

Save. Preserve. Build.



The sweet spot
for sustainable
fisheries

Local fish
for local
businesses

Raising the
quality of
animal feed

Welcome to the future of Saudi Arabia

This is the official report and news from KAUST Beacon Development – a department within KAUST Innovation. Our mission is to help the nation achieve the objectives of Vision 2030. To do that, we need to provide the strategic advice that will support those objectives.

So over the last year, we've been hard at work surveying, researching, consulting and developing frameworks to help clients meet those goals. In this issue, you'll find stories ranging from how we're helping the aquaculture sector to breed and farm fish in the Red Sea to how we're saving turtles from extinction. We've even discovered a brand-new species of snake and recorded a new fish and octopus for the Red Sea.

We'd like to thank those who contributed to this report – the project leaders and scientists who make all this possible. Without their knowledge and hard work, none of these projects would be possible.

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We'd like to thank those who contributed to this report – the project leaders and scientists who make all this possible. Without their knowledge and hard work, none of these projects would be possible.

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A focus on

رؤية VISION

2030

المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

Vision 2030 seeks to revolutionize the Kingdom. The three key pillars – Ambitious Nation, Thriving Economy, and Vibrant Society – are fundamental to the objectives here at KAUST Beacon Development.

Through our research and frameworks, we enable Vision 2030's goals. By creating a framework to farm seafood and produce adapted species of algae, we not only help offer a healthy and fulfilling lifestyle for locals but increase employment and diversify the economy. Similarly, our environmental work with reserves, fisheries and the giga-projects helps enable environmental and social responsibility.

The voyage to reach Vision 2030 relies on information. Information about how to develop new businesses and opportunities. Information about how to balance the economic, cultural, and environmental needs of the nation as well as information about how to build, without harming what's already there.

We provide that information, so that the Kingdom can make their voyage – knowing what lies ahead.



Local fish for local businesses

The more seafood our country produces, the healthier our people and our economy will be. Fish can keep your heart and liver healthy, contribute towards better mental health, and have a variety of nutrients that help protect against disease and infection. They're also a far more efficient food source than other animals. This makes aquaculture – a mix of farming fish, shrimp, sea cucumber, algae and more – an attractive prospect for entrepreneurs.

That's why seafood is so important to Vision 2030. In Saudi Arabia, we eat around 320,000 tons of seafood a year, but only produce around 120,000 tons. While that's drastically increased since 2016, there's still a long way to go until we hit the 530,000 tons target. If we hit that target, we'll have enough to sustain a healthy population and have enough left over to export to other countries.

But how do we farm seafood in Saudi Arabia? Which fish can we farm and where can we do it? These are the questions that the Aquaculture Development Program set out to answer.

Gilthead seabream Preadults

320,000
tons
of seafood
eaten in
Saudi Arabia
a year

Forming the framework to farm fish

Our Aquaculture Development Program (ADP) had a very simple goal: Provide the solutions, advice and answers that will allow people to farm seafood in Saudi Arabia and make it publicly available, so businesses have everything they need to get started. We investigated which species would be suitable, how to improve the feed conversion ratio (FCR) for those fish, which locations would be suitable for farming, and how to run a breeding program.

We'll be promoting it to the market in 2023 as a public package. Any entrepreneur that wants to begin farming fish in the Red Sea will be able to see what technology they'll need, potential sites for farms, and a framework for making sure the fish and environment are safe and healthy. It's essentially the instruction manual for setting up an aquaculture business.

Sampling
activities





1. Which fish can we farm?

Not all fish can live in all waters. To date, we've been culturing two species under Red Sea conditions for the past 12 years. Recently – through ADP – we've identified and promoted another three species: Sobaity Seabream, Mangrove Red Snapper, and Pompano. With these advances, we are able to support Saudi Arabia's aquaculture industry by using most of the Red Sea's waters.

The two main species are the Asian Seabass and the Gilthead seabream – both suitable for a decent plate of food at a competitive price. We've also, for the second year running, been able to close the cycle in the hatchery and breed the larva under Red Sea conditions.

Both species have had very positive feedback, with individuals noting that both species have great flavor, texture and taste. On top of that, as warm-water fish, they're quite novel for the European market, making them excellent candidates for export.

It was also important to consider what would happen should the fish escape the farm. Having fish that are native to the Red Sea not only makes it easier to create their

environment but makes sure that any escapees don't disrupt the local ecosystem. It was also vital to make sure that we did not cause any genetic pollution in the Red Sea.

2. How do we farm these fish?

Unlike farming cattle or poultry, fish need a more delicate touch. You can't just fence off a section of land – you need to build an enclosed structure to contain them, such as a cage, pond or tank. You also need to carefully monitor this structure to make sure they don't get stressed and that the entire ecosystem is running properly.

We do this through technology. A network of cameras keeps an eye on how many fish there are and how they behave. Meanwhile, there are automatic feeders and systems to recirculate the waste from the fish, feeding the algae and other flora inside the net. The net itself protects everything inside from predators. This means that it becomes a self-sustaining ecosystem, safe from the outside world. While also stopping them from escaping.



3. How do we feed these fish?

As these fish are not traditionally farmed, we've needed to develop new feed that's suitable for them. It's important that the feed conversion ratio (FCR) is as close to one-to-one as possible – bearing in mind that the average FCR for farm fish is between 1.0 to 2.4.

Already, we've developed formulas for feed that can sustain these species at different stages of their life. We've lowered the FCR by 33% in the last year, compared to the average FCR before our Aquaculture Development Program began.

4. Where can we farm fish?

Not every location along the coast is a suitable location. As part of the project, we've identified suitable places that could house these farms.

These are regions that have ideal conditions for the fish themselves, but also areas that won't disrupt the local environment. It's vital that these farms don't impact any other habitats. For example, the report takes into account whether the farming would affect local fisheries – as those businesses rely on wild fish.



ADP Pompano
Broodstock

Sampling activities -
average body weight
determination





Raising the quality of animal feed

Since at least 2015, scientists have known that using algae in animal feed is a wise decision and a good alternative to traditional feed. Algae could cut down the amount of methane cows produce, improve the immune system, fertility and overall health of the animals, and is better for the environment when farmed.

That's because algae has a wealth of nutrients, including proteins, carbohydrates, and lipids - making it a suitable substitute for the more traditional wheat and soybeans. It's also far more efficient to farm. Typically, a hectare can produce about 10 to 25 tons of wheat. With algae, you could produce 40 tons per hectare.

Most countries aren't taking advantage of this opportunity, though. Like a company that's invested in decade-old software, it's difficult to move their infrastructure over to newer, more-efficient technology.

If we could farm algae on Saudi Arabian land, we could be the revolutionary that breaks the mold and skips to the latest technology. We have the land and we have the remit. With algae, we could stop relying on 100% of our animal feed coming from imports from regions like Brazil, Argentina, and Peru, bring new jobs into the economy, and become self-sufficient for our feed production. All while also cornering the market on this valuable opportunity - exporting algae to the rest of the world.

The question is: How can we farm algae on Saudi Arabian land?

**40
tons per
hectare**

**this means you
get 60% more
feed per hectare
than traditional
methods.**

Concentrated microalgae cultures after downstream process

Teaching the algae to thrive

Part of the project is making sure that there are suitable strains of algae available to a variety of stakeholders - such as entrepreneurs, existing businesses and universities. So we breed the algae to deal with the harsher climate in Saudi Arabia - hotter temperatures and salt water.

The process for breeding these algae is basically selective adaptation. Take a strain, grow it in higher temperature, take the survivors, grow those in higher temperature. Repeat. After several generations, we can adapt the strain to cope with a suitable environment.

Testing the waters

Once we've adapted the algae to live in Saudi Arabia, we can develop the models and framework for creating an algae farm, and run a pilot to prove it all works.

We've already adapted several strains of algae, and have set up a pilot farm of 1,000 square meters to test whether they can survive the Saudi Arabian conditions. The results show that we could potentially create 40 to 100 tons of algae a year on the Red Sea coast (using sea water, rather than the typical fresh water). For context, the total amount of microalgae biomass produced in Europe was around 500 tons in 2019.



Seaweed cultures in DABKSA laboratory

DABKSA staff operating downstream process equipment



DABKSA staff measuring main abiotic parameters in production raceways (open systems) at pilot plant facilities



3D renders of phase II - DABKSA project

Another consideration is how these farms affect the environment. So we've been testing new strains of algae that can naturally absorb more CO₂ than traditional algae. The results so far show that it should be possible to make the farms carbon neutral - moving us ever closer to our Vision 2030 targets.

In 2023, we will release the full framework to explain what algae is possible to farm and what technology to use to begin production. We already have around 50 species of local algae and some exotic that are adapted to the local environment.

Building our own algae bank

Around the world, there are algae banks where you can source the algae you need, similar to how you need a seed to start a farm. As part of this project, we're creating the first Saudi Arabian algae bank. It will have a full library of over 60 local species alongside other commercial species.

All these species will be tested and verified to be safe, meeting

national and international safety standards and regulations for animal feed.

More algae, more jobs

When creating the framework for the technology and setup for the farms, we've considered how it would be sourced. Not only will people in Saudi Arabia be able to run the farms, around 80 to 90% of the construction could be made with local materials. This includes the overall structure as well as elements like the filtration systems.

This means that any algae farms set up on Saudi Arabian soil will create jobs for the Saudi population. The farms themselves can bring jobs to regions all along the Red Sea coastline, but also further inland - should the water be pumped in.

By our estimate, algae should create multimillion-dollar businesses across Saudi Arabia, generating 200,000 rural jobs along the Red Sea and Eastern Province coast.

DABKSA staff operating photobioreactors (closed systems)



200K

rural jobs will be generated by this multimillion-dollar business along the Red Sea and Eastern Province coast.

DABKSA staff operating photobioreactors (closed systems)



Al Qunfuda, traditional Dhow and Tarrad fishing boats

The Sweet spot for sustainable fisheries

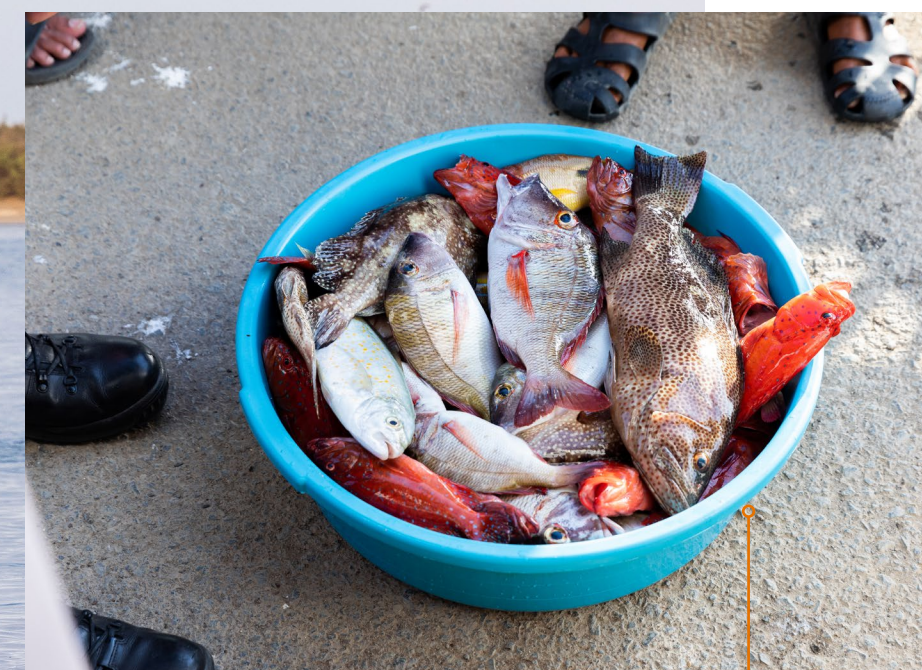


The famous Thomas Huxley once said: “Probably all the great sea fisheries are inexhaustible.” But that’s a myth. Fish an area too much and it’s all too easy to decimate the local population.

Sustainable fishing is all about finding the right balance. Catch some fish and it can encourage the population to grow faster. Catch too many and the population will suffer. As a result, the local fishing communities suffer from a reduced income. This has already happened with seafood like oysters. In the past, humans caught far too many. The more we caught, the harder it became to catch them. The harder it became, the more the price rose.

By making sure that our fishing is sustainable – living in that Goldilocks zone – we keep the population healthy and the price reasonable.

The only way to do that is to survey the area and figure out how many fish there actually are in the sea.



Red Sea coast, typical catch from the small-scale fishery



The Goldilocks zone for fishing



Al Qunfuda, typical fishing port

24
species of
sea life

are being
evaluated to
determine the
regulations and
quotas to sustain
fish populations.

KAUST Staff sampling of catches



KAUST staff collecting
biological data in the Lab. -
otolith extraction



Finding the needle in a haystack

We have three fishery projects that are determining how many fish there are and how much fishing the Red Sea can support. These projects are evaluating 24 different species of sea life, including fish, sea cucumber, shrimps and lobster. Once we've determined how many fish there are - using statistical analysis - we can recommend what regulations and quotas are needed to sustain the fish populations.

We also occasionally discover a few surprises along the way, such as the recording that the Indian Zebra Sole can be found in the Red Sea.

But these projects aren't just about managing the fish populations. They're about the people - and how we balance the cultural, environmental, and socio-

economic needs. How much do people want to eat fish? How much can the sea support and how much will it affect the local businesses?

It's all tightly interconnected. If people stop fishing, it'll have a direct impact on their livelihoods as well as the environment. Too many individuals in a specific species could lead to them having a population explosion - which could spread across the entire sea. Too much fishing and local businesses will have an unpredictable revenue stream - catching lots of fish one month and hardly any the next.

The projects are still underway, but we'll be drawing up any solutions towards the end of 2023. At which point, we'll be recommending exactly how much fishing can - and should - take place in the Red Sea.



Green turtle with a satellite tracker recently deployed by KBD returns to the sea. Al Wajh Lagoon.

Save. Preserve. Build.

KAUST Beacon Development is also running projects that save animal lives, reserve the environment and help the government to build conservation initiatives.

Dr. Hector Barrios measures a green turtle after she laid eggs in Ras Baridi Marine Turtle Conservation Initiative. Ras Baridi, Yanbu.



1,250
hatchlings
saved



Turtle hatchlings lost their way due to light pollution, were recovered by KBD team and returned to the sea. Ras Baridi, Yanbu.

Saving turtles from extinction

Ras Baridi, north of Yanbu, hosts the largest Green turtle nesting beaches in Saudi Arabia and the Red Sea, as well as the critically endangered Hawksbill turtles. Both these species return to these beaches to breed, so it's important to the entire life cycle of the Red Sea that we protect these turtles.

Due to us humans, turtles are becoming increasingly rare and endangered. Turtles take a long time to breed, particularly the larger species, and return to the same beach generation after generation. These beaches are becoming increasingly perilous, making it difficult for the baby turtles to survive the trek back to sea. It also seriously impacts adult turtles. For example, plastics can block their throats, causing gasses to build up that means they can't dive down to where they feed.

Another problem is that these baby turtles navigate by moonlight. Artificial lights, confuse the baby turtles – causing them to head in the wrong direction.

Should these turtles perish, it'll cause a knock-on effect for the rest of the environment. Turtles

are vital to keeping corals and seagrass healthy. As keystone species, they maintain the fragile balance by eating organisms that damage or overgrow these sensitive blue-carbon storage ecosystems.

Keeping habitats safe

Since 2021, we've been researching their habitats, cleaning up the beaches, and advising local businesses on how to avoid confusing and harming the turtles. Using GPS trackers, surveys, and drones, we've been able to locate key areas that need protecting. There are many dangers that humans cause: off-road cars drive over nesting beaches, fast boats strike the turtles, fishing nets accidentally trap them, and tourists leave plastic on beaches.

By learning more about where the turtles are and how they behave, we've been able to remove over half a ton of trash and saved 12 female turtles and 1,250 hatchlings. This is particularly important as the two key species we're focusing on are both nearing extinction. So our work will keep making sure that the species can live on.



Protecting entirely new species



*Violet-backed starling,
a Sub-Saharan African
species found at 3000 meters
above sea level, in the Al
Soudah mountains*

Saudi Arabia has a diverse natural environment – and our research has shown that there are potentially undiscovered species hiding away on the land. If we could manage our herding and agriculture, it could be even more diverse.

Part of Vision 2030 is to leave the environments we touch better off than we found them. This is why there are over 13 reserves across the Kingdom that are protected land.

But to preserve an environment, one must first understand it. This was why we were asked to advise the Prince Mohammad Bin Salman Nature Reserve (PMBSR) – which covers around 24,500km.

Unearthing surprises

In PMBSR, we've been conducting surveys to research and learn more about the land. What wildlife calls these reserves home? How many species are there? And do they live there permanently

or travel there for some other reason? Specifically, we've been looking at bats, birds, reptiles, small mammals and vegetation.

The results so far have been encouraging. While we knew the area to be diverse, we've found that there is far more life in the area than we originally realized. We've found species never seen in Saudi Arabia before and have re-evaluated how birds, bats and reptiles travel to include the reserve as part of their range. But most surprisingly of all, we discovered a completely new species of snake, similar to a grass snake but with different coloration. We'll be publishing our findings at the end of 2023.

As part of the project, we shall be advising the reserve on how best to keep these species safe from human activity, such as agriculture and grazing. We'll also be performing more studies in the future to inform those recommendations.

Building with care

Large projects can cause large damage. But only if done without forethought. It's key to the environment and to the project themselves that everything is done with care and attention.

That's why we've been consulting for the giga-projects – such as NEOM, ROSHN, AMAALA, Soudah Development, and The Red Sea Development Company – on how best to build, without hurting the environment in the process. This work has been crucial to making sure that their projects get off the ground in the first place. The work we've done has broken down the barriers and set new standards across the world.

With the spotlight on, we can raise the standards across the world. It's an opportunity to show the world how to build a new generation of wonders. We can set the standard for quality and sustainability. While also creating jobs for local people – training them to become world-leaders.

Supporting through advice, strategy and solutions

Each of the giga-projects is very distinct. But all of them share a concern for the environment. Our role is to consult and answer the big questions – to spot potential problems and provide solutions. How will these projects affect the environment? How will they impact dolphins, turtles, birds, and more?

We come up with an action plan to not only mitigate any impact, but to actually create a net benefit. A plan that leaves the region enhanced by the end of the project. In fact, we've crafted the Value Driven Approach towards Ecosystem Services (VDA), which is a framework to help the Red Sea Development Company achieve their aim of 30% net gain of biodiversity.

Let's look at two projects in particular to see the effect of our recommendations.

*The soft coral,
Dendronephthya sp.*

Coral is a vital part of the Red Sea's ecosystem, and we must work to protect it. One way is to move the reef elsewhere. But projects can affect coral, even if they're not in the immediate vicinity. Dredging can release a plume of sediment into the area of the sea surrounding the marine construction works. This plume can drift with the currents, and if the sediment land on a coral reef it can essentially smother it.

Using satellite imagery and weather models, we can predict how the sea currents will move and whether that plume will reach the coral reef. This lets us be proactive, slowing down the dredging or pausing it until the currents change. With this information, we can make sure that the plume is as small as possible so that it causes the least damage possible to the coral reef.

Restoring habitats affected by human activity

In the 1970s, some islands within NEOM were connected by human-made causeways. While this was useful for humans to travel, it also inadvertently made it easier for dogs and cats to reach the islands.

But the local birds and turtles hadn't evolved to cope with these predators – rats in particular enjoy eating bird eggs. So it was necessary to find a way to fix this problem.

With our recommendations, NEOM has begun work on removing these earth causeways, this will once again isolate the islands. Once finished, these islands can return to their natural state – and the birds and turtles can get their habitats back.





What the future holds

All our efforts at KAUST Beacon Development are about delivering sustainable projects, whether that's food, development or conservation. We advise government entities on how to sustainably meet the needs of a growing population, across a range of sectors.

By developing a sustainable future for Saudi Arabia, people will see more variety in their diet, businesses will find opportunities, and everyone will see more biodiversity.

The work we do will also indirectly create jobs. We will see plenty of fish and algae farms, successful fisheries management, and the economy will flourish due to the advice that we've provided.

We shall continue to provide that advice. We'll keep supporting the giga-projects, investigating aquacultural techniques, and developing sustainable solutions.



More variety in local diets



More jobs for locals



Increased biodiversity



Lush and beautiful landscapes for tourists



Opportunities for small businesses

Ultimately, we'll keep developing frameworks and find the necessary information to protect and enhance Saudi Arabia.





Leading environmental consulting services in Saudi Arabia

innovation.kaust.edu.sa/beacon-development