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The Role of Nature-based Solutions and Innovation in Creating Resilient Food Security in the UAE

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Summary

- This insight gives an overview of the United Arab Emirates food security landscape linking it to the expected climate change impacts in this region. Some of these impacts include higher temperatures, increased frequency of heatwaves driving further desertification, changes in hydrological cycles and more frequent flash floods. The insight highlights the importance of early planning for climate change adaptation and building resilience within the food system.
- Furthermore, this insight considers the UAE's necessary natural resources for domestic production such as soils and water, discusses the importance of further trade diversification, and explores opportunities in innovation and agricultural technology with a focus on novel foods – specifically alternative proteins.
- Finally, this insight makes recommendations focusing on three main areas:

Continuous improvement and alignment of the UAE's food security policies.

Protection and improvement of the critical natural assets that support food systems.

Investment in innovation, research & development.

The Issue

The Food and Agriculture Organisation (FAO) defines food security as "... a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". [1,2]

The Sustainable Development Goal (SDG) 2 has an ambition of ending world hunger by 2030. According to the FAO's 2023 State of Food Security report, there are currently around 735 million people in the world facing hunger which is far from the desired state. Additionally, current trends are not showing any signs that the zero-hunger goal will be reached by 2030. In fact, estimates from the same report show that there will be around 600 million people still facing hunger in the world in 2030. Some of the reasons the report identifies for these stark numbers are conflicts, the COVID-19 pandemic, economic slowdowns and downturns, growing inequality and increasing occurrences of climate extremes.

The relationship between climate change and food security is complicated. The food system is not just about food production. It also includes transport, processing, packaging, storage, retailing, consumption and food waste. In general, the food system is a significant contributor towards climate change. The Intergovernmental Panel on Climate Change (IPCC) estimates that around one third of total human-caused greenhouse gas emissions are coming from the food system.[3] The most emitting activities within the system are livestock activities, land use changes (notably deforestation and peat degradation), supply chains and food loss and waste.

At the same time the changing climate has already had, and is projected to have, significant implications on the food system, exacerbating global food insecurity. Climate change is expected to have further negative effects on crop yield nutritional quality which in turn is likely to increase crop prices. The IPCC estimates up to a 29% increase in cereal prices by 2050 as a direct consequence of climate change. Furthermore, changing temperatures and weather patterns are likely to facilitate the spread of dangerous pests and diseases and invasive alien species which can pose a threat to economically important crops and natural environment.

The UAE's food security landscape

The Arab region is afflicted by the highest level of economic and social inequality globally which contributes significantly to the region's food insecurity.[4] The reasons for this disparity are similar to those causing global hunger. While some countries in the Arab region are considered as food secure (such as the Gulf Cooperation Council countries), the least developed countries suffer from high rates of poverty and hunger. Food insecurity in conflict-affected areas is only exacerbated by the compounding effects of climate change related environmental shocks (high temperatures, floods and droughts) and environmental degradation.[5]

Although considered as food secure, the UAE still has food security challenges. As a hyper arid country, the UAE has limited natural resources for domestic production. The main constraints connected to domestic food production are scarcity of arable land and water suitable for agriculture. Additionally, high temperatures in the summer months make it challenging to grow food conventionally.

The population in the UAE is on the rise and this trend is expected only to continue, creating further pressure on the UAE's food system. In 2022, according to The World Bank Data, the UAE's population was around 9.5 million.[6] By 2030 this number is expected to surpass 10 million, and by the year 2100 the number is predicted to reach 14 million.[7] The growing population means increased demand for affordable, nutritious, high-quality and safe food.

The UAE is thus highly dependent on food imports – up to 90% of UAE food is imported leaving it exposed to volatile global markets. The current imports policy is not immune to external shocks, food shortages and price inflation. This was demonstrated during the COVID-19 pandemic where trade was limited due to movement restrictions. The 2022 Russian-Ukraine War has also had an impact on imports of goods, specifically sunflower oil and wheat. Another recent example that effected the UAE's food trade market is the Indian ban on rice export in July 2023 due to poor yields caused by intense rains. This in turn prompted the UAE Ministry of Economy to ban the export and re-export of rice.[8] Studies show that climate change and extreme events are expected to continue to have an impact on food production globally, leading to challenges such as these in the trade of food items.

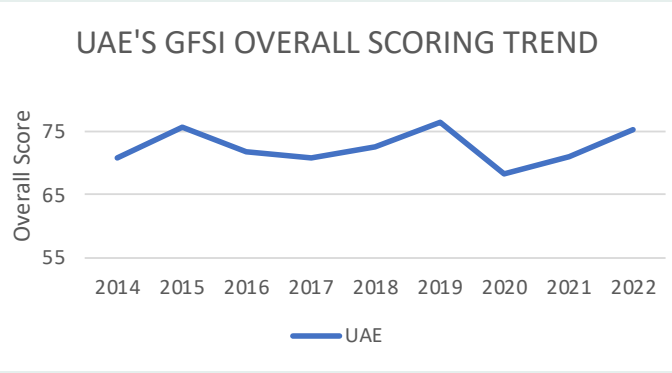
The impact of volatile markets on food security in the UAE is somewhat reduced due to the benefits of high GDP per capita and its ability to invest in imports and re-exports. The UAE has made significant investments in recent years to expand the range of countries from which it imports its food but there is room for more diversification. For example, Latin America and Caribbean countries have great potential to be the UAE's new import markets, specifically for oil and oil seeds, nuts, pulses, meat products, and various fruits such as grapes, granadilla, guavas, bananas and plantains.[9] Latin America and the Caribbean hold a significant share of 15% of the world's agricultural export and the US, China and Europe are currently its main importers.[10] In addition to diversifying imports, the UAE has also started growing food abroad, mainly in Romania, Serbia, Egypt, Morrocco and Namibia through the Al Dahra Group.[11] These trade-related strategic plans play a crucial role in enhancing the UAE's food security.

With alarming climate change predictions, the UAE has an opportunity now to create a resilient food security landscape that will serve generations to come. Indeed, strengthening food security is very high on the UAE's agenda. The government published a Food Security Strategy in 2018 and has since reported on its progress towards achieving that goal in the 'Future of Food Report'. It also published the UAE Water Security Strategy 2036[12] in 2017 and the UAE Circular Economy Policy[13] in 2021, both of which play an important role for the UAE's food security. The UAE's position on Global Food Security Index (GFSI) has improved since 2012 (Box 1) which is a direct outcome of the country's efforts to improve its food security.

Several new initiatives and partnerships, mainly focusing on innovation and technology, have been triggered as part of the strategy. However, there is an evident research gap evaluating the current state and the drivers of food security in the UAE.[14] Without appropriate scientific data that underpins policy decisions and interventions related to food security, there is a risk of investing in inefficient projects that may not deliver desired outcomes.

Box 1: The Global Food Security Index and the UAE's Ranking

The Global Food Security Index (GFSI), developed by Economist Impact first started publishing data on food security in 2012 (2014 for the UAE). The UAE was ranked 31st in 2018 and improved 10 places to 21st in 2019. This was a significant leap for the UAE and in line with its ambition, as per the UAE's Food Strategy, to reach 10th place by 2031 and 1st place by 2051. Achieving this is a tall order, but its overall trajectory is relatively positive.



The GFSI covers four different dimensions across 113 countries:

- Affordability
- Availability
- Quality and safety
- Sustainability and adaptation

Each of these dimensions is further described by different sets of indicators.

The two dimensions that the UAE excelled at in 2022 is availability and quality and safety, ranking above the world average (7th and 16th rank, respectively). The affordability dimension puts the UAE in 31st place indicating that there is still some scope for improvement. The lowest scoring dimension for the UAE at 53rd place was sustainability and adaptation. This is partly due to its dry climate and its scarce resource availability, especially concerning the indicators that are measuring agricultural water risk, predicted temperature rise, projected susceptibility to droughts and soil organic content. The areas which can significantly improve the ranking of this dimension (and have a potential to improve water and soil indicators) are within the composite indicator – 'political commitment to adaptation'. This includes the following indicators: 'environmental- economic accounting implementation', 'early warning measures/ climate smart agriculture', 'commitment to managing exposures' and 'sustainable agriculture'.

However, the UAE should not solely rely on the GFSI as it is not a perfect measure of the food security in one country. When designing food security policy, the UAE should also look at other indicators and drivers and define which ones are specifically relevant for the UAE. Other indicators and frameworks have also been developed. For example, FAO's Suite of Food Security Indicators includes the Prevalence of Undernourishment Indicator (PoU) and Global Hunger Index. Another 'locally developed framework' is an analytical framework for estimating food security indicators and it focuses on indicators suitable specifically for the UAE.

Nationally Determined Contributions (NDC)

The interlinkages between food security and climate change are being increasingly acknowledged by the international community and governing bodies. Food, Agriculture and Water is one of the thematic days at COP28 where discussions will focus on innovation, regenerative agriculture and national transformation pathways. Previous notable decisions made at COPs include the Glasgow COP26 which addressed methane emissions for the very first time (40% of methane emissions come from agriculture). The Sharm el-Sheikh COP27 adopted a decision in 2022 for a four-year plan on agriculture and food security with a focus on adaptation, soil health and livestock management. It is a step forward but to improve food security and achieve the targets set in SDG2, bolder decisions are required at subsequent COPs.

The UAE has published the third update to its second National Determined Contributions (NDC) in 2023 in which waste and agriculture, and environment and food systems feature as part of its mitigation and adaptation strategies, respectively.[15] According to the document, waste was responsible for 12 Mt of CO_2e (2019), out of which 60% came from the landfills. Landfills are a significant challenge as they emit methane which has 80 times the warming potential in the first 20 years compared to CO_2.

The UAE has some targets in place (Table 1) to tackle GHG emissions coming from waste but they don't go into detail on how to tackle food loss and waste in the UAE. It is important to differentiate between food loss and food waste as they should be tackled using different policies and interventions. Food loss occurs in the system prior to retail and consumption stages,

while food waste occurs in the retail and consumption stages. The UAE's food waste plan heavily relies on waste to energy power production which could divert attention from the original food waste and food loss problems.

Agriculture is responsible for 6Mt CO_2e (2019), which includes emissions related to energy consumption, animal digestion, manure management and soil emissions. As per the table below the UAE has set its targets related to agricultural emissions with heavy reliance on use of technology. Improving natural assets, especially soils and groundwaters, which domestic production relies on, could be a beneficial approach to explore given its cross-cutting potential as a mitigation and adaptation strategy.

When it comes to climate change adaptation incentives relative to food security, the NDC document points out that this is the first time that the food system featured in the UAE's NDC, which is a significant step forward. Although the latest document does not indicate current targets, it does state that future targets will be on carbon in the food system, regenerative agriculture, alternative proteins and water.

Table 1 Overview of the UAE's NDC quantifiable targets relative to the food security, Source: Accelerating Action 2023 Towards a Green, Inclusive and Resilient Economy

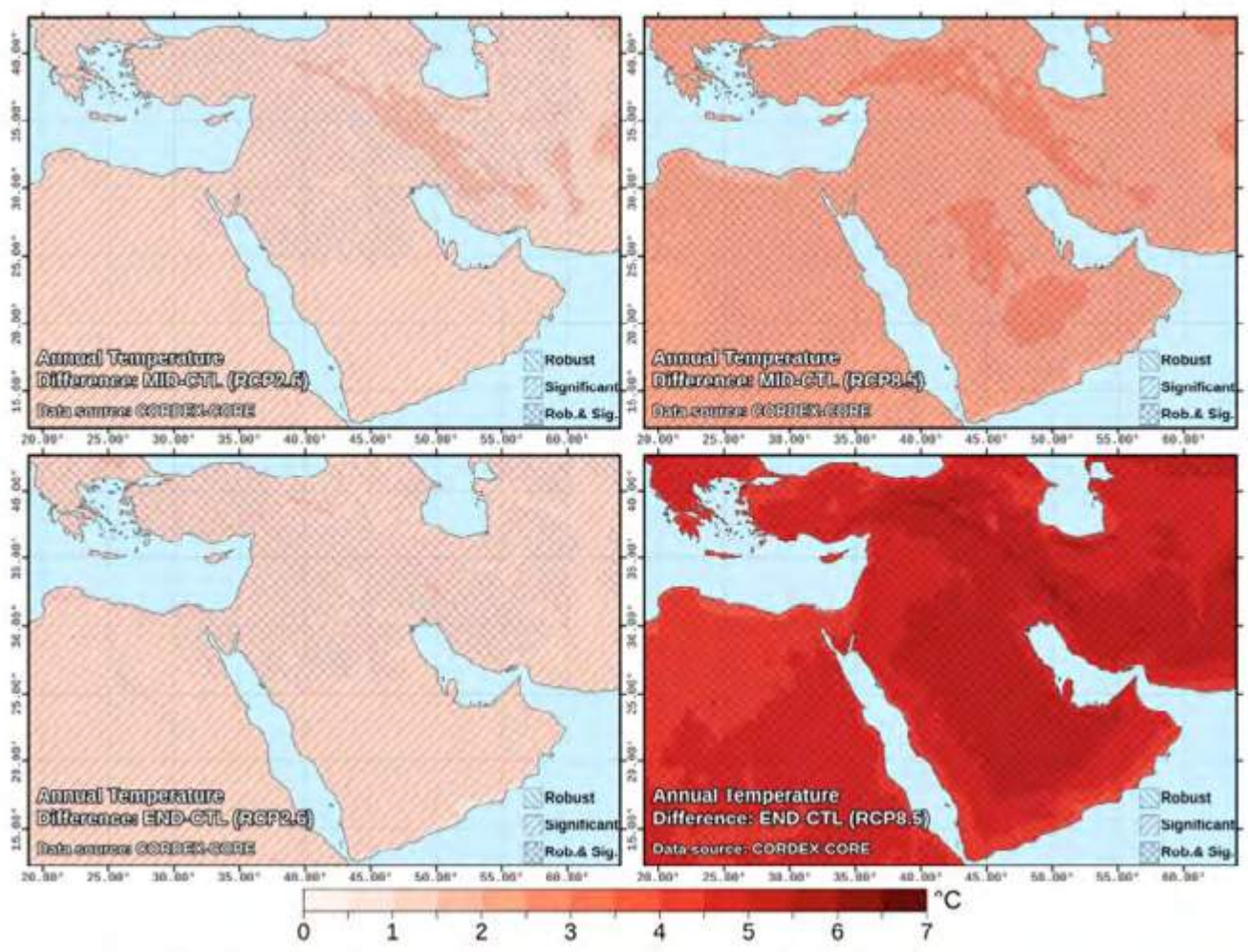
Target definition	Area	Target value	Target timeline
Cut down CH_4 emissions	Mitigation, Waste	30%	By 2030
Increase in overall emission expected	Mitigation, Waste	8%	By 2030
Reduction of food waste and loss	Mitigation, Waste	50%	2030
Cut down emissions	Mitigation, Agriculture	22%	2030
Increase of domestic production of selected food items	Mitigation, Agriculture	15%	Not specified
Reduction of water used for irrigation	Mitigation, Agriculture	15%	Yearly reduction
Increase mangrove tree cover	Adaptation, Blue Carbon Ecosystems	75 million seedlings and explore options to additionally plant 100 million seedlings	2030
Increase the adult fish stock	Adaptation, Agriculture	increase to the sustainable threshold size of 30% decline (from current 90% decline)	2030

Climate change potential impacts on food production in the UAE

The UAE and this region are expected to feel the consequences of climate change more than anywhere else in the world. A recent study of climate change in the East Mediterranean and Middle East region have concluded that this region is already "...heating up faster than any other inhabited region".[16] This is a direct consequence of greenhouse gas emissions, urbanisation, desertification as well as the region's unique geology.

According to the same study, this region has also already experienced changes in hydrological cycles, severity and duration of heatwaves, droughts and dust storms. The negative effects are only expected to worsen by the end of the century unless the emissions are cut as per the Paris Agreement (Figure 1). The study predicts that by 2100 Middle Eastern extreme heatwaves are likely to increase in duration, frequency and amplitude, with temperatures reaching 56°C. Similarly, droughts are expected to become more severe, with prolonged dry periods. Relative humidity is expected to increase by 5% under a business-as-usual scenario, while sea level in the Gulf is expected to rise by up to one metre. Extreme precipitation is also likely to intensify with flash floods causing damages to infrastructure which was built factoring in regular precipitation.

Figure 1 Projected changes of mean annual temperature (with respect to the 1986–2005 reference period). Source: CORDEX-CORE climate projections, for RCP2.6 (left panels) and RCP8.5 (right panels) and for mid-twenty-first (2041–2060, top panels) and end-of-century projections (2081–2100, bottom panels).



According to the same study, higher temperatures and prolonged droughts are expected to have further negative impact on UAE soil, specifically driving further desertification and decreasing availability of arable land. The predicted sea level rise is likely to affect infrastructure on the coastline, including desalinisation plants which are crucial to agriculture. Furthermore, there is a danger of sea salt intrusion into coastal aquifers, adding to the current high salt levels in soils and groundwaters. Mangrove ecosystems and coral reefs, which are important for healthy fish stocks, are also likely to be negatively affected by the sea level rise.

These predictions are worth noting when planning for the UAE's future food security. They are likely to have a significant impact on domestic food production, whether it is traditional and organic agriculture or more innovative agriculture such as hydroponics. The demand for water, soil and energy used to cool down greenhouses and buildings could become a challenge to adequate food supply. The storing of grain stock is likely to face further challenges as the humidity and temperatures rise.

Domestic food production and natural resources

There are around 38,000 farms operating in the UAE contributing around 1% to the GDP. The UAE grows 156,000 tonnes of vegetables and produces 200,000 tonnes of fruit annually (dates, citrus and mango).[17] Although domestic production does not represent a considerable portion of the UAE's food system, it has an important cultural significance and is part of the UAE's heritage.

Likewise, the fishing industry in the UAE is culturally and financially important. According to the government's Aquaculture Pulse 2020,[18] the country consumes more fish than the world average, around 220,000 tonnes per year. However, around 75% of this is still imported. The UAE is home to several fish farms, with one producing Scottish salmon and a few fish hatcheries producing juvenile fish. However, the sea is the UAE's greatest asset for food and nutrition, and it should therefore be protected and managed accordingly to decrease reliance on imports and keep a healthy fish stock.

As per the Food Security Strategy published in 2018, the UAE is keen to increase its domestic production of strategic food items by 15% (year is not defined). It is also committed to increasing the acreage utilised for organic production by 5% annually. To achieve these ambitions, it will be essential for the country to fully understand the available natural assets that support domestic production and the impact of climate change on the production of these strategic items, specifically the state of the UAE's water and soil.

Water scarcity

Water is a key component of the food security landscape. It is critical for crop irrigation and for livestock farming. The UAE is an arid country and natural water resources are scarce, which in turn impacts its domestic food production and food security. A significant amount of the UAE's potable water comes from desalinisation plants. It is estimated that 42% of drinking water comes from 70 major desalinisation plants.[19] The UAE does have other sources of water such as surface water and groundwater but they are insufficient in supporting the water needs of the country. The availability and quality of groundwater has decreased over the years due to rapid population growth leading to increased need for potable water and for use in agriculture and industry (the agricultural sector uses 73% of the UAE's fresh water).[20] Changing land management practices also meant that water and soil were used more extensively causing an increase in salt levels in fertile soils and groundwater.

Climate change could exacerbate water stress due to expected increase in evapotranspiration caused by higher temperatures. Salt water is likely to penetrate groundwaters as the sea level rises making it unsuitable for agriculture and domestic use. There is an urgent need to comprehensively assess the state of the UAE's groundwater system, create maps and put plans in place to monitor and protect existing aquifers and, finally, to improve the condition and extent of natural water resources.

However, the UAE cannot do it alone. The groundwater system, just like many other natural ecosystems, does not respect borders. The UAE shares its aquifer called Umm er Radhuma – Dammam (South) with the Kingdom of Saudi Arabia, Oman and Yemen and it is mostly being used by Oman and the UAE in agriculture and for domestic purposes.[21] These 680,000 km^2 of water resource require regional cooperation between and among these countries to assess, monitor, protect and recharge this aquifer.

In addition to protecting and recharging existing groundwater, more attention should be given to the reuse of treated wastewater. Presently, the UAE's usage of treated sewage effluent accounts for around 11% of its annual water demand.[27] This water is mainly used for landscaping irrigation. This could be further expanded for the irrigation of certain crops (especially fodder), refilling aquifers, filling ornamental lakes and streams, among other examples.

Box 2: Jordan, Tunisia and Israel as regional champions in wastewater reuse

Like the UAE, Jordan suffers from water scarcity and is considered to be the 2nd most water scarce country in the world.[22] This is why the country has made significant investments and efforts into treating and reusing their wastewater. As a result of continuous efforts in this field, Jordan's treated wastewater represents 25% of its total water usage.[23] This has been made possible through early adoption of legislation and policies. In 1998, Jordan published its Wastewater Management Policy detailing the future use and management of wastewater.[24] This has helped them pave the way towards creating a set of standards and policies for wastewater treatment and reuse. They mainly use their treated wastewater in agriculture, to recharge groundwater, streams and wadis, and for landscaping.

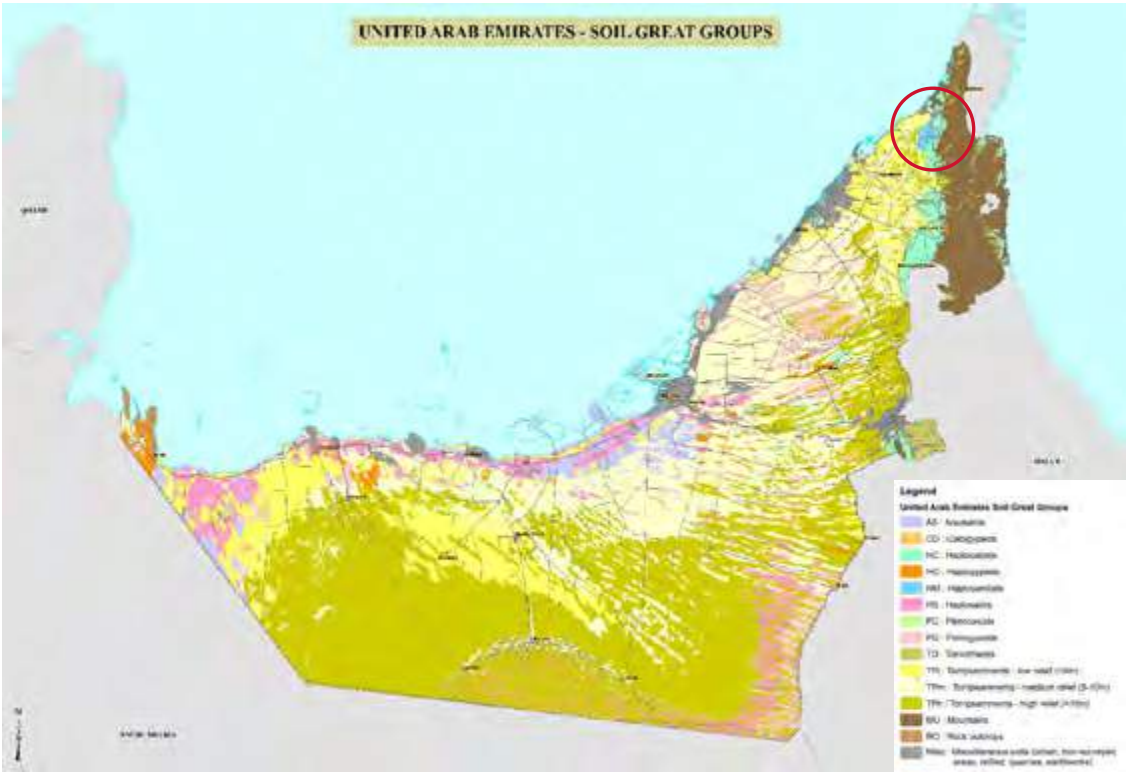
Tunisia is another regional example of a country that has adopted the reuse of treated wastewater. In the 1980s, the country started its nationwide water reuse programme and has since made it its priority. Today, with strong government support and monitoring, farmers use wastewater for irrigation of all crops except vegetables. However, social acceptance in Tunisia still remains a challenge as farmers still prefer to use groundwater for irrigation.[25]

In contrast, Israel's social acceptance of treated wastewater is high which has allowed the country to reuse 90% of its treated wastewater for agricultural irrigation, easing the stress on freshwater resources. Through innovation and knowledge, Israel has developed a sustainable water management system to deal with its water stress, which has significantly improved its water security. Currently, desalinated water and treated wastewater account for half of its water supply.[26]

Soil

Arable soils are already scarce in this region (Figure 2). According to the World Bank, the percentage of the UAE's arable land decreased from 8% in 2002 to 5.5% in 2020[28] mainly due to urban development, grazing practices and changes in land use. Haplocambids type of soil, which is highly suitable for agriculture, only represent 0.2 % of total land cover.[29] The priority should be to protect and maintain the cover of existing haplocambids and to increase arable land by generating more soils and regenerating soils that once were arable and/or have a potential for agriculture.

Figure 2 United Arab Emirates – Soil Great Group. Soil type in red circle represents haplocambid soils which are highly suitable for agriculture. Source: Emirates Soil Museum



Desertification in this region is already a major issue especially for food production and biodiversity loss. The main causes for land degradation, thus causing further desertification, are wind erosion, soil salinisation, loss of fertile soil and organic matter.

A sustainable solution that has been gaining traction in recent years for improving soil, air and water quality and ecosystem biodiversity, while contributing towards GHG emission goals by storing carbon, is regenerative agriculture. This holistic farm system is designed to work in harmony with nature, while also maintaining and improving economic viability.

One example where a local practice fits well with this type of nature friendly solution is sustainable grazing. The UAE has a long tradition with rangeland grazing and, if done correctly, it can provide many benefits to the ecosystem recovery of rangelands.[30] The UAE has started issuing licences to owners and breeders of livestock which allows them to graze in wild open areas if they follow a set of rules that enables recovery of native vegetation. The government should also prioritize putting in place measures which are specifically aimed at protecting the soil.

Agricultural technology and alternative proteins

The UAE is investing in agricultural technology through various initiatives, investments and partnerships (Table 2). These will certainly play an important role in the UAE's future food security resilience. However, these are not without challenges. For example, vertical farming can only produce limited types of produce, mainly leafy greens, herbs and microgreens, tomatoes and cucumbers. They still require a vast amount of energy, especially in the summer, to cool the systems. Intuitively, one of the solutions is to invest in solar energy to power their production.

Table 2 Examples of UAE's Innovation Initiatives Focusing on Agriculture

UAE Agriculture Initiatives	Type	Aim
Aim for Climate	Partnership between the US and the UAE	To address climate change and global hunger by uniting participants to significantly increase investment in, and other support for, climate-smart agriculture and food systems innovation over five years.
The Food Tech Valley	UAE-government-led initiative, an AgTech city	To serve as a testbed for pioneering agricultural innovations such as hydroponic systems (including vertical farming).
Agriculture 4.0	UAE-government-led initiative	To upgrade traditional farms with the new technology.

Research and development in alternative proteins is another field that is gaining attention and attracting more investment around the world.

The global animal industry, including meat, eggs and dairy products counts as one of the major contributors to climate change. It has been widely recognised that people should be consuming less meat to lower GHG emissions. This is particularly the case with cow's meat where, in addition to the release of a methane gas during the production, the environmental degradation, land use changes and water usage are also concerns. These animals need large spaces for grazing and to create such spaces, natural habitats such as rainforests are being cleared, thus removing natural CO_2 storage and sequestration capabilities. In addition to environmental degradation, water consumption is also an issue. This is particularly significant in the Middle East where water is scarce.

Convincing people to switch to plant-based or alternative diets can be challenging due to its taste and texture but with today's fast biotechnological developments, this transition is becoming easier. The UAE has already seen a surge in alternative meats made from various plants which are now widely available in fast foods outlets, shops and restaurants. Impossible™, Beyond Meat, Tindle and home grown food tech startups, Switch and Thryve, are some options that are available in the UAE and such options are growing.

Additionally, a great amount of research and investment is going into cultivated meat and microbial fermentation. The US, UK, South Korea, China,

Israel, Singapore and Europe are some countries investing their capital in R&D of cultivated meat and fermentation.

Box 3: Singapore's investments in food security

Singapore, similar to the UAE, has limited natural resources required to support agriculture. The country imports more that 90% of its food from 183 countries/regions. Singapore has focused on diversifying its imports to create resilience in case of supply disruptions. Singapore is committed to increasing its domestic food production to account for 30% of its food consumed by 2030 and to also growing food overseas.

In addition to these food security policies, to create resilience and meet future demand for protein, the country has been investing in food technology, specifically in alternative proteins. Singapore is considered as one of the world leaders in alternative proteins alongside Israel, the US and the Netherlands. As a result of its investments and policies, Singapore is now considered a hub for startups and companies developing alternative proteins. Singapore was the first country in the world to put in place legislative framework that allows companies to sell cultivated meat on the market.

The next challenge that awaits Singapore is scaling up the production of cultivated meat and products using precision fermentation. Singapore's biggest challenge here could be the land needed to build large manufacturing plants and cost of labour and energy.

In this respect, the UAE has a few advantages over Singapore in that it does not lack space or labour force and it can harness solar power for energy production. It also enjoys favourable geographic placement and good supply chain networks to countries and regions such as Singapore, Europe and Asia.

However, the UAE is yet to embark on a R&D track in biotechnological field and it needs to invest in attracting talent and experts, building facilities and research laboratories to place themselves on par with Singapore.

Cultivated meat and fermentation

The Good Food Institute (GFI), a nonprofit think tank comprised of international organisations aiming to advance alternative proteins, defines cultivated meat as "... meat produced directly from cells. The process of cultivating meat uses the basic elements needed to build muscle and fat and enables the same biological process that happens inside an animal. Cultivated meat is identical to conventional meat at the cellular level." In addition, meat is not the only form of protein being produced this way. Fish, seafood, poultry, dairy products, and eggs are also part of this picture.

Fermentation in the food industry includes:

- Traditional fermentation – for example, yoghurt and cheese
- Biomass fermentation – uses the high-protein content and rapid growth of microorganisms to make large amounts of protein-rich food, like Quorn
- Precision fermentation – uses microorganisms to produce specific functional ingredients, like proteins (such as cheese protein and egg protein), enzymes (pepsin), flavour molecules, vitamins, pigments, and fats

Food or an ingredient made by the fermentation process can be a product itself (like Quorn) or used in conjunction with other cultivated meats or plant-based products to improve the taste, texture or appearance of the product such as cheese.

Cultivated meat and fermented food are significantly more efficient to produce in comparison to traditional products as they do not require land or water resources. It also contributes to lowering GHG emissions and environmental pollution. Recent research concluded that if we can replace 20% of our beef consumption with fermentation derived protein, we can halve annual deforestation and CO_2 emissions by 2050.[31] In addition, there is no concern for animal welfare or need to use antibiotics and antifungal agents. From climate, environmental and animal welfare perspectives, it is a more sustainable way of producing meat and animal products.

Unlike plant-based meats, cultivated meat is not yet widely available due to its relatively recent investment in R&D. The first cultivated meat in burger form was made in 2013 by a Maastricht University team. Eight years later, the first meat in chicken nugget form was produced by a Californian startup and sold to a restaurant in Singapore.

Today, there are over 150 cultivated meat companies around the world hoping to win the race to be the first to scale up production and sell their cultivated meat to the public. In 2022, cultivated meat and seafood companies secured $896 million in funding, mostly through venture capitalists. So far, the only country in the Middle East

actively investing in cultured meat is Israel. The US is still the most active country in this space with 43 companies actively involved with cultured meat.[32]

Regarding investment in fermentation, according to GFI, 136 companies around the world raised $842 million in 2022.[33] The Middle East and Africa saw a 26x increase in funding in 2022. Oman is developing a mycelium fermentation production facility that will use dates as a feedstock for protein-rich biomass fermentation. Israel, the world's leading alternative proteins technology hub, is home to 11 fermentation companies and has recently announced further funding for precision fermentation infrastructure.

The UAE has signed an agreement with the US-based precision fermentation company Change Foods to design and construct a facility in Abu Dhabi to produce casein (a protein used to make cheese). Through Next Generation FDI Initiative the UAE is building a 1.2-million-litre precision fermentation facility expected to be ready by 2025. According to the company, the facility will use one-tenth less water and one-fifth less energy to produce cheese in comparison to traditional way of producing cheese.[34]

Challenges and opportunities

There are a few challenges when dealing with cultivated meat and fermentation. One of them is the cost of scaling up their production. The price to produce cultivated meat to serve one person is around $100. Although this is still too high, there might be an opportunity for them in high-end restaurants until researchers find a way to upscale the production at a lower cost.

Another challenge is the regulatory landscape and labelling of the produce. So far, Singapore is the only country that has approved cultivated meat for sale. The US's food safety regulatory body FDA recently passed cultivated chicken product as part of its pre-market safety review. Especially relevant to this region is a question of whether meat produced in this way can be labelled as 'halal'. Studies have argued that for cultured meat to be halal, the "identifying source cell and culture medium needs to be extracted from a halal slaughtered animal and no blood or serum is used in the process."[35]

However, people's attitudes towards 'lab meat', as well as religious and ethical issues remain a challenge. It is a new concept and might require awareness for people to get comfortable with it.

In conclusion, there are challenges that need to be overcome when it comes to alternative proteins but there is a lot of investment and research channelled into overcoming these barriers. Cultivated meat could particularly be beneficial for the MENA region and the UAE where conditions to farm animals are not favourable due to high temperatures, water and soil scarcity. It could be an option for more diversified food sources contributing to overall food security and resilience, especially with predicted growing protein demands due to population growth. Investing in cultivated meat would also contribute towards GHG emissions, particularly towards methane reductions. It is an opportunity to invest in the growing industry and research and development that might play a significant role in the future world's food security landscape.

Recommendations

A. Food Security Policy

1. Continuous improvement and alignment of the UAE's food security policies

- One way of achieving better alignment between linked strategies such as the Food Security Strategy, the Water Strategy 2036, the Net Zero Strategy, and the UAE Energy Strategy 2050 is continuously assessing them and reporting their progress.
- For maximum efficiency and optimal outcomes future policy developments and interventions need to be underpinned by research and scientific evidence and described by quantifiable targets.
- To improve the GFSI ranking to 10th place by 2031, it would be beneficial to focus on the UAE's least performing dimension – sustainability and adaptation, with emphasis on the following GFSI indicators: environmental – economic accounting implementation; early warning measures/climate smart agriculture; commitment to managing exposures and sustainable agriculture.

B. Natural Assets

2. Protection

The sea, fresh water, biodiversity and soil are critical assets that support domestic production of food. To secure the delivery of food related ecosystem services derived from these assets, it would be valuable for these assets to be assessed, mapped, monitored, protected and improved. This could be done as a national effort, covering all the seven emirates.

3. Regional cooperation as a key to natural asset protection

Natural assets do not recognise borders, and protection and improvement of critical assets should be done as a joint effort between countries sharing an asset. For instance, regional cooperation and partnerships to improve and protect groundwater aquifers, which are currently shared with Saudi Arabia, Yemen and Oman, will be essential for safeguarding it for future generations.

4. Unlocking the potential of wastewater

Given the UAE's water constraints, the government could seek to maximise the safe use of treated wastewater, especially for irrigation and recharging freshwater. It could draw from the regional examples of Jordan, Tunisia and Israel when designing policy and regulation and dealing with public perception of the treated wastewater.

5. Building agricultural sector in partnership with nature

For the UAE to increase its domestic production, it has to improve its soil. This can be done in partnership with nature focusing on organic farming and regenerative agriculture which will help build soil and water reserves and increase biodiversity.

C. Innovation and research & development

6. Investing in alternative proteins

Alternative proteins such as plant-based meat, cultivated meat and fermentation for alternative proteins present an opportunity for food that meets our protein requirements while lowering the GHG emission and the need for water and arable land. It could be beneficial for the UAE to:

- Start investing in alternative proteins startups
- Create public-private partnerships
- Develop domestic research and development in alternative proteins
- Develop manufacturing capabilities in alternative proteins.

These initiatives would help diversify the UAE's food security landscape and place it on the global stage for food innovation, which also have commercial benefits.

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