 million citizens are already served by separate diaper collection. Municipalities therefore organise dedicated collections, but paradoxically, diapers collected separately still end up in traditional disposal facilities.

What are some of the regulatory barriers slowing down progress?

GL: The main barrier is the lack of harmonised extended producer responsibility (EPR) schemes for AHPs in most countries, which limits investment in separate collection and recycling. Italy leads Europe with an EoW regulation specifically for AHPs and 13 plants under construction via the PNRR. Expanding similar policies in other countries is essential to scale the solution

MME: Measures such as establishing mandatory minimum shares of recovered materials or providing incentives for their use could significantly accelerate market integration and help these materials compete with traditional resources. Although the EU is progressively strengthening its Circular Economy strategy, concrete initiatives to actively support material recovery and its introduction in the industry are still limited and need further development to unlock the full potential of projects like ICARUS.

1. Cellulosic waste from toilet paper across the European Union is estimated at around 4.3 million tonnes per day.
Photo: Konstantin Volke / Unsplash
2. Sewage treatment plant, Zurich, Switzerland.
Photo: Patrick Federi / Unsplash
3. Partners visited the i-Foria partner Absorbent Hygiene Products (AHP) recycling demo plant in Spresiano.
Photo: Carmela Navarro / REVOLVE

“Considering that each European citizen uses between 10 and 50 grams of toilet paper per day, the resulting generation of cellulosic waste across the European Union is substantial and estimated at around 4.3 million tonnes per day.”

Mireia Marcé Escalé, Innovation & Technology Transfer Technician, ACCIONA Water Business.

Life That Ran Away



REVIEWED BY **STUART REIGELUTH**

Solar
Ian McEwan
London: Vintage Books, 2022,
317 pages, 12.95 euros.

A tragic-comic journey with a Nobel-prize winning physicist embarked on saving the world, and by extension, his life.

It is rare that a book related to science makes you laugh out loud, but Ian McEwan makes you chuckle and smile at the repeated gaffes of his anti-hero, a renowned scientist in free fall. Here we are on a visit to Longyearbyen in Svalbard, Norway, where our protagonist is invited to see the field work of other scientists working on the effects of global warming on the cryosphere. The account of the snowmobile trip across the ice, the pit-stop to urinate in the sub-zero blizzard conditions, getting his little member stuck on the zipper only to unstick it with his flask of whiskey, the near-death experience with the hungry polar bear, these are incredibly witty and amusing moments. (pp. 54-89)

(It's worth mentioning that 'it's illegal to die in Longyearbyen' in the sense that in this small 2,000-person town, you have to go somewhere else to die because you no longer can be buried there. This is due to the corpses that were buried there during the Spanish influenza in the early 1900s that may still contain the virus: the corpses have frozen in the permafrost and with global warming when the permafrost thaws it will release methane (30 times more potent than carbon dioxide) but the risk is that the corpses will also thaw and release their incubated Spanish influenza virus. So no more new dead in Longyearbyen, just so you know.)

This is not climate science fiction or a rant about path dependency. This is an amusing encounter with the fictional Michael Beard – a Nobel laureate in Physics – and his awkward attempts to keep his life on track after the glory of his Beard-Einstein Conflation theory. Ian McEwan brilliantly develops Beard into this overweight, arrogant, indifferent, selfish character that represents, in many ways, the broader concept of humanity he is supposedly trying to save from itself. But Beard cannot get his act together, falling in and out of marriages, over-indulging in alcohol, incapable of addressing his shortcomings, not being able to see the bigger picture, caught in his routines and bad habits, going from one keynote speech to another, he is lost and rudderless, so he latches on to a concept his PhD student is pursuing:

"I'm talking of artificial photosynthesis, of copying the methods nature took three billion years to perfect. We'll use light directly to make cheap hydrogen and oxygen out of water, and run our turbines night and day, or we'll make fuels out of water, sunlight and carbon dioxide, or we'll build desalination plants that make electricity as well as fresh water." (p. 172)

Beard basically steals the PhD student thesis about artificial photosynthesis and runs with it as far it can take him, giving speeches, fund raising, building research centres, writing papers, and generally keeping a semblance of normality and composure behind the amusing turmoil of his meandering mind. It's hard to empathise with Beard because he single-handedly

causes the damage in his personal life, much like humanity at large and anthropogenic impacts on the planet, and you feel encouraged by his artificial photosynthesis pursuits. Still, it's not really his passion or his idea, much like our attempts to recycle or go electric. His life just keeps on unravelling, much like the incremental climate-related episodes of flash flooding, forest fires, sporadic tsunamis, heat waves, and rising temperatures, similar to Beard's growing paunch and double-chin going deep in his 60s.

In many ways Beard is a despicable person, but he is also genuinely human, and this makes us relate and want to see him succeed, just like the many women in his life do, just like his daughter Catriona (precocious 3-year old) sees him as a saviour because: "She understood that his job was to save the world, and since the world was her mother, Primrose Hill, the dance shop and her playgroup, she was fiercely proud." (p. 246) This short sentence is poignant and makes us all proud of Beard for trying, not very elegantly perhaps in its implementation, but a good effort, Michael. What does your world look like?

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1. Longyearbyen, Svalbard, Norway. February 2026. Photo: Stuart Reigeluth / REVOLVE



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