Innovation and Drivers for Circularity and Bioeconomy

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Foreword

The bioeconomy not only plays an important role in today's society but will also be essential in solving the problems of the future. A sustainable bioeconomy, long-term increased access to sustainable biomass, a circular economy and climate adaptation are crucial elements in effective climate action that should be promoted in Sweden, within the EU, and internationally. At the same time, the bioeconomy is creating economic growth, regional development, job opportunities, security of supply and resilience. For the bioeconomy to be able to deliver, it is important that its industries are competitive.

Sweden is a forerunner in the bioeconomy field and has expertise and experience to share, both from the development of existing value chains and from research and innovation. In its 2025 publication[i], the Swedish FAO Committee chose to highlight examples of Innovation and Drivers for Circularity and Bioeconomy both from Sweden as well as from Swedish actors working internationally.

The subject matter is very topical in relation to the FAO, as bioeconomy is one of the organisation's 20 prioritised programme areas in its 2022–2031 strategic framework.

The bioeconomy is cross-sectorial and encompasses all bio-based sectors from land, water and sea, which is why we need to work on promoting collaboration between various bio-based sectors.

The forest-based sector plays a significant role in the Swedish bioeconomy. Forestry is central to Swedish climate action, partly through access of biomass, which is of great importance in the transition to fossil-free materials and fuels, and partly as a carbon sink in forests, land and wood products.

Agriculture plays a central role in the bioeconomy by supplying both food and other biomass. The bioeconomy also provides new business opportunities for the agricultural sector through refined and innovative products. Competitive and profitable production processes create the conditions for agriculture to continue playing this key role.

The blue bioeconomy uses aquatic organisms for food and to create new materials, which in many cases do not have an equivalent on land. We need to unlock the potential of marine bioresources to continue producing food and as a basis for new products and processes.

The bioeconomy is closely linked to the circular economy, they interact and support each other. The development of both the bio-based and the circular economy is necessary for the green transition and to achieve our climate goals.

State Secretary Daniel Liljeberg, Chairman of the Swedish FAO Committee.

[i]The publication as a whole is a product of the Swedish FAO Committee. The content of the individual articles is the responsibility of the respective writers.

Content

Bioeconomy – From Research Field to Global Model for Sustainable Development

Ivar Virgin, Stockholm Environment Institute, SEI

Bioeconomy – a concept making headway

In the past 10 to 15 years, the bioeconomy has gained increasingly widespread recognition and developed from a research-driven field of expertise into a cross-sectoral and inclusive model for circular and sustainable economic development.

Today, despite lacking a uniform definition, bioeconomy is a widely recognised concept that generally relates to economic activity based on renewable biological resources and processes. It includes primary production such as agriculture, forestry, fisheries and aquatic production systems, as well as industrial processes in which biomass is used. Throughout history, the economy has to a large extent been based on the relatively rudimentary and frequently inefficient use of biological resources. The Industrial Revolution and the transition to fossil fuels led to a period of strong economic growth, but also to extensive environmental problems, climate change and the unsustainable exploitation of nature's resources. The modern bioeconomy strives for more sustainable and efficient use of renewable biological resources. It is considered to be an important tool for driving long-term sustainable economic growth and employment, as well as accelerating the transition from an economy dependent on fossil fuels to a circular, resource-efficient bio-based economy. The promotion of biodiversity and functioning ecosystems are also core principles of the modern bioeconomy. The bioeconomy thus plays a key role in realising the 2030 Agenda and the Sustainable Development Goals (SDGs).

One of the bioeconomy's most prominent characteristics is how modern bioscience research, knowledge and innovation enable the development of new bio-based products with advanced functions and broad areas of application within green industries, the pharmaceutical industry and the chemical and energy sectors. Breakthroughs in bioscience are not only reshaping medicine and health care, but also improving productivity and resource efficiency in agriculture, forestry and food production. Modern industrial biotechnology and bioprocessing are enabling the transition from inefficient and often environmentally damaging bio-based industries to high-tech biorefineries, in which a wide variety of renewable and climate-smart bioproducts can be produced. The bioeconomy also plays a crucial role in the circular economy by efficiently harnessing and processing organic by-products and waste flows from green industries, food- and bio-processing industries, and wastewater from treatment plants. There is huge potential in efficiently transforming these bio-based waste flows – which are often environmental burdens –

into valuable products such as bioenergy, biofertiliser, feed and green chemicals. The bioeconomy can therefore be a potent force for innovation and new value chains in which biomass and biological resources are used more flexibly and efficiently than ever before.

Meanwhile, there is debate over whether the development of the bioeconomy automatically leads to a more sustainable future. Many point out that the bioeconomy is no panacea for our sustainability challenges. Rather, it needs to be designed, regulated and supported through well-balanced bioeconomy strategies and policy instruments that make it a driving force for resource efficiency and sustainability across the board: ecologically, socially and economically.

Bioeconomy strategies in the EU and Sweden

Bioeconomy as a global concept began to emerge after the turn of the millennium. In 2002, the European Commission published a strategy for a knowledge-based bioeconomy for research and innovation. And in 2009, the organisation for Economic Co-operation (OECD) published a report entitled The Bioeconomy to 2030 – Designing a Policy Agenda, which highlighted the importance of previous bioeconomy policies, especially in agriculture, health and industry. The OECD report has been cited as a key starting point for the national bioeconomy strategies that several countries developed in subsequent years. The EU presented its first bioeconomy strategy in 2012 with the goal of moving away from fossil dependency and towards a more bio-based economy. The strategy inspired several European countries, including Germany and Finland, to develop national strategies designed to promote the growth of the bioeconomy. In 2018, the European Commission launched an updated bioeconomy strategy with concrete measures to accelerate the development of a sustainable bioeconomy in the EU. This update highlighted the potential of the bioeconomy as a key to achieving the goals of the Paris Agreement, the 2030 Agenda, the European Green Deal and the transition to a circular economy. In the strategy and Council conclusions of 2023, EU Member States are encouraged to develop and update their national and regional bioeconomy strategies.

In Sweden, the Government appointed a special inquiry in 2022 to draft proposals for a national strategy for a sustainable, competitive and growing bioeconomy. According to the inquiry's terms of reference, such a strategy should achieve three main objectives:

- promote sustainable growth and employment throughout the country;
- contribute to climate benefit; and
- strengthen supply capacity and reduce the vulnerability of society based on biomass from forestry, agriculture and fisheries, as well as waste products from food processing.

The inquiry presented its proposals in December 2023, which made it clear that the bioeconomy plays a vital role in Sweden's economy. In 2021, it accounted for just over 8 per cent of total value added and more than 20 per cent of Sweden's total exports by value. Bioeconomy businesses also accounted for approximately 12 per cent of total turnover of

the Swedish business sector. The number of people employed in the sector (measured as actively employed) amounted to 345 000, equivalent to 6.4 per cent of the total workforce.

The inquiry's proposal for the overarching objectives is that by 2040, Sweden should have a more resource-efficient, resilient and competitive economy. A bioeconomy that supports sustainable growth and employment throughout the country contributes to environmental and climate benefit, and strengthens supply capacity and reduces the vulnerability of society. Furthermore, the inquiry proposes that Sweden's bioeconomy strategy focus on promoting:

- a competitive, sustainable and resource-efficient forestry industry, including reuse of waste flows for energy and material;
- growing chemistry, textile and manufacturing industries with increased use of bio-based raw materials as well as an efficient bioenergy sector;
- optimised use of waste flows from food production, fisheries and agriculture not used for food;
- production and processing of non-food products from fisheries and aquaculture;
- efficient recycling and processing of bio-based waste flows from industry and society, and sustainable bioenergy use;
- increased demand for bio-based goods and services, as well as support to sectors that use bio-based raw materials; and
- collaboration between different sectors to maximise resource-efficiency and the reuse of bio-resources, for example through biorefineries and industrial symbiosis.

A large number of responses to the inquiry have been submitted to the Ministry of Rural Affairs and Infrastructure. The closing date for responses was 30 August 2024. The Ministry continues its work regarding the inquiry's proposals.

The bioeconomy in a global context

Interest in the bioeconomy as a development agenda and a tool to align with and implement commitments associated with global conventions to curb climate change, preserve biodiversity and stop desertification has inspired countries all over the world to develop bioeconomy strategies and policy agendas.

The International Advisory Council on Global Bioeconomy (IACGB) has compiled facts and an overview of existing bioeconomy strategies[1] at global level clearly indicating considerable differences between goals and priorities. These variations are due to differences in countries' biological resource bases, industrial structures, technical and scientific capacities, innovation capacity and social and economic conditions. Put simply, it can be stated that bioeconomy strategies within the EU primarily aim to accelerate the transition from a fossil-dependent economy to a more bio-based and circular economy

[1] https://www.iacgb.net/lw_resource/datapool/systemfiles/elements/files/52440fb0-f35d-11ee-9ed1-dead53a91d31/current/document/Global_Bioeconomy_-_April_2024_IACGB.pdf

in which the development of bio-based industries is prioritised. However, countries such as the US and China focus largely on technological development and advanced biological engineering. In Africa, where Sweden and the Swedish International Development Cooperation Agency (Sida) have played a key role in the development of bioeconomy strategies, the creation of new jobs and the development of modern bio-based value chains are prioritised. Particular importance is given to creating stronger connections between smallholders, markets and processing facilities to improve their economic outlook. In Latin America, many countries have a strong focus on biotechnology-based bioeconomy in agriculture and forestry. At the same time, there is an emphasis on the need to protect the Amazon's threatened biodiversity and its critical ecosystem services. This requires bioeconomy solutions, a 'socio-bioeconomy' that integrates nature conservation, reforestation and climate measures with income generation and improved livelihood opportunities for local communities and indigenous peoples.

In the multilateral arena, it is worth noting that the Food and Agriculture Organization of the United Nations (FAO) now has bioeconomy as one of its 20 priority focus areas. It has made substantial efforts to develop a monitoring framework for bioeconomy development focused on agriculture, forestry and fisheries. The G20 and World Economic Forum (WEF) also play a key role in promoting bioeconomy development at the global level. Since 2015, the Global Bioeconomy Summit (GBS), an international platform and meeting place established by the International Advisory Council on Global Bioeconomy[2], has brought together decision makers, businesses, civil society organisations and academia to discuss bioeconomy in a global context. GBS2024[3], co-financed by Sid) and convened by BioInnovateAfrica[4], Stockholm Environment Institute (SEI) and the East African Council for Science and Technology (EASTECO), was held in Nairobi in October 2024. The event clearly demonstrated how the bioeconomy has now become an integral part of the global development agenda.

Through its development assistance and Sida, Sweden has actively supported capacity building in sustainable bioeconomies, particularly with initiatives in Africa. Examples include Sida's support to BioInnovateAfrica, Africa's most successful bioeconomy platform, and to WIOMSA[5] and its work on value chains for marine resources.

Bioeconomy and its relevance to FAO's areas of activity

The green and blue industries – agriculture, forestry, seas and aquaculture – form the foundation of the bioeconomy. Ensuring long-term, sustainable primary production of biomass in these sectors is largely managed though existing strategies and frameworks. However, the bioeconomy perspective offers new innovation capacity, new strategies, policy

[2] https://www.iacgb.net/
[3] https://gbs2024.wpcomstaging.com/
[4] https://bioinnovate-africa.org/
[5] https://www.wiomsa.org/

frameworks and concepts that strengthen primary production. It also develops value chains and optimises the utilisation of waste flows from these sectors. This publication presents several examples of practical bioeconomy applications within the green and blue industries. It includes examples of applications in Sweden, as well as how Swedish actors have worked on bioeconomy development in an international context, especially in collaboration with countries in Africa.

Within the European bioeconomy, and internationally, more resource-efficient and circular food production is vital. In her contribution entitled *From a Linear to a Circular Food System*, Madeleine Linins Mörner writes about Axfoundation's Future Food[6] and Future Materials[7] programmes. It describes how food production can be more resource-efficient and sustainable by better utilising waste flows and reducing food waste. Ms Linins Mörner highlights several initiatives that aim to harness unused resources within agriculture, fisheries and food production, with the aim of creating a more circular and bio-based economy.

The blue bioeconomy, which includes mariculture, aquaculture and the sustainable use of marine and aquatic resources, is vital for a sustainable future in which water resources are used efficiently to promote food security, ecosystem services and economic development. Peter Linder from Fiskbranschens Riksförbund, Sweden's national fishing industry association, highlights the potential and challenges within the Swedish blue bioeconomy in his contribution *The Bioeconomic Sky Is Blue, but for How Long?* It describes a number of successful initiatives in which renewable natural resources from both salt and freshwater can be used in ways that are innovative and climate-smart. It also describes political and structural sectoral challenges, as well as the need for strong industrial clusters and cooperation between research and enterprise to further develop Sweden's blue economy.

In her contribution *Agriculture and Bioeconomy in Flux: How Young Farmers Can Shape the Future*, young dairy farmer Anna Vägermark is interviewed about her views on circularity in primary production and modern agricultural entrepreneurship in a bioeconomy of the future. Ms Vägermark describes the challenges facing the Swedish agricultural sector, such as the generational shift, sustainability and economic prospects. She highlights the need for investment, the skills supply and the creation of attractive working conditions to ensure future food supply and agriculture's role in the green transition.

Forestry is the part of the Swedish bioeconomy in which development to create added value and high processing value has made the most progress. Several pulp mills and sawmills have been developed into modern biorefineries in which bio-based raw materials are fractionated for different applications. Hanna Lindberg from Holmen writes in her contribution *From Paper to Large-scale Timber Construction of the Future* about how one of Sweden's oldest and largest forest companies has undergone a strategic transition from

[6] https://www.framtidensmat.se/
[7] https://www.axfoundation.se/program/framtidens-material

traditional paper producer to a leading actor in sustainable timber construction and bioeconomy. The paper describes how Holmen has adapted to reduced demand for printing paper by investing in wood products, renewable energy, climate-smart packaging and innovative building materials such as cross laminated timber (CLT), which helps reduce the climate impact of the construction sector.

However, bio-based forestry is not free from conflicting objectives. In his contribution, *Multifaceted Goals and Means for Greener Landscapes*, Anders Malmer from the Swedish Forest Agency reveals challenges with utilising forestry and reforestation as tools for sustainable development. Expectations differ in industrialised and low-income countries, with industrialised countries being motivated by carbon sequestration and biodiversity to a greater extent. Low-income countries, meanwhile, have expectations of economic and social development related to a bio-based transition. Mr Malmer argues that reforestation must create local economic advantages, for example through markets for timber and forest products, to be sustainable in the long term.

In her contribution, *Bioeconomy in Development Assistance: Solutions for Agricultural Challenges*, Sara Törnros from We Effect highlights how bioeconomy can be used as a tool to strengthen smallholder farmers' livelihoods and increase their resilience to climate change and economic instability. This includes concrete examples from Africa and Latin America of how We Effect, with its partners and through innovative bioeconomy solutions, can contribute to sustainable food production, economic independence and increased biodiversity.

Improving the food supply and nutritional security in Africa's drylands is a high priority and an area in which Swedish development research and assistance have a long track record. Ingrid Öborn, Gert Nyberg and Aida Bargués-Tobella write about this in their contribution entitled *Landscapes, Grazing Management and Livelihoods in Transition – Prospects for a Sustainable Bio-Based Economy in the African Drylands*. The paper describes challenges and opportunities in efforts to achieve a sustainable bio-based economy in Africa's drylands, where rapid population growth and climate change are affecting the food supply and the management of natural resources.

Sweden can contribute to a global bioeconomy

Sweden's strength in research, innovation and sustainable resource use makes it an important actor in the global bioeconomy transition, in which agriculture, forestry and fisheries play a key role in creating long-term sustainable and resilient societies. Sweden can contribute significant bioeconomy initiatives in agriculture and fisheries in the following areas:

- Sustainable and resource-efficient agriculture – Sweden has extensive experience of integrating sustainability into agriculture through circular production systems,

efficient waste flow use and the development of innovative bio-based products. Swedish research and innovation can contribute to improved food supply adaptation to climate change both domestically and internationally. Sweden provides substantial development assistance to smallholder farmers, especially in Africa, to help such farmers benefit from bio-based value chains.

- Sustainable forestry and bio-based materials – Sweden's forestry sector is one of the most advanced in the world, with innovative biorefineries, circular value chains and climate-smart construction materials such as CLT. By sharing experiences of sustainable forest management and forest restoration, Sweden can support low-income countries to develop their own bioeconomy and create new markets for forest-based products. Sweden has a unique history of reforestation, small-scale forest ownership, economic integration of forests in society and steady progress towards more sustainable forestry. This knowledge is vital to countries that conduct reforestation and rural development programmes.
- Development of the blue bioeconomy – Swedish fisheries, aquaculture and marine innovations show the potential of using renewable water resources more efficiently and more sustainably. By promoting the sustainable cultivation of fish, shellfish and algae, as well as optimising the use of marine and aquatic waste flows, Sweden can also provide technology and knowledge to partner countries in Africa, Latin America and Southeast Asia.
- Circular bioeconomy and industrial symbiosis – Sweden has successfully developed systems to utilise organic waste flows and transform them into new products such as bioenergy, biofertiliser and sustainable chemicals. Through collaboration between industry, academia and the public sector, Sweden can contribute to the development of new circular solutions globally.
- Policy development and strategic support – Through development assistance and development cooperation, for example via Sida, the Swedish Forest Agency and civil society organisations, Sweden has supported and can continue to support partner countries in Africa, Latin America and Southeast Asia to develop sustainable bioeconomic systems and value chains.

From a Linear to a Circular Food System

Madeleine Linins Mörner, Axfoundation

A key part of the transition to a sustainable bioeconomy involves harnessing bio-based residual streams in a manner that is resource-efficient and creates value. In today's linear food systems, large amounts of potential raw materials are lost – from animal by-products and overgrown vegetables to fish waste and discarded wool. Here, Axfoundation shows that there are innovative ways to turn these resources into new foods, products and value chains. Concrete projects from Boden in the North of Sweden to Öland in the South highlight how we can reduce waste, increase profitability and create a more sustainable future – where nothing unnecessarily goes to waste.

A smarter way to harness what we already have

Photosynthesis is the most energy-efficient system there is. The sun's rays help grow crops that can become food directly or indirectly in the form of feed for animals that we subsequently eat. The leftover biomass that does not belong in anyone's stomach can be used in various industrial processes. The trick is to not let anything go to waste, rather to utilise everything based on a strict hierarchy consisting of 1. Food, 2. Feed, and 3. Material.

The problem is that this doesn't happen today. Instead, products that could have become food directly become feed, what could have become feed becomes biogas and what could have become bioplastics becomes waste. This system is linear and not particularly efficient.

Agriculture and the food chain currently account for approximately one third of global greenhouse gas emissions and around 70 per cent of freshwater use. Furthermore, the food sector accounts for around 70 per cent of terrestrial biodiversity loss and nearly 90 per cent of the world's marine fish stocks are fully exploited, overexploited or depleted. The planetary boundaries simply demand more resource-efficient and circular food production.

The fact that one third of all the food we produce never ends up in anyone's stomach, but instead is lost or thrown away, is the ultimate proof of a system in decline. This is why we need to shift from a linear food system to a circular one, and we need to maximise what we produce.

Peels, leaves, irregularly shaped vegetables and meat by-products – these are just a few examples of the untapped resources in Swedish primary production and the food industry that are currently not used efficiently. Today, almost half of by-products from beef and pork are used for biogas or feed – despite the fact that they could become food.
In addition, significant volumes of vegetables are sorted out before they even reach the

store – because they are too big, too small or deemed difficult to sell for other reasons. A factor behind this waste of resources is often low current profitability for these varieties of produce. This can be due to a lack of infrastructure and logistics, strict buyer requirements and consumer scepticism.

Resource waste occurs at all levels and across the entire value chain, from primary production all the way to households. This means that there are untapped business opportunities for all actors in the value chain. At Torsåker Farm, Axfoundation's development centre for future food and materials, new food and materials are developed from raw materials and resources that are deemed safe and environmentally sustainable. In the 'Blood & Turnip' project, Axfoundation collaborates with partners to map and assess the potential of raw materials that were previously classified as food waste, biogas or animal feed.

In circular food systems, food waste and residual flows are minimised and, where residual streams cannot be avoided, they are utilised in the most sustainable way. This approach presents business opportunities to transform material flows currently considered as waste or put into valuable assets.

Torsåker Farm, Axfoundation's development centre for future food and materials.

We can do so much more

There are many good initiatives to reduce resource waste, increase profitability and spare the environment. But these are just a drop in the ocean compared to what could be done if we had a map for navigation. We currently know very little about what residual streams exist in food production. If we had a mapping of the residual streams that arise at each stage of the agri-food chain, as well as their volumes and their nutritional content, we could achieve great things.

Our food shouldn't eat our food

In Sweden, 70 per cent of arable land is used to grow food for our animals. Food could be grown directly for people there instead. It is more resource-efficient if our food eats what we can't or don't want to eat. Axfoundation and the Swedish University of Agricultural Sciences (SLU) gather both researchers and practitioners from Boden in the North of Sweden to Öland in the South in order to address two of the food system's biggest challenges: resource waste and the environmental impact of feed production. This project will test and evaluate a number of innovative feed ingredients, including insects fed with residual streams, mycoprotein grown on residual products from the forest industry and mussels that grow from eutrophication in the Baltic Sea. The goal is to establish production with sales of fish, pork, poultry and eggs from laying hens raised on feed with low climate impact and ingredients that benefit biodiversity. This project draws on the results of '5 Tons of Green Fish on the Plate' project, which proved that it is possible to farm Swedish rainbow trout with insect-based feed that has up to a 70 per cent lower climate impact than conventional fish feed.

Swedish wool

There are substantial residual streams in the food system that are not suitable for becoming food but do represent possibilities for a circular and bio-based economy. Swedish wool is one such example. Currently, approximately 1 000 tonnes of wool are produced annually, but more than half is discarded. This is an enormous waste of a raw material that can provide Swedish industry with regionally produced, bio-based and recyclable material. Since 2020, Axfoundation – together with researchers and representatives from the entire wool value chain – has worked to create market conditions for Swedish wool. These efforts have included developing a Swedish wool standard that has simplified both selling and purchasing raw Swedish wool material of high and consistent quality. Moreover, the project has transformed the innovation process of Swedish brands in the fashion, outdoor and home decor sectors by using raw material available locally in Sweden. This work has resulted in a Circular Design Guide for Swedish wool.

Photo: Axfoundation

Axfoundation is a non-profit sustainability organisation that works in the Future Food and Future Materials programme areas. Circular systems and resource efficiency are key to both programmes, which often involve cooperation in projects where what can be eaten becomes food and what's inedible becomes material.

At Torsåker Farm, together with researchers and the entire value chain, we transform sustainable ideas into practical solutions – in the soil, in the water, in the test kitchens and in test facilities.

www.axfoundation.se/en

The Bioeconomic Sky Is Blue, but for How Long?

Peter Linder, The Swedish Fish Industry Association

Knowledge, innovation and strong industrial clusters are required to develop the blue bioeconomy. Academia and researchers need to form a close relationship with the industry to realise ideas and take them from the laboratory into the real world. Sweden has fantastic examples that clearly show how vibrant the Swedish blue bioeconomy is, despite having its challenges. The Swedish blue bioeconomy has both the will and entrepreneurship, and through cooperation between companies, academia and innovators we can create sustainable development – ecologically, socially, and economically.

The blue bioeconomy is about using renewable natural resources from both salt and freshwater to reduce the environmental impact of fossil materials. This economy is contributing to sustainable development and innovation by optimising the use of what has been caught, harvested or produced. This makes the most of, and also develops, new products from maritime assets, as well as recycling material for new purposes. The blue bioeconomy is also part of the circular economy, where resources are used efficiently and residual products are recycled, thereby reducing environmental impact. Cooperation and innovation, both in Sweden and internationally, play a central role. This can include digital solutions to streamline fishing, and creating new applications for marine biomass, such as food supplements, foodstuffs, agricultural plant food, energy or biogas. By doing so, the blue bioeconomy can contribute to a more sustainable and climate-smart future for both nature and business.

One obstacle to the management of residual streams is that global fishing for mainly smaller pelagic species is directed towards raw material for the animal feed industry. That is industrial fishing that delivers whole fish for fish meal and oil. This has led to significantly reduced natural residual streams from fish caught in the wild. Pelagic fishing is done by midwater trawling for species that live in schools in the open water. The most important fish types in the North-East Atlantic and the Baltic Sea are herring, sprat, mackerel and blue whiting. Globally, the most important types are sardines and anchovies.

Swedish fishing and aquaculture from a bioeconomic perspective

Fishing has always been important for Sweden, primarily as a source of food. The blue industries, which include fishing and shipping, are an important part of Swedish culture and history. Over the years, shipping and trade, along with fishing, have played a major role in the country's economy and food security.

Today, the blue industries focus on utilising a broader range of renewable resources from the oceans and lakes, such as fish from commercial fishing and the cultivation of aquatic animals and plants. Seaweed and algae are also important and are used for various products. This aquatic biomass consists of proteins, fats and oils. Residual products from fish can become high-value proteins and omega-3 oils. Aquaculture and fishing have great potential to be more efficient and create more value for the blue bioeconomy.

Unfortunately, environmental problems and shrinking fish stocks have led to a decrease in fishing in Sweden. Today, much of the fish processed in Sweden is imported from Norway. A large proportion of the fish caught in Sweden is landed in other countries, where it is used as fish meal for animal feed.

Handbag made of salmon skin.

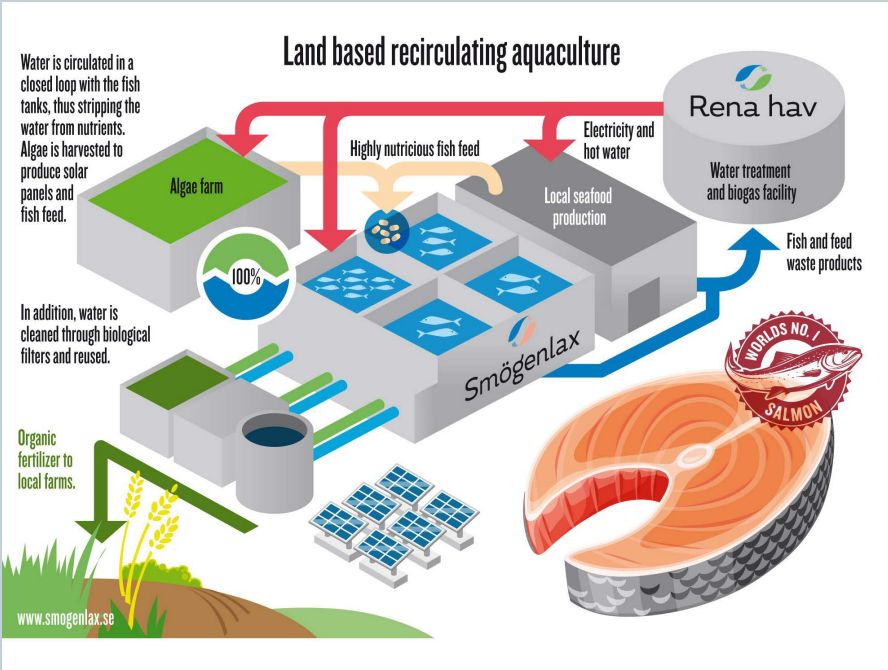
In 2022, the total number of fish caught by professional fishing amounted to some 121,000 tonnes, 80,000 tonnes of which were landed abroad and/or for purposes other than human consumption, mostly animal feed production. This can largely be explained by the fact that the animal feed industry pays well for whole fish from the Baltic Sea, and that this type of fishing is very rational and profitable. Another explanation is that many foreign ports have larger capacities for primarily pelagic fishing, which is why Swedish catches tend to be unloaded in foreign ports. This development has, in turn, led to a depletion of Swedish reception and processing capacity. The national problem from a blue bioeconomy perspective is therefore that residual currents presuppose that there is a sufficiently large main stream.

Aquaculture in Sweden produced some 12,700 tonnes of fish and mussels in 2022. The EU and the Swedish Government highlight aquaculture as an area with great potential for growth. Aquaculture is developing all the time, both in Sweden and globally, and now includes many different systems for growing both fish and plants, on land and in water. Residual aquacultural products are used in fish oil and fish meal, as well as food supplements and hair products. However, a challenging regulatory framework means that Sweden's dependence on the import of farmed fish (mainly salmon) exceeds 90 per cent of consumer demand.

A fundamental problem, therefore, is the lack of volume in both primary production and the processing industry. In addition to ideas within academia and elsewhere, innovation requires an industry that has expertise and resources to turn ideas into practical reality. Should Sweden be left behind in the blue bioeconomy? Not at all! Despite difficult conditions, Swedish academia and industry are working tirelessly on sustainable and circular solutions.

Residual streams from pelagic fish processing

When herring, for example, is fished for human consumption, it is filleted by machine leaving some 60 per cent of the weight over, in the form of its head, fins, guts and backbone. This residual stream is useful, not least in the production of animal food stuffs. However, in recent years, several different innovations have shown that the backbone is a source of protein and nourishment and (not least) has a nice taste. The two large-scale herring processing industries on the east and west coast of Sweden have both industrialised the method and, in the case of Orkla Foods, commercialised a mince product based on this technique. Using this method, the amount of food extracted from the herring is increased from 40 to 60 per cent of the weight. Research and development are also being carried out on extracting food from other parts of the residual streams.



Circular use of residual streams from the food industry

Kungshamn in Bohuslän is home to several of the largest players in the Swedish seafood industry. There are obvious historical reasons for this – fishing has been a prime source of food since time immemorial, but throughout the generations, there has also been impressive entrepreneurship in preparation and refinement. There is also strong cohesion and the capability to adapt to new times and demands. One exciting example of this is Renahav, a company founded on the belief that everything can be done better. Regardless of whether it's society, industry or processes, there is always room for improvement and refinement. The requirements imposed on municipalities and industry regarding emissions and water treatment are getting more stringent all the time to protect people, animals and the environment. We have to meet these requirements (and those in future) in the most efficient and economical way possible.

Three large seafood producers in Kungshamn (Orkla, Marenor and Leröy) send processed water and residual products to the wastewater treatment plant at Renahav. The treatment takes place in two stages, and the water then released into the sea is considerably cleaner than the requirements placed on the municipal processing plants demand. That's good, but it's afterwards when the story gets really exciting. What remains, the substrate, is hygienised by heating it up and digesting it into sludge.

During digestion, biogas is formed which is then used partly by Orkla's production, reducing fossil-based Liquefied Petroleum Gas usage by 90 per cent, and partly for the production of electricity via a gas turbine. The electricity and warm water drive Renahav's own facility as well as supplying external customers in the neighbouring cluster.

The solid material left after digestion is nutritious and highly useful, both as fertiliser and animal feed. KRAV-approved fertiliser is delivered to a neighbouring farm. Fertiliser for domestic use on the consumer market is also produced, and this too is organic.

Alongside this, the management at Renahav are working on establishing land-based salmon farms with a proposed volume of production that would increase Swedish salmon farming production by around 60 per cent compared to today. The company, Smögenlax, has been working together with Swedish researchers on refining the technology and developing the possibility of becoming self-sufficient in feed for salmon farming. This includes receiving forage crops (with grass protein) from the nearby farm to which fertiliser is delivered, which can replace the soy protein often used in salmon feed. Anchovy resin from Orkla has also been tested, with very positive results. The idea behind salmon farming is also to recycle nutrients that usually end up going straight into nature (mainly urine and excrement) in products like fertilisers. The facility will be built in late 2025, and production will start as soon as possible.

Cooperation required to continue development

All development requires knowledge and innovation. In the case of the blue bioeconomy, we also clearly need industrial clusters and industrial expertise. Which academies are developing innovations for the motor industry in countries or regions that don't have a motor industry? Which researchers are being funded with no realistic possibility of realising their ideas? And how can someone take their innovation from the laboratory and turn it into reality without having industrial competence to call on? And who will finance the industrialisation and commercialisation of good ideas?

The Renahav example clearly shows that the Swedish blue bioeconomy is alive and well. There is no lack of will, innovative power or entrepreneurship in the Swedish blue bioeconomy. But for the sky to remain blue, we must all jointly safeguard Swedish primary production, processing and the food industry together. Strong businesses and clusters, together with academia and innovators, can enable sustainable development ecologically, socially and economically.

Agriculture and Bioeconomy in Flux: How Young Farmers Can Shape the Future

Katarina Wolf, The Federation of Young Swedish Farmers

Sweden's agricultural sector is facing a significant generational shift. In recent decades, the number of agricultural holdings has significantly decreased, and today a large proportion of farmers are over 65. This trend raises questions about our future food supply and bioeconomy, and the need to make it easier for young p eople to establish themselves in the industry.

Ninety years ago, there were almost 430 000 agricultural holdings in Sweden. Today, that number is 59 000. How many will be left in 90 years' time? One in three Swedish farmers is above retirement age and growing numbers are choosing to wind up their companies instead of passing them on to the next generation. This is having far-reaching consequences for the future of the green business sector and Sweden's supply capacity in peace time and in the event of war or crisis. The same challenges are apparent elsewhere in Europe – only 12 per cent of Europe's farmers are under the age of 40.

At the same time, young farmers have a key role to play in the farming and bioeconomy of the future, which features heavily in the European Commission's vision for agriculture of the future that was presented in February 2025 and includes wording on how young farmers want to drive innovation. To achieve this, more young people need the right conditions to take over or start agricultural holdings, invest in circular solutions such as biogas production, and test new crops or identify new applications and value chains for their produce. A survey of members of the Federation of Young Swedish Farmers found that 94 per cent would like to own a farm in the future. Meanwhile, 69 per cent reported feeling that it was difficult to start or take over a farm as a young person[1]. A number of obstacles preventing young people from taking over and running agricultural holdings were identified, from a lack of capital to the expense, unprofitability and psychological demands that being a farmer can entail.

Becoming a farmer requires courage

One person who did decide to start an agricultural holding is Anna Vägermark. Together with her partner, she bought a dairy farm in Västernorrland Region in 2015. Anna grew up in Sörmland County on a small horse farm and several members of her family were involved in various types of agriculture business. Anna qualified as a livestock agronomist but the lack of practical experience led her to apply for a job at a dairy outside Uppsala, north of Stockholm.

[1]Many want to – few can. Report on ownership and generational shift; spring 2023. Federation of Young Swedish Farmers.

"I thought that I may as well work and gain practical experience, and I loved it. I spent a lot of my free time, holidays and weekends there. So, that was probably where my interest in cows started."

After she graduated, Anna worked at a company that develops milking equipment. However, she felt that she had got too far away from the cows. While she was studying, she met Joakim who ran his own contracting business. One day, a farm in Sundsvall, in the northern part of Sweden, came onto the market. They went to look at the farm together, and despite it being a long way from family and friends, they thought the prospects for running a dairy were good. Moving away from your home town and setting up in a new area is a big step, but Anna saw a future in milk.

"It's a really exciting industry. If you ask me, it's the Rolls Royce of businesses in many ways. You don't just have to be good – you have to be good with every fibre of your being to really make a go of it."

Anna was just 25 when she and Jocke acquired the farm and even though they had always wanted to run their own business, it was a huge life change and they had no previous experience of running a dairy.

"I remember the first evening we had signed everything. We stood in a culvert full of manure the entire evening. Before we were up and running, we really wondered what we'd got ourselves into."

Photo: Anna Vägermark

Anna Vägermark started a dairy farm in the region Västernorrland together with her partner in 2015.

The first few years were also tough financially because the price of milk was historically low and Anna and her partner had to work hard to keep the business afloat. There were already staff on the farm, but the ultimate responsibility always falls to the owner. It also took time to build relationships with neighbours and collaboration partners because neither Anna nor Jocke had any previous links to the area.

Dairy businesses of the future

Today, they have 220 cows that are milked by machine, and they farm 350 hectares of arable land. Over time, they have built contacts with actors in the local area and share machinery and staff. Anna also thinks that they have both challenged neighbouring farms with new harvesting methods and inspired other farms to develop and move forward to the next generation.

The issue of sustainability also interests Anna, who says that the phrase encapsulates so much. For her, it is obvious that environmental sustainability forms the basis of what she does with her business on a daily basis. The circular ecocycle is an integral part of milk production: feed is transformed into milk in the cows and manure is returned to the ground to produce new feed. She also believes that northern Sweden will play a key role in the green transition.

"We need to grow more and we definitely need to grow more in northern Sweden. We have the necessary conditions to do so with good water quality and pasture cultivation. And then we need to think in new ways in terms of crops. I think we'll also see a lot happening with cows in terms of higher yields."

She feels that societal demands in terms of sustainability issues are onerous. Dairies are still small businesses and do not have the capacity to employ sustainability strategists to work on these issues. Farmers have to take on that responsibility along with everything else. Despite this, she is convinced that Swedish agriculture has a key role to play in the green transition. In terms of dairies' role in a future bioeconomy, she believes that we have to get better at looking at production holistically.

"We know what we're doing. Milk production is an ecocycle with carbon sequestration and biodiversity as central components. But we need to work out how to demonstrate this externally and we're not really there yet. However, we definitely will be in a few years' time and I believe that then, when we've cracked it, we'll see actors who may want to start investing in agriculture and green industries."

But there are more sustainability perspectives than the environmental ones. Anna feels that it is also important to include economic and social sustainability issues in the discussion as well.

"We need to get the banks to understand that when we're granted funding, we're not going to throw money around. Rather, we'll make the right investment decisions and buy input goods at the right time so we can push down prices. We know what we're doing and sometimes I wish there was more understanding from the banking sector. We run pretty big businesses these days after all."

Anna also stresses the importance of investing in and developing the business to make it attractive for the next generation to take over – attractive companies will increase belief in the future. Social sustainability is also important. Skills supply in the form of labour is a challenge and, being self-employed, it is important, but difficult, to find time to recuperate.

"Recuperation is important, and I believe it'll be even more important for the next generation to feel that there is more to life than just work. Previous generations perhaps had time between barn duties to take a nap and have an extended coffee break. Today, businesses are so much larger and everything happens so much faster, so the recuperation that you perhaps once had during the day, we need to snatch at some other time. The idea of constantly working doesn't stand up because such a person just doesn't exist. It can't be done."

Although Anna sees many challenges in the diary business – increasing responsibility with greater demands – she does not regret taking the decision to move north and buy the farm. The flexibility and the daily challenges of running a business keep her going. Getting to work on different things all the time is really enjoyable and outweighs the negative aspects of the job. She feels optimistic about the future, as do many other young farmers across the country.

"There will always be jobs because we produce food, for which there will always be a need."

Ruminant animals play a vital role in a sustainable food system and a bioeconomy. The ability to live on grass and other materials rich in cellulose is the strength of ruminant cattle that make it possible to use land throughout the country in a resource-efficient way. With the right grazing methods, cows and their manure can improve soil structure and fertility, as well as sequestration storage in the ground. Similarly, they also creates added values such as ecosystem services, circular flows and jobs in rural areas throughout Sweden.

Ley cultivation has positive effects that improve soil fertility, enhance the soil's water-holding capacity and reduce seepage of nutrients from fields. At the same time, the animals provide us with manure for crop cultivation through the return of plant nutrients such as phosphorus and nitrogen in manure.

Cattle play a vital role in the development of circular, bio-based economy in which food, feed and energy production are interlinked.[2]

[2] Framtidens Jordbruk report ('The Future of Farming'): Milk and beef

From Paper to Large-Scale Timber Construction of the Future

Hanna Lindberg, Holmen

In a short space of time, Holmen has evolved from being a traditional paper manufacturing giant into being a leading player in large-scale sustainable wood construction. At a time when the world is facing major challenges with climate changes, Holmen is demonstrating how a Swedish forestry company can drive the transition towards a bio-based economy.

How can a traditional industry such as forestry help to meet today's challenges and drive the transition to tomorrow's fossil-free society? For Holmen, one of Sweden's most eminent forestry companies, the answer has been to marry proven experience with green innovation.

Holmen's journey started back in 1609, when Duke Johan of Östergötland laid the foundations for Holmen's Mill in Norrköping. In the 20th century, the company consolidated its position as one of Sweden's leading players in the paper and cardboard industry, when demand for high-quality products and the company's vast land ownership created the necessary conditions for its strong growth and export success.
Increased digitalisation and new consumer behaviours have reduced demand for printing paper. As early as the millennium, it was apparent that the company needed to develop further in order to meet the demands of a new era. At the same time, major societal challenges started to emerge in the form of climate change, global loss of biodiversity and a rapidly growing population, which increased both the demand for efficient use of resources and sustainable solutions.

To meet these challenges, Holmen chose to diversify the business and position itself as a key player in the emerging bioeconomy. While continuing to be a premium supplier of paper and cardboard products, the Holmen Group has invested heavily in renewable energy and timber products for the construction industry. The latter exemplifies a business nous with the potential to not only meet the future need for renewable materials, but also to contribute towards mitigating one of the major climate challenges of our time: the construction industry's carbon footprint.

The shift to a bio-based economy – Holmen 'grows' houses

Holmen's sustainable business model is based on harnessing every part of the forest, while protecting biodiversity and ecosystems. The goal is to constantly optimise the balance

between profitability and long-term benefits. Over the past 20 years, the company has successfully reduced its fossil emissions by 90 per cent through energy efficiency and by investing in fossil-free technology.

By investing in renewable energy production on its own land, Holmen has created a unique opportunity to generate added value from its forest ownership. The company currently has two wholly-owned wind farms with an annual production capacity of just over 0.5 TWh, and additional wind power capacity is being added. Together with dispatchable hydropower, almost 2 TWh of renewable energy is produced from wind and water per year.

While Holmen has been diversifying its business, the perception of forests has changed. This is a paradigm shift, one where forests are no longer perceived as a source of raw materials, but as a key sector in the transition to a fossil-free society. Holmen's forestry activities now have a simple but powerful strategy: to 'grow' houses.

This strategic shift is more than just adapting to market changes. It is a conscious investment to meet today's demands for sustainability and climate transition. By taking active measures to create the right conditions for biodiversity in forestry, Holmen has developed a sustainable business model in which forests are not merely a resource, but a solution to today's greatest climate challenges

"Holmen's starting point for its strategy is that the world must transition to the sustainable use of energy and material." Henrik Sjölund, President and CEO of Holmen.

Strategies for sustainability and increased production

The construction sector accounts for a large proportion of the world's collective carbon dioxide emissions, both during construction and over the course of buildings' life cycles. Therefore, interest in sustainable building materials has increased substantially in recent years. Wood has become an integral part of the construction industry of the future, especially as concrete and steel start to bear their true environmental cost.

According to a survey by market intelligence provider Prognoscentret, the proportion of buildings constructed with timber frames in Sweden increased from 12 to 23 per cent between 2018 and 2023. As many as 40 per cent of buildings commissioned by the public sector in health care, schools and social care are currently constructed with wooden frames.

The growing demand for wood products is one of the reasons for Holmen's strategic investment in more refined products such as cross-laminated timber (CLT) and glue-laminated timber, in which the company has positioned itself as a leader player.

CLT is an innovative building material consisting of layered wooden planks glued together under high pressure. The resulting product is strong, light and durable, and can be used in

buildings of ten stories or more. This offers many advantages: CLT boasts high climate performance properties, is fireproof and facilitates significantly speedier construction processes than traditional materials.

By offering sustainable alternatives to steel and concrete, Holmen is helping its clients to reduce their climate footprint and become part of the global climate transition.

The Sara Cultural Centre – a landmark for sustainability and innovation

A clear example of Holmen's vision for sustainable construction is the Sara Cultural Centre

The Sara Cultural Centre in Skellefteå.

in Skellefteå – a spectacular building that has become an international landmark. One of the world's tallest timber-framed buildings, the cultural centre has attracted the attention of press and architectural experts all over the world since its opening in 2021.

With its 20 floors and a height of 75 metres, the building is not only a technical feat, but also an example of how to combine sustainability, aesthetics and functionality. The wood used in its construction acts as a carbon sink and binds carbon throughout its lifetime, while the production and construction process has generated significantly lower emissions than equivalent constructions in steel and concrete.

The Sara Cultural Centre is more than a building – it is symbolic of the sustainable transformation facing the construction industry. By showing that it is possible to build tall, innovative and sustainable buildings in wood, Holmen has helped to push the boundaries of what is considered possible in architecture and urban planning.

Beyond net zero

Today, Holmen's expanding forests' uptake and products' carbon dioxide storage are three times greater than the company's total emissions. However, the company's ambition extends far beyond this – achieving net zero is not the finish line, but the starting point for even greater change. Through its expanding forests and innovative products, the company wants to create solutions that also actively contribute to a more sustainable future for

Photo: Maria Nilsson

generations to come. To not only consider its own impact, but to contribute positively to the rest of the world and go Beyond Net Zero: how Holmen's forests, products and expertise are helping the world to adapt to the future.

Holmen's journey has shown that it is possible to combine long-term profitability with climate benefits. By cultivating and managing the company's own forests, Holmen not only binds more carbon dioxide than it emits, but also creates products that replace fossil- and energy-intensive materials such as concrete, steel and plastic. This means not only a reduction in carbon footprint for its own operations, but also for the company's clients and their end products.

By constantly evolving the business, investing in innovation and strengthening partnerships with customers and communities, Holmen wants to drive change on an even greater scale. The company's operations are part of the solution, not only for the climate challenges of today, but for the global society of tomorrow. With forestry at its core and the pursuit of sustainability as its driving force, Holmen is building a future where economic success and climate benefits go hand in hand.

With a history spanning more than 400 years, Holmen has a storied tradition of harnessing and refining nature's resources. The foundation of the business has always been the same – to harness nature's resources and refine them to the greatest possible value. The products may have changed over time, but the desire to evolve and offer new solutions to current challenges remains the same.

Further reading:
www.holmen.com
www.swedishwood.com

Multifaceted Goals and Means for Greener Landscapes

Anders Malmer, The Swedish Forest Agency

Differing expectations between industrialised and low-income countries regarding the role of forests in sustainable development make it difficult to develop a scalable circular bio-based economy. While industrialised countries are incentivised by carbon sequestration and biodiversity, low-income countries expect bio-based transition to result in economic and social development. There are obstacles to the transition at the village level in particular, as traditional large-scale agriculture and local values (food supply and opportunities for a better life) are prioritised on the same land where large-scale carbon sequestration and biodiversity interventions are planned.

Internationally, trust capital for the sustainable use of forests as a value-creating alternative to other, treeless land use is extremely low. Sweden has an unusual history of reforestation and restoration since the early 1900s, which has contributed to regional economic and social development. As knowledge has developed, so too has the understanding that the value of forests is not merely economic, and their use has steadily been adapted to also reflect social and ecological values. Despite forestry's contribution to Sweden's prosperity and its importance to the production of essential products for the climate transition, mistrust of sustainable forestry persists – even in Sweden to a certain extent. So, can Swedish experiences – past and present shed light on the opportunities for a bio-based transition in low-income countries to drive sustainable social, economic and ecological development?

The emergence of forests as a means to counteract climate change

Over the course of almost 40 years, forests have become increasingly important in terms of human-caused climate change. Long-term deforestation is a net contributor to increased levels of carbon dioxide in the atmosphere and has been estimated to account for more than 15 per cent of total emissions; but today, with the development of global models and reductions in deforestation, it accounts for less than 10 per cent. Conversely, long-term reforestation of treeless land results in net sequestration of carbon from the atmosphere. Industrialised countries' commitments to support the preservation and restoration of forests in low-income countries are therefore comprehensive and reflected in the poorest countries' commitments to reforest hundreds of millions of hectares[1].

[1]CDM Clean Development Mechanism, from the Kyoto Protocol 1997.

Given where the resources are and where deforestation takes place, variants of the Clean Development Mechanism (CDM) and Reduced Emissions from Deforestation and reduced Degradation (REDD+) have been developed for offsets for the use of fossil fuels and materials in industrialised countries through increased forest cover in low-income countries. These instruments have frequently been justified with the aim of compensating for emissions. However, in recent years, some have questioned whether these incentives have indirectly slowed reductions in fossil fuel use in regions of high consumption.

Forest and landscape restoration

Over time, interest in reforestation grew due to both the climate threat and synergistic factors such as the preservation of biodiversity and improved ecosystem services for local populations. In the past 15 years, the term 'restoration' has been ascribed to such interventions. The widely-used term 'forest and landscape restoration' (FLR) has come to mean essentially all measures intended to result in larger numbers of trees. This includes everything from individual trees in agricultural landscapes to agroforestry, forest planting and the protection of existing forests. The World Resources Institute (WRI) has identified FLR as a potential solution to restore damaged and degraded areas of forest amounting to two billion hectares. In 2011, the Bonn Challenge platform was established to support national and regional FLR commitments. It has brought together commitments amounting to several hundred million hectares by 2030. The poorest countries have accounted for the largest commitments in terms of surface area.

FLR in low-income countries produced weak results in its first decade, both in pilot projects for REDD+ in development cooperation and other national efforts. According to statistics from the UN Food and Agriculture Organisation (FAO), the total area of new forest decreased between 2010 and 2020 compared to the previous decade, so more forest was restored before the increase in multilateral commitments.

Slow improvement and the impacts of REDD+

In 2010, the UN Green Climate Fund (GCF) was established to provide thematic support from industrialised countries to low-income countries to reduce their climate impacts. The GCF started to use REDD+ to support FLR in 2010, but it was not until 2024 that the GCF finished developing its formal support for REDD+, which had previously only been implemented as a pilot scheme.

One glaring weakness in the implementation of the FLR is related to scale. The majority of areas designated for FLR are landscapes with mosaics of extensive farming, grazing and forest areas that are heavily disturbed by wood harvesting and charcoal production for urban energy needs. Actors currently engaged in land use are mainly farmers with limited resources and rural populations who operate locally on a small scale with little economic or social connection to national and multinational commitments. Moreover, major REDD+ and development assistance programmes struggle to operate effectively at local level.

The number of intermediaries tends to be high and outcomes for rural communities hardly represent an alternative to existing forms of livelihoods.

A corresponding obstacle to the success of initiatives is the lack of ownership and engagement in project goals. The basis for many of these REDD+ programmes funded by industrialised countries is carbon sequestration and biodiversity. At the same time, those who currently cultivate affected landscapes risk, at worst, threats to their livelihoods due to reforestation. Trials with 'participatory forest management' are also being implemented within these programmes, which often involve villagers being able to collect honey or raw materials for handicrafts from the new forest. However, there is a lack of market analysis for those products and new forests still do not add value locally, which makes such initiatives unsustainable. The development of sustainable forestry for anything other than 'non-wood-based products' in newly created forests is therefore difficult and successful examples are extremely rare.

Overall, even with promised efforts running into the hundreds of billions of dollars, it is unlikely that REDD+ and other related aid would be sufficient for the vast commitments to changed and sustainable land use. A significant obstacle to successful efforts is that this type of project often has too short a timeframe, while sustainable methods for land use involving trees require decades to establish.

If a (new) forest lacks local value, it will not survive

If a forest lacks local value, deforestation will persist or land use will develop in other ways. Neither biodiversity, carbon sequestration nor economic development is achieved. So, what conditions are needed for the demand for timber and other ecosystem services to drive reforestation based on local values and also differentiate people's livelihoods locally?
In theory, REDD+ can include support for sustainable forestry in new or existing forests, but in reality this is extremely rare and almost non-existent in terms of local involvement. Less-passive disbursements are unsuitable for support and the acceleration of entrepreneurship and investment in new value chains. National conventions and traditions dominated by large-scale state ownership of land and limited right to local use also often represent major obstacles.

Scant international understanding of forests as a motor for economic development

International attitudes to the sustainable use of forests are largely negative. This is mainly based on the (accurate) picture of decades of unsustainable forestry and deforestation for large-scale commercial agriculture and plantation farming in low-income countries, often driven by economic interests in industrialised countries. Furthermore, there are extremely few countries (especially among industrialised states) that have traditions and substantial economic outcomes based on forestry. Virtually all countries in the Northern hemisphere have experienced significant historical deforestation, but very few have carried out

controlled industrial reforestation. Investment in, and policies for, a growing forest sector are not prioritised in donor countries.

At the same time, many countries in Africa face soaring prices for timber imports (for flooring, windows, doors and furniture) in fast-growing cities. In countries such as Kenya, Thailand and South Africa, interest in wood construction as a climate-positive alternative to concrete is growing, which is key development for the bio-based economy.

Sweden past and present as a model for understanding what can enable FLR

Sweden has a unique position internationally in that it has: 1) reforested and restored degraded forests over an extended period; 2) half of Sweden's managed forest is privately owned in small holdings; 3) forests contribute significantly to both the regional and national economy; and 4) positioned itself at the forefront of research and development of new materials and techniques for forests' contribution to a circular bio-based economy.

The driving force behind the historical reforestation and restoration of forests and timber stocks has been multifaceted for an entire century. Continued demand in circumstances in which natural forests were clear-felled precipitated state and institutional measures such as legislation on replanting, national forest statistics and research and education. Industrialisation and urbanisation reduced pressure on extensive land use and grazing in southern Sweden, and the organisation of small forest owners helped ensure that forestry could provide reasonable local incomes. A mix of 300 000 individual forest owners organised in successful cooperatives, state-owned managed forests and private, industrial forest owners endures. This has primarily been driven by economic and technological developments. Only in the 1970s and 80s did ecological and social values begin to emerge and gradually drive the trend towards more sustainable forestry with smaller clear-cut areas, conservation measures in managed forests and increasing allocations for nature conservation – a development and dialogue/polemic that continues to this day.

When Sweden was one of Europe's poorest countries, the return of managed forests became one of several pathways to social and economic prosperity from the beginning of the 1900s onwards. Today, low-income countries live in a different reality. For example, it is not possible to allow more than 20 per cent of the population to emigrate, as Sweden did, and thereby reduce pressure for livelihoods and land. However, analysing these processes can be worthwhile. Conditions that enabled scalable industrial forestry development without external economic assistance include governance framework legislation, publicly available statistics on the state of forests and timber prices, various forms of land ownership including the freedom to change ownership, an open and positive attitude towards private entrepreneurship and private cooperative collaboration.

Locally controlled forest restoration

Since 2021, the Swedish Forest Agency, with the support of the Swedish International Development Cooperation Agency (Sida), has run a capacity-building programme named Locally Controlled Forest Restoration – A Governance and Market Oriented Approach to Resilient Landscapes (LoCoFoRest) in nine countries in Africa and Asia. The programme is aimed at young professionals in the public sector, academia, civil society and the private sector who are interested in FLR and local, social, economic and ecological development. The programme activities are broadly based on the dissemination of current global and regional knowledge and conditions for FLR, as well as coached project work on how business-driven FLR can drive scalable growth. In conjunction with a workshop in Sweden on options and launching participants' projects, everyone has the opportunity to exchange experiences from their respective countries and gain an understanding of the background and development of the Swedish forestry sector.

More information:
www.skogsstyrelsen.se/en/locoforest
https://www.svenskafaokommitten.se/artiklar/

Bioeconomy in Development Assistance: Solutions for Agricultural Challenges

Sara Törnros, We Effect

The bioeconomy offers new ways to meet some of the greatest global challenges of our time. At the intersection of the climate crisis, food insecurity and economic inequality, smallholder farmers are facing an increasingly tough landscape. By integrating bioeconomic solutions in development cooperation, we can promote more sustainable and resilient agriculture in which innovation, local resources and circular methods strengthen both people and the environment.

From hunger to sustainability – bioeconomy as a tool in development cooperation

In recent years, we have experienced many types of global crises and disasters. These crises are all very severe when viewed in isolation, but when we look at how they affect each other it is clear thatthe consequences are devastating. For example, 2024 was the first year in which the global average temperature increase exceeded 1.5 degrees Celsius – the threshold that the world agreed not to exceed in the Paris Agreement. According to the UN World Food Programme (WFP), a two-degree increase in the global average temperature means an additional 189 million people around the world at risk of hunger. At 4 degrees, this figure would rise to 1.8 billion people. According to the UN Convention to Combat Desertification (UNCCD), three quarters of the Earth's land has become permanently drier in the past 30 years due to climate change and human activity[1]. More arid land makes it more difficult to grow food and earn a living from agriculture, leading to increased poverty and hunger.

In many of these crises, smallholder farmers are among the most vulnerable groups and are severely affected by climate change, biodiversity loss and global economic instability. This places greater demands on global development cooperation to strengthen their opportunities, rights and living conditions. As a development assistance actor, We Effect has had to adapt to manage the escalating problems faced by smallholder farmers in order to help ensure food security and the right to food.

In this transition, We Effect has used various methods and approaches. One of the most powerful and sustainable tools in this transition is innovative solutions that put the

[1] The global threat of drying lands: Regional and global aridity trends and future projections | UNCCD)

bioeconomy at the heart of economic development and the transition to productive and sustainable agriculture. By using the bioeconomy in development assistance, we can take a different route of economic development in which nature does not pay the price through overexploitation and increased emissions. At the same time, bioeconomic development cooperation is a more economically sustainable approach than traditional development assistance models, as it creates opportunities for rights holders to become self-sufficient and reduce their need for continued financial support. Meanwhile, the solutions offered by the bioeconomy make smallholder farmers less dependent on – and therefore less vulnerable to – disruptions in global trade. Below, we show how this works in practice in two examples from our projects.

From waste to feed and fertiliser: innovation projects in Kenya's food markets

Kenya is undergoing a major economic crisis in which the cost of living has increasingly exceeded the income of most Kenyans. This includes the price of fuel, housing and, not least, food. These problems began during the pandemic, but have since increased in severity. A number of regions in the country have experienced a prolonged drought that has severely hampered farmers' ability to grow food for both the local and global markets. At the same time, Russia's full-scale invasion of Ukraine and the economic turmoil caused by the conflict have sharply increased import prices of many essential inputs for farmers and the price of key staples, such as wheat and cooking oil, for consumers.

To help resolve this widespread crisis, We Effect, together with the research institute International Centre of Insect Physiology and Ecology in Nairobi, is running a project funded by the Swedish Postcode Lottery exploring opportunities to convert urban food waste and organic waste into fertiliser and chicken feed. This project creates a circular system in which more resources are harnessed while providing farmers with cheaper and more reliable access to fertiliser and feed that they previously purchased on the global market – particularly from Ukraine and Russia. At the same time, the project creates new jobs in Kenya's cities, especially for women.

The project is based on the discovery that larvae from the American soldier fly have a fantastic ability to decompose organic waste. In a relatively short period of time, they can convert large amounts of food waste into residue that can be used as fertiliser. However, this is only half of the larva's benefit – while doing this, the larva itself grows bigger. At a specific point in time, the larva can therefore be harvested and turned into chicken feed. This project is carried out in Kenyan cities, especially around marketplaces where the majority of food is sold. This has created new jobs primarily for women, such as in the case of this project. The process is relatively simple and requires neither expertise that is difficult to acquire nor expensive equipment from those implementing it, making the project easy to scale up and replicate. The modest investment required quickly pays off.

Biofactories produce local sustainable solution for fungal infestations in coffee plantations

In Latin America, where the effects of climate change are evident, smallholder farmers face both socio-economic and environmental problems. These include soil degradation, economic instability and pests such as fungal infestations. Soil degradation is closely linked to conventional agriculture that relies on chemical inputs, leading to reduced soil fertility and thus reduced production. Almost half of the coffee plantations in Central America have been affected by the La Roya (coffee rust) fungus. Over the years, coffee rust has devastated entire plantations and affected hundreds of thousands of farmers' financial situations. Coffee rust also benefits from climate change, which is why it has hadan increasing impact on coffee production over the past 15 years. To address this problem, our cooperation partners in Guatemala, El Salvador, Honduras and Colombia have started to produce biological fungicides, pesticides and biofertilisers in biofactories.

A biofactory is a facility for the production of biofertilisers and other organic inputs using natural raw materials and beneficial microorganisms. These inputs are designed to improve soil fertility, nutrient content and plant health and support sustainable agricultural practices. They also offer an alternative to artificial fertilisers and therefore contribute to biodiversity, soil health, sustainable food production and reduced pollution. Biofactories are not only a sustainable but also a low-cost alternative, helping farmers increase both the productivity and resilience of their agricultural systems. An evaluation of these projects shows that the biofactories have helped strengthen economic empowerment and productivity, while also improving the sustainability of the coffee, vegetable, cocoa and cardamom value chains. By offering an alternative that restores and maintains coffee plantations, biofactories provide farmers with tools to mitigate the effects of the coffee rust fungus and adapt to changing climate conditions.

One of the most tangible effects of biofactories is the improved quality of agricultural products. Using biofertilisers, biostimulants and natural pesticides provides plants with balanced nutrients free from chemicals. This results in more robust crops with greater resistance to pests and diseases, which contributes to superior performance over time. In some productions, crop losses due to pests have been reportedly reduced by up to 50 per cent, directly increasing productivity and helping ensure local food security.

Products made in these biofactories are a sustainable alternative to chemical pesticides and artificial fertilisers, improving the health of the producer, the consumer and nature. As chemical inputs in agriculture are often oil-based, the transition away from these chemical products also contributes to reduced emissions and a better climate. In addition, many of the products our partners make in their biofactories utilise value chain residues, which contributes to resource efficiency and waste reduction. Moreover, biofactories have helped reduce import dependency, thereby strengthening resilience to economic crises and trade disruptions as a result of war.

Biofactories are an innovative model that combine traditional knowledge with modern sustainable methods to transform agriculture in rural communities. They provide space for experimentation and implementation of natural techniques that aim to replace the use of agrochemicals and thus promote more environmentally friendly agriculture adapted to local needs.

This innovation is reflected not only in the creation of ecological and organic inputs, but also in the adaptation of production processes to the resources and capacities of each community, demonstrating an ability for continuous and flexible innovation. In addition, biofactories promote social innovation by engaging various parts of the community, such as adults, young people and community leaders, in a joint process to develop technological expertise. This integration promotes a sense of belonging and empowerment, which are key factors for sustainability.

Bioeconomy as part of future development assistance

Agriculture is currently considered a risky activity due to climate change and its effects such as extreme weather events. When we also consider other serious risks that farmers face, such as inflation, desertification and biodiversity loss, we realise that we need to support smallholder farmers to address these challenges with sustainable and long-term methods. To reduce smallholder farmers' risks and ensure that their rights are respected in a time in which resources for development assistance have decreased, we need a more efficient, innovative and strategic way of working with such assistance. Bioeconomy is one way to do this. It can be used to reduce global hunger and poverty while at the same timecombating the climate and nature crisis and its consequences. Moreover, a bioeconomic approach enables development assistance to carve out a more economically sustainable future, where initiatives reduce the need for assistance in the long term and strengthen rights holders' autonomy and self-sufficiency.

Landscapes, Grazing Management and Livelihoods in Transition – Prospects for a Sustainable Bio-Based Economy in the African Drylands

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Africa's population continues to grow, especially in drylands, and improving livelihoods and food security are top priorities. Development on the continent has led to higher living standards for many people. This, together with population growth, is increasing demand for food, water and fuel (e.g. for cooking), as well as a greater need for improved infrastructure, schools, and health and medical care. However, this positive development is often slower in drylands. Functioning governance systems for decision-making and the management of common resources in drylands, which are often sparsely populated and far from capital cities, are also needed. Swedish development research and assistance has a long tradition in the African drylands, where recent research has focused on evidence-based support for scalable, social and ecological development for a sustainable bio-based economy.

Challenges and trends

Climate change, with more variable and unpredictable precipitation, and consequently longer/more frequent dry periods, requires adapting livestock management (for example, more goats and camels and fewer cattle), including the planning of grazing management, usage and maintenance of pastures, and other land uses. Increasingly, people in drylands are combining animal husbandry with the cultivation of food crops, both for household consumption and for sale, as well as with other income-generating activities. Sustainable intensification of agriculture and livestock production and the responsible use of ecosystem services is one way to improve livelihoods and living conditions in dry areas. This requires land, plant and water resources to be well used and managed, that rainwater is harvested, eroded land revegetated with seeds from native grasses and forbs, trees and shrubs planted or allowed to sprout and grow (natural regeneration), and maintaining a high level of biodiversity and ecosystem functioning. To improve local living conditions in drylands so that they become part of a growing bioeconomy, livestock keeping and crop farming need to be integrated with value chains and demand from local and urban markets.

Drylands Transform, a research project funded by the Swedish Research Council Formas, has developed a conceptual model of the current change processes in drylands, and how negative, reinforcing, development trends can be reversed. Two important transformation

pathways are the restoration of degraded dryland ecosystems, and improved, well-functioning governance of rangelands and other dryland resources.

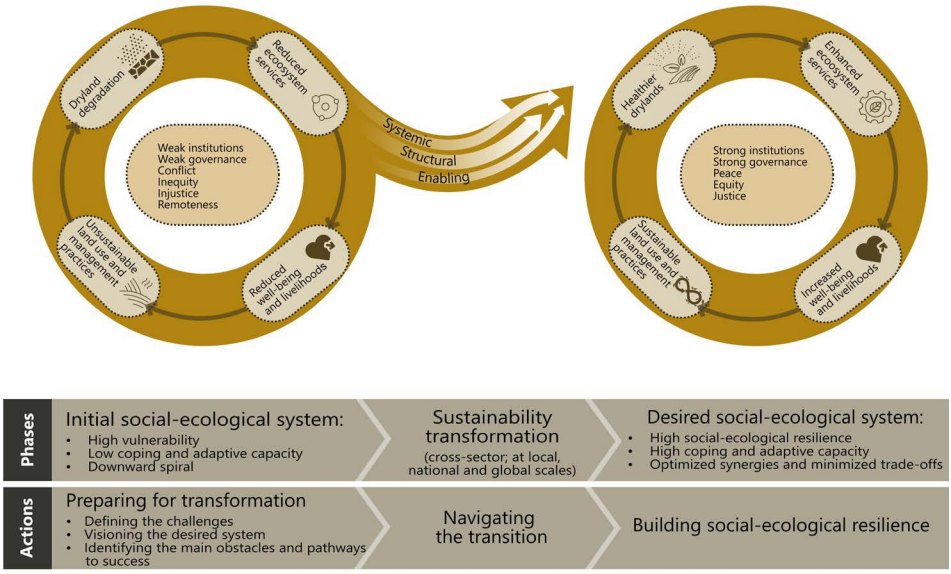


Figure: A conceptual model of change processes in the drylands of East Africa (based on Bargués-Tobella et al 2025). 'Socio-ecological' refers to the connections between social and ecological systems.

What does the research say about ways forward?

Through knowledge hubs known as 'Livestock Cafés' in villages in Kenya and Uganda, local people, advisors and researchers from Drylands Transform have developed and evaluated different methods of collecting surface run-off water (water harvesting), halting erosion and restoring degraded land through various soil conservation measures and the replanting of grasses and other plants that can easily be scaled up. This is known as proof of concept. Together with a traditional knowledge bank, this knowledge is necessary to create conditions for a sustainable use of resources and improved living conditions in drylands. This has proven to be very successful, and now, Vi Agroforestry, a Swedish NGO based in East Africa, together with local organisations and farmer groups, is working to develop and spread the methods further within the follow-up Formas-funded research project Restore4More. This project has also further developed an app that compiles data on various rangeland restoration interventions to monitor and gauge their effectiveness, as well as their geographical reach. Drylands Transform has also examined living conditions in terms of livelihoods, nutrition, education and gender roles in over 900 households in the most sparsely populated area along the Kenya-Uganda border (Karamoja) (Schumann et al 2025). They have also carried out 200 in-depth interviews on land governance, tenure and various types of land management.

Cultivation trials are conducted in the Livestock Cafés, where grasses and other plants are harvested and dried for feed and stored so that livestock have extra feed (in addition to grazing) to grow before they are sold or slaughtered. Research on cattle fattening with locally grown feed is being conducted in north-eastern Uganda, where livestock keepers allow their animals to be included in the trials to establish how growth rates are affected. This work contributes to the development of value chains that connect products from livestock keeping and crop farming to expanding local and urban markets and the local bioeconomy. There are established cattle markets in the area with developed contact networks both locally and with links to major cities. Mobile phones have allowed pastoralists and agropastoralists to follow changes in livestock prices. This allows them to decide when to sell their animals and ensure that they are getting a reasonable price. The Drylands Transform and Restore4More projects are initiating and developing value chains related to feed production, the storage and sale of hay/dried feed to be used partly during dry periods when there is a lack of grazing land, and partly for strategic feeding to fatten cattle before they are sold and slaughtered.

Kitchen gardens that conserve water and nutrients through the cultivation of various kinds of crops (e.g. cereals, grain legumes), roots and tubers, and vegetables, are demonstrated and developed together with advisors, pastoralists and agropastoralists in the Livestock Cafés as well as in villages near homes and water sources. This is done through practical training at repeated intervals over the growing season where knowledge can be spread among farmers. When agropastoralists/pastoralists see how kitchen gardening works and what it can yield, they want to try it themselves. In the kitchen gardens, perennial and annual crops and shrubs/trees are grown, contributing to food and nutrition security and providing income, especially for women and young people. By experimenting together, participants can develop their own, or shared kitchen gardens at home or by the nearest watercourse or source of water.

Growing, planting, and promoting trees and shrubs for various products and services is another activity conducted in the Livestock Cafés. Trees and shrubs are integral components of pastoral landscapes and increase the capacity of the soil to infiltrate water. Moreover, they are important sources of feed for livestock, fruits and berries for human consumption, as well as materials for fencing and bioenergy.

To find grazing land during various times of the year there is a need for 'migration corridors' where livestock keepers and their animals can migrate and graze without disturbing surrounding land uses (e.g. private farms) during movements to and from dry season grazing grounds. Setting aside areas that are not being used by single agropastoralists/pastoralists but function as migration corridors is an example of active governance in managing the combination of private land ownership and the common right to use grazing land. Clear, yet flexible solutions on owning and using land for private or common use are a key element in the development of a sustainable bio-based economy in African drylands.

To disseminate research results and experiences from the Livestock Cafés and other research, the project involves not only universities and research institutions but also 'scaling partners', that are responsible for spreading and applying knowledge both locally (Vi Agroforestry) and regionally through the Intergovernmental Authority on Development (IGAD).

Vi Agroforestry and its local partners provide advice and support to groups of smallholders. This includes training community facilitators ('training of trainers'), holding workhops with agropastoralists and pastoralists to collect grass and herb seeds and then planting them where they want to grow feed, and planting and growing trees. They also support the feeding of livestock with local feed and help establish kitchen gardens. IGAD is a regional intergovernmental organisation specialising in policy dialogues in the drylands of East Africa. It arranges education and training sessions and disseminates technical information to promote innovation and development in the area. Through IGAD and national partners in Kenya and Uganda, the projects are able to take part in policy-level meetings with representatives of local, central and regional agencies and other forums.

Scenarios for sustainable development in dry areas

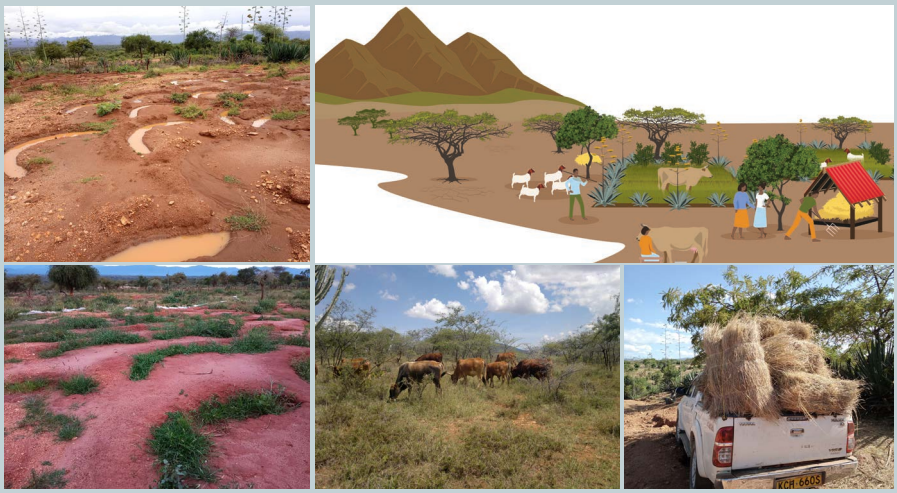
Based on discussions with agropastoralists, pastoralists, local and regional administrators and research within Drylands Transform, two possible development paths (scenarios) on the future of the drylands in East Africa have been drafted: (i) Renewed mobile pastoralism, and (ii) Innovative agropastoralism. The different development scenarios have been discussed and evaluated through group discussions with women, men and young people locally, and civil servants and other actors at district-county and national levels in Kenya and Uganda. To date, most participants have advocated innovative agropastoralism as the most effective approach, partly because it provides the possibility for more income streams and better opportunities for schools and healthcare. The two scenarios are likely to be developed in parallel, with larger features of renewed mobile pastoralism in more sparsely populated dry areas, and a dominance of innovative agropastoralism in areas of higher population density and somewhat more rainfall.

Conclusions

There are good opportunities for sustainable biobased economy in African drylands. These are areas of great potential and that are rich in both human and natural resources. Active, knowledge-based management at various levels, from local to district/county, national and regional, with the active participation of pastoralists, agropastoralists and other actors in the landscape and along value chains, is a prerequisite for sustainable development in drylands.

Develop livestock farming and increase incomes through feed production and strategic feeding prior to sale and slaughter

Rainwater is collected by digging half-moon-shaped indentations in the ground. Organic material and fertiliser are added to the indentations before grasses and herbs are sown with seeds that have been collected or purchased locally. Through joint activities in Livestock Cafés with local pastoralists, agropastoralists, advisors and researchers, grass and herbs are harvested and dried into hay. This is used as feed during dry periods and to fatten animals prior to sale or slaughter. The hay can either be sold to generate income for food, school fees or health care, for example, or used as feed for farmers' own animals. In the Livestock Cafés in northeastern Uganda and northern Kenya, students and researchers, together with advisors and livestock keepers, conduct feeding trials with locally grown feed for cattle and goats. This is an example of the development of value chains for animal products through the improved use and management of local land, water and plant resources. For the continuation of the project, Vi Agroforestry and local organisations will work with groups of pastoralists and agropastoralists to scale up and disseminate their work on feed value chains and develop ties with local and national markets. Through IGAD's participation in the project, knowledge and experience are disseminated to other areas and countries in East Africa's drylands through informational materials, training and policy dialogues.



Livestock Cafés are meeting places for knowledge exchange and practical implementation. Based on discussions with pastoralists and agropastoraists, local advisors and researchers, half-moon indentations have been dug to collect water and nutrients. Grasses and herbs have been replanted for cattle grazing and for the harvesting of feed (hay) for the dry season or for sale. Images/photos are from the Drylands Transform Livestock Café in Cheperaria, West Pokot, Kenya. Photos to the left by Margeret Nyaga, University of Nairobi.

Read More

Drylands Transform – Achieving the sustainable development goals in East African drylands: Pathways and challenges towards a social-ecological transformation; https://www.slu.se/drylandstransform

Restore4More - Scaling rangeland restoration in drylands through synergies in the biodiversity - water- climate nexus; https://www.slu.se/restore4more

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Photo: Gert Nyberg

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