Food and Agriculture Organization of the United Nations

NFIAP/C1232/5

FAO
Fisheries and
Aquaculture Circular

ISSN 2070-6065

REGIONAL REVIEW ON STATUS AND TRENDS IN AQUACULTURE DEVELOPMENT IN THE NEAR EAST AND NORTH AFRICA – 2020

FAO Fisheries and Aquaculture Circular No. 1232/5 NFIAP/C1232/5 (En)

REGIONAL REVIEW ON STATUS AND TRENDS IN AQUACULTURE DEVELOPMENT IN THE NEAR EAST AND NORTH AFRICA – 2020

by

Malcolm Dickson
FAO Consultant

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2022

Required citation:
Dickson, M. 2022. *Regional review on status and trends in aquaculture development in the Near East and North Africa – 2020.* FAO Fisheries and Aquaculture Circular No. 1232/5. Rome, FAO. https://doi.org/10.4060/cb7818en

ISBN 978-92-5-135381-3

Preparation of this document

The regional review for the Near East and North Africa region was prepared by Malcolm Dickson, FAO Consultant. Alessandro Lovatelli, Aquaculture Officer, FAO Aquaculture Branch, was the lead review coordinator. FAO headquarters colleagues in the Fisheries and Aquaculture Division Junning Cai, Ana Menezes, Melba Reantaso, Xinhua Yuan, John Ryder, Nada Bougouss, Davide Fezzardi, Victoria Chomo, Stefania Vannuccini, Jennifer Gee, Adrienne Egger, Roxane Misk, Xiaowei Zhou, Gabriella Laurenti, Nicola Ferri, Housam Hamza are acknowledged for their valuable inputs and review of the document. FAO regional and sub-regional fisheries officers Lionel Dabbadie (Subregional Office for the GCC States and Yemen), Valerio Crespi (Subregional Office for North Africa), Ahmed Al-Mazroui (Regional Office for the Near East and North Africa) and Haydar Fersoy (Regional Office for Europe and Central Asia) contributed valuable information along with reviewing the document. FAO country offices in the NENA region are all acknowledged for facilitating the preparation of the review and for their valuable inputs and comments particularly Abdulsalam AlKawri (FAO, Yemen), Saeed Shami (FAO, Saudi Arabia), Nora OurabahHaddad, Hasna Alharthy and Ziyin Zhang (FAO, Oman). Also gratefully acknowledged are the following experts that kindly shared their knowledge of the region: Samir Majdalani (Retired, former Head of Department of Fisheries & Wildlife, Ministry of Agriculture, Lebanon), Sherif Sadek (President, African Chapter, World Aquaculture Society, Egypt), Issam Krouma (Retired former Director, Fisheries Department, the Syrian Arab Republic), Izzat Feidi (Aquaculture Consultant and retired FAO Fisheries Officer, Egypt), Victoria Alday Sanz (Director of Biosecurity and Breeding Programs, National Aquaculture Group, Saudi Arabia), Patrick White (FAO Consultant), Abdul Redha Jassim Shams (Aquaculture Consultant, Bahrain), Dawood Al-Yahyai (Assistant Director General for Fisheries Resources Development, Ministry of Agriculture and Fisheries, Oman), Hisham M. Ghmati (General Director, Marine Biology Research Center, Libya) and Imad Saoud (American University of Beirut, Lebanon). Inputs to this review have also been received with appreciation from the sector authorities of the FAO Members countries in the region. Brian Harvey and Devin Bartley (World Fisheries Trust) contributed with editing of the document while final editing and layout was carried out by Alessandro Lovatelli and Chorouk Benkabbour, respectively.

Data used in this regional aquaculture review derives mainly from the FAO fisheries and aquaculture statistics (FishStat), including the FAO Yearbook Fishery and Aquaculture Statistics, accessible through online query panels and FishStatJ. A brief description on the collection and consultation of FAO statistical is provided in Annex 1.

In continuing the global efforts to achieve aquaculture sustainability through dissemination of up-to-date information on the status and trends of the sector, FAO publishes Aquaculture Regional Reviews and a Global Synthesis about every 5 years. This process started in 1995. Previous reviews, along with recordings of the aquaculture review webinars held 26–29 October 2020, can be found here: www.fao.org/fishery/regional-aquaculture-reviews/aquaculture-reviews-home/en/

Abstract

The Near East and North Africa (NENA) region covers 18 countries and territories: Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates, Western Sahara and Yemen with a total land area of 9.8 million km^2. The region is mostly arid or semi-arid but has extensive coastlines and includes a wide range of different economies from high income, hydrocarbon-rich countries to low-income states, some of which have been severely impacted by conflict in recent years.

NENA aquaculture production was worth USD 2.3 billion in 2018, two-thirds of which came from Egypt and around one-quarter from Saudi Arabia. Production has grown rapidly since the 1980s, more than doubling over ten years and increasing by 50 percent over the five years preceding 2018 to reach 1.7 million tonnes. Egyptian fish farms accounted for 92 percent of production and Saudi Arabia for 4.2 percent while other significant producers included Iraq (25 737 tonnes), Tunisia (21 826 tonnes), Algeria (5 100 tonnes), the United Arab Emirates (3 350 tonnes) and the Syrian Arab Republic (2 350 tonnes). Although current aquaculture production levels are low, all these countries have high ambitions with further developing the sector, often for improved food self-sufficiency.

A total of 43 species of finfish, shellfish and aquatic plants were farmed in the region. Tilapia (mainly *Oreochromis niloticus*) was produced in 14 of the 17 countries in NENA and represented 63 percent of total 2018 production, followed by mullets (14 percent) and carps (12 percent).

Marine finfish (gilthead seabream, European seabass and meagre) represented around six percent of total production and shrimp (mainly whiteleg shrimp produced by Saudi Arabia) accounted for around three percent. The capacity to grow tropical marine finfish such as grouper, amberjack and yellowtail is increasing in all the Gulf States but the quantities remain limited, while Asian seabass was mainly produced in Saudi Arabia and the United Arab Emirates. Small amounts of bivalve shellfish are grown in Algeria, Morocco, and Tunisia and more recently in the United Arab Emirates while even smaller quantities of aquatic plants are grown in Morocco and Tunisia. There is good potential for further growth of aquaculture production in the region through sustainable intensification of inland, freshwater and brackishwater aquaculture as well as expansion of marine aquaculture systems backed by strong policy and financial support.

Egyptian aquaculture production was built on commitments by the government to allocate space and resources for development of the sector in the 1980s. Similar commitments have been made recently in other NENA countries including Bahrain, Morocco, Oman, Saudi Arabia and the United Arab Emirates including establishing dedicated aquaculture development zones and carrying out consultation processes with other resource users as recommended in the FAO Ecosystem Approach to Aquaculture (EAA). Fish farmers need to improve the efficiency of feed and water use while fish health can be improved by implementing the FAO Progressive Management Pathway approach. Environmental legislation has been enacted by most countries, although management systems need to be strengthened.

Until now, most aquaculture production in NENA region has been for domestic markets, often with little attention paid to maintaining effective cold chains in post-harvest handling and market systems. Several countries lack the capacity to participate effectively in global

aquaculture trade as they have not implemented essential testing frameworks or lack effective marketing approach and organizations. There is very little processing or packaging, and the COVID-19 pandemic has demonstrated the importance of local and flexible marketing systems, including on-line retailing. However, Saudi Arabia exports high quality shrimp to global markets and several other countries are also investing in the infrastructure and processes for exports. Egyptian aquaculture demonstrates that the sector can improve food self-sufficiency and food security as well as providing employment and incomes in rural areas where there are few alternatives.

Aquaculture in the region has been impacted by climate change, conflict and the COVID-19 pandemic suggesting that effective resilience planning is needed. Management of the sector varies across the region and needs to be reviewed to ensure that regulatory frameworks provide appropriate levels of support. Representative organisations need to be strengthened to play a greater role in co-management of the sector. FAO has helped to build management capacity in several countries in line with the FAO Strategic Objectives, the SDGs and the FAO Blue Growth Initiative. It will be important for aquaculture sectors to actively engage with high-level bodies and ministries managing SDG processes to ensure that aquaculture contributions to SDGs are taken into account. FAO can continue to play an important role in continued success of the sector through its unique position as a trusted partner for governments, NGOs and the private sector in NENA region.

Contents

Tables

Figures

Abbreviations and acronyms

AAAID	Arab Authority for Agricultural Investment and Development
AARTC	Africa Aquaculture Research and Training Center (Egypt)
ADAFSA	Abu Dhabi Agriculture and Food Safety Authority
ADC	Aquaculture Demonstration Centre
ADF	Agricultural Development Fund (Saudi Arabia)
ADIA	Abu Dhabi Investment Authority
ADP	Aquaculture Development Programme (Saudi Arabia)
AMSC	Aquaculture and Marine Studies Centre (United Arab Emirates)
AMShP	aquaculture multi-stakeholder platform (GFCM)
ANDA	Agence Nationale pour le Développement de l'Aquaculture (Morocco)
ANDI	National Agency of Investment Development (Algeria)
AOAD	Arab Organization for Agricultural Development
APIA	Agence de Promotion des Investissements Agricoles
AQUAMED	The Future of Research on Aquaculture in the Mediterranean Region
ARASCO	Arabian Agricultural Services Company
ASC	Aquaculture Stewardship Council
AZA	allocated zones for aquaculture
B2B	business to business
B2C	business to consumer
BAP	best aquaculture practices
BDB	Bahrain Development Bank
BGI	Blue Growth Initiative
CBA	capture-based aquaculture
CCRF	Code of Conduct for Responsible Fisheries
CFS	Committee on World Food Security (UN)
CGIAR	Consortium of International Agricultural Research Centers
CLAR	Central Laboratory for Aquaculture Research (Egypt)
COMESA	Common Market for Eastern and Southern Africa
COP	Conference of Parties
CORDIS	Community Research and Development Information Service (European Commission)
COVID-19	coronavirus disease 2019
CWP	FAO Coordinating Working Party on Fishery Statistics
DED	Department of Economic Development (Abu Dhabi, United Arab Emirates)

DGPAq	Direction générale de la pêche et de l'aquaculture (Tunisia)
DoF	Directorate of Fisheries (Bahrain)
DoFR	Department of Fisheries Resources (Syrian Arab Republic)
DRR	disaster risk reduction
EAA	ecosystem approach to aquaculture
EAD	Environmental Agency – Abu Dhabi (United Arab Emirates)
EAF	ecosystem approach to fisheries
EBRD	European Bank for Reconstruction and Development
EFC	Egyptian Fish Council
EIA	environmental impact assessment
EICA	Egyptian International Centre for Agriculture
EMP	environmental monitoring programme
EUMOFA	European Market Observatory for Fishery and Aquaculture Products
FAO	Food and Agriculture Organization of the United Nations
FAO RNE	FAO Regional Office for Near East and North Africa
FDI	foreign direct investment
FTE	full-time equivalent
GAA	Global Aquaculture Alliance
GAFI	General Authority for Investment (Egypt)
GAFRAL	General Authority for Fisheries Resources and Aquatic Life (Syrian Arab Republic)
GAFRD	General Authority for Fisheries Resources Development (Egypt)
GBFRD	General Board of Fish Research and Development (Iraq)
GCC	Gulf Cooperation Council
GDP	gross domestic product
GFCM	General Fisheries Commission for the Mediterranean
GHG	greenhouse gas
GNI	gross national income
GOVS	General Organization for Veterinary Services (Egypt)
GTZ	German Agency for Technical Cooperation
HAB	Harmful Algal Bloom
HDPE	high density polyethylene
HORECA	hôtellerie-restaurant-café
IAA	integrated agriculture-aquaculture
ICZM	integrated coastal zone management
IDAL	Investment Development Authority of Lebanon
IDH	Sustainable Trade Initiative

IFAD	International Fund for Agricultural Development
ILO	International Labour Organization of the United Nations
IMF	International Monetary Fund
IMTA	integrated multi-trophic aquaculture
INDC	intended nationally determined contribution
IPAQ	Investment Promotion Agency of Qatar
IPRS	in-pond raceway systems
ITPS	International Technical Panel on Soils
IUCN	International Union for Conservation of Nature
IUU	illegal, unreported and unregulated (fishing)
JFRC	Jeddah Fisheries Research Centre (Saudi Arabia)
JIC	Jordan Investment Commission
JICA	Japan International Cooperation Agency
KAUST	King Abdullah University of Science and Technology (Saudi Arabia)
KDIPA	Kuwait Direct Investment Promotion Authority
MAAR	Ministry of Agriculture and Agrarian Reform (Syrian Arab Republic)
MDGs	Millennium Development Goal
MEWA	Ministry of Environment, Water and Agriculture (Saudi Arabia)
MoALR	Ministry of Agriculture and Land Reclamation (Egypt)
MOCCAE	Ministry of Climate Change and Environment (Abu Dhabi, United Arab Emirates)
MOCI	Ministry of Trade and Commerce and Investment Promotion (Oman)
MODON	Saudi Authority for Industrial Cities and Technology Zones
MoU	memorandum of understanding
MoWRI	Ministry of Water Resources and Irrigation (Egypt)
MPRH	Ministere de la Pêche et des Resources Halieutiques (Algeria)
NAQUA	National Aquaculture Group (Saudi Arabia)
NDCs	nationally determined contributions
NENA	Near East and North Africa
NFDP	National Fisheries Development Programme (Saudi Arabia)
NGOs	non-governmental organizations
NMC	National Mariculture Centre (Bahrain)
NSAAH	National Strategy on Aquatic Animal Health
NWRC	National Water Research Center (Egypt)
OECD	Organisation for Economic Co-operation and Development
OIA	Oman Investment Authority
ONSSA	Office National de Sécurité Sanitaire des produits Alimentaires (Morocco)

PAAFR	Public Authority for Agriculture Affairs and Fish Resources (Kuwait)
PCB	polychlorinated biphenyl
PIPA	Palestinian Investment Promotion Agency
PMP	Progressive Management Pathway
PPT	parts per thousand
RAMSAR	Convention on Wetlands of International Importance especially as Waterfowl Habitat
RAIS	Regional Aquaculture Information System
RAS	recirculating aquaculture system
RECOFI	Regional Commission of Fisheries
ROPME	Regional Organization for the Protection of the Marine Environment
RTD	Research and technology development
RWR	renewable water resources
SAGIA	Saudi Arabian General Investment Authority
SAMAQ	Saudi Arabia Mark of Aquaculture Quality
SAS	Saudi Aquaculture Society
SDG	Sustainable Development Goals
SIA	Syrian Investment Agency
SIPAM	Information System for the Promotion of Aquaculture in the Mediterranean
SMEs	small and medium-sized enterprises
SOs	Strategic Objectives (FAO)
SOTUPAP	Société Tunisienne de production d'aliment de poissons d'élevage
SPF	specific pathogen free
SPT	specific pathogen tolerant
TIA	Tunisia Investment Authority
TiLV	Tilapia lake virus
UAC	Union of Aquatic Cooperatives (Egypt)
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USSEC	United States Soybean Export Council
WAIPA	World Association of Investment Promotion Agencies
WB	World Bank
WFP	United Nations World Food Programme
WHO	World Health Organization
WSSV	white spot syndrome virus

1. Social and economic background of the region

1.1 STATUS AND TRENDS

1.1.1 Overview

The Near East and North Africa (NENA)[1] region extends from the Atlantic Ocean in the west to the Gulf and Gulf of Oman in the east and includes States along the southern shore of the Mediterranean, both shores of the Red Sea, the western shores of the Arabian Sea, and the Gulfs of Suez, Aqaba, Aden and Oman.

The names of the 18 countries and territories covered in this review are Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, the Syrian Arab Republic, Tunisia, United Arab Emirates, Western Sahara and Yemen.[2]

The region covers a total area of 9 860 810 km^2 and is predominantly arid or semi-arid, crossed by only a few large river systems, including the Nile, Tigris and Euphrates. While agriculture is an important source of income for the region, arable land is limited and varies in quantity and quality from country to country. Around 30 percent of land in Lebanon and the Syrian Arab Republic, 3 percent in Algeria and Egypt, and only 0.5 percent in Oman and Saudi Arabia, are classified as productive (FAO and ITPS, 2015). Natural resource degradation is a threat in all countries of the region and remains a major limitation to the reliable supply of food. In most countries, salinization, water and wind erosion, loss of vegetation cover and soil physical degradation (including compaction and surface crusting) are the main threats to the soil's capacity to provide ecosystem services. The expansion of agriculture into marginal lands has greatly aggravated water erosion and consequently soil degradation. In almost all countries in the region, extreme climatic conditions, overgrazing, unsuitable cropping patterns and accumulation of salts have rendered large areas of land unproductive (FAO and ITPS, 2015) while recent floods have also been challenging. Aquatic resources also face multiple threats.

Countries in the region face many common socio-environmental challenges as a result of persistently high rates of population growth, increasing urbanisation, high levels of youth and female unemployment, low growth of food production and an overall decline in land productivity. The Food and Agriculture Organization of the United Nations (FAO) Regional Office for Near East and North Africa (FAO RNE) highlights a number of key issues as priorities for the region. These include: water scarcity, small-scale agriculture, livestock and food security, nutrition, food loss and waste, building resilience (for food security and nutrition), and fisheries and aquaculture (FAO, 2020a).

1.1.2 Demography

The population of the region was 357.7 million in 2018 and is projected to reach 435 million in 2030 (FAO, 2020b) (Table 1). The demographic data shows significant variation between countries ranging from sparsely populated countries such as Libya to highly urbanised small states like Bahrain, Qatar and the United Arab Emirates. The country with the largest

[1] The NENA region is also indicated as the Middle East and North Africa Region and abbreviated to MENA Region by the UN Secretariat and World Bank.

[2] The list of countries in the region differs from the list in the 2015 NENA aquaculture review (FAO, 2017a) as it excludes Iran (Islamic Republic of), Mauritania, South Sudan and Sudan.

population is Egypt, representing around one third of the NENA total. Between 2018 and 2030, populations are projected to increase by an average of 22 percent, ranging from a drop of ten percent in Lebanon due to migration and repatriation of refugees to a growth of 57 percent in the Syrian Arab Republic, again due to movement of refugees.

TABLE 1. Demographic data for the Near East and North Africa region

Country/territory	Country/ territory area (km^2)	Population (2018)	Population density (people/km^2)	Urban population (%)	Projected population growth 2018–2030 (%)
Algeria	2 381 741	42 228 408	17.7	72.2	19.3
Bahrain	779	1 569 446	2 017.3	89.1	28.3
Egypt	1 001 450	98 423 598	98.9	43.1	22.8
Iraq	435 052	38 433 600	88.5	72.1	30.6
Jordan	89 320	9 965 318	112.2	90.4	6.9
Kuwait	17 820	4 137 312	232.2	100.0	14.7
Lebanon	10 450	6 859 408	670.5	78.7	-9.7
Libya	1 759 540	6 678 559	3.8	77.6	13.9
Morocco	446 550	36 029 093	80.7	62.7	13.5
Oman	309 500	4 829 473	15.6	84.5	22.9
Palestine	6 220	4 862 979	781.8	79.1	30.4
Qatar	11 490	2 781 682	239.6	96.0	19.6
Saudi Arabia	2 149 690	33 702 756	15.7	83.5	16.7
Syrian Arab Republic	185 180	16 945 057	92.3	58.4	57.4
Tunisia	163 610	11 565 201	74.4	69.5	10.3
United Arab Emirates	98 648	9 630 959	135.6	85.7	10.7
Western Sahara	266 000	567 402	2.1	86.7	30.0
Yemen	527 970	28 498 683	54.0	37.2	27.7
Total NENA	9 860 810	357 708 934	36.4	60.4	21.8

Source: FAO, 2020b.

1.1.3 Macro-economics

The NENA region has a wide range of economies from conflict-affected and fragile states such as Libya, Syrian Arab Republic and Yemen to countries that depend on their natural resources such as Algeria, Egypt, Morocco and Tunisia, and hydrocarbon-rich countries which includes Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. The total Gross Domestic Product (GDP) of the NENA region (excluding Syrian Arab Republic) was USD 2 645 billion in 2018 (World Bank, 2020a). Saudi Arabia was the largest economy with a GDP of USD 787 billion, followed by the United Arab Emirates (USD 414 billion) and Egypt (USD 250 billion). Information on GDP distribution throughout the NENA region is shown in Table 2.

Annual GDP growth in 2018 was negative in Iraq and Yemen but strongly positive in Egypt and Libya while inflation was highest in Yemen (47 percent) and Egypt (21 percent). The percentage of GDP derived from agriculture, forestry and fishing indicates the degree of dependence on natural resources. This was highest in Algeria, Egypt, Morocco and Tunisia and lowest in small, hydrocarbon-rich states. All the North African states apart from Libya imported more than they exported, whereas the Arabian Gulf countries were all net exporters (Table 2).

TABLE 2. Macro-economic data for the Near East and North Africa region in 2018

Country/territory	GDP (USD billion)	GDP growth (%)	Inflation (%)	Agriculture, Forestry and Fishing value added (% of GDP)	Imports of goods and services (% of GDP)	Exports of goods and services (% of GDP)	Net official development assistance (USD million)
Algeria	173.8	1.4	7.6	12	32.3	25.6	144
Bahrain	37.7	1.8	4.7	0.3	71.7	79.9	0
Egypt	250.9	5.3	21.4	11.2	29.4	18.9	2 064
Iraq	224.2	-0.6	15.4	2	35.9	44	2 299
Jordan	42.2	1.9	1.8	5.6	54.6	35.6	2 523
Kuwait	140.6	1.2	14.6	0.4	43.8	56.7	0
Lebanon	56.6	0.2	5.9	2.9	39.6	23.3	1 419
Libya	48.3	7.9	15.8	n/a	40.1	62.2	303
Morocco	117.9	3	1.1	12.3	49.3	38.7	811
Oman	79.3	1.8	10.3	2.2	44.5	58.3	0
Palestine*	14.6	0.9	-0.1	n/a	59.7	19.9	2 240
Qatar	191.3	1.5	13	0.2	34.4	53.6	0
Saudi Arabia	786.5	2.4	11.5	2.2	26.7	39.9	0
Syrian Arab Republic	n/a	n/a	n/a	n/a	n/a	n/a	9 991
Tunisia	39.9	2.5	6.9	10.4	62	48.9	805
United Arab Emirates	414.2	1.7	7.8	0.7	68	93.9	0
Western Sahara	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Yemen	26.9	-2.7	47.2	4	n/a	n/a	7 985
Total NENA	2 644.9	--	--	--	--	--	30 584

Source: World Bank. 2020a.
* West Bank and Gaza in World Bank database.
n/a: Data not available.

Several countries in the region benefit from significant levels of development assistance from donor organizations including Egypt, Iraq, Jordan, Lebanon, Palestine, the Syrian Arab Republic (almost USD 10 billion in 2018) and Yemen (USD 7.9 billion in 2018) (Table 2). In most cases this reflects the impacts of regional conflicts.

1.1.4 Socio-economic status

The socio-economic status of countries in the region varies widely (Table 3). The World Bank classifies countries according to per capita gross national income (GNI) ranging from low income (USD 1 025 or less) to lower-middle income (USD 1 026 to USD 3 995), upper-middle income (USD 3 996 to USD 12 375) and high-income (USD 12 376 or more). There was a significant gap between high income and middle income countries as GNI in high income countries ranged from USD 63 410 in Qatar to USD 15 330 in Oman, while the highest GNI in middle income countries were in Libya (USD 7 640) and Lebanon (USD 7 600). The region includes two low-income countries, the Syrian Arab Republic and Yemen.

Life expectancy in the region in 2018 ranged between 66 years for Yemen and 80 years for Qatar with a trend towards higher life expectancy in high income countries, but no clear division between income levels (Table 3). Fertility rates tended to be higher in countries with lower average incomes with three births and above per woman in Algeria, Egypt, Palestine and Yemen while the birth rate was two or below in Bahrain, Qatar and the United Arab Emirates. Unemployment ranged between 25.7 percent in Palestine to 0.1 percent in Qatar,

although many countries did not have up-to-date figures (Table 3). Other countries with low levels of unemployment included Bahrain, Kuwait, Oman and the United Arab Emirates. High employment levels in the high-income countries of the region, makes them attractive to migrant workers while many middle-income countries in the region have large informal economies which makes it difficult to compile accurate employment statistics.

Net migration figures illustrate the significant movements of people that occurred in 2017. All the high-income states had net migration of people into their country. There was also migration into Iraq, Jordan and Yemen and very large migration (over 2 million people) out of Syrian Arab Republic was associated with conflict in the region. These mass movements indicate the importance of migrant labour forces in high income states that come partly from other countries in NENA region while conflict and economic pressures continue to cause movement of people out of the region to other regions of the world. While fishing boats have been involved in assisting mass migration from the North African coast to Europe, there is evidence that expansion of aquaculture could have a role to play in reducing migration by offering stable jobs in coastal areas (Emam, 2018).

TABLE 3. Socio-economic data for the Near East and North Africa countries and territories

Country/ territory	World Bank classification (income level)	GNI per capita in 2019 (current USD)	Life expectancy at birth in 2018 (years)	Fertility rate in 2018 (births per woman)	Unemployment most recent value (% of total workforce)	Net migration in 2017
Algeria	Lower-middle	3 970	77	3	13.6	-50 002
Bahrain	High	22 110	77	2	1.2	239 000
Egypt	Lower-middle	2 690	72	3.3	9.8	-190 164
Iraq	Upper-middle	5 740	70	3.7	13.0	39 171
Jordan	Upper-middle	4 300	74	2.8	16.9	51 099
Kuwait	High	34 290	75	2.1	2.2	197 600
Lebanon	Upper-middle	7 600	79	2.1	6.4	-150 060
Libya	Upper-middle	7 640	73	2.2	19.0	-9 997
Morocco	Lower-middle	3 190	76	2.4	9.3	-257 096
Oman	High	15 330	78	2.9	1.8	437 000
Palestine (West Bank and Gaza)	Lower-middle	3 710*	74	3.6	25.3	-52 816
Qatar	High	63 410	80	1.9	0.1	200 000
Saudi Arabia	High	22 850	75	2.3	6.0	674 895
Syrian Arab Republic	Low	n/a	72	2.8	8.6	-2 136 954
Tunisia	Lower-middle	3 360	77	2.2	15.1	-20 000
United Arab Emirates	High	43 470	78	1.4	2.2	200 000
Western Sahara	n/a	n/a	n/a	n/a	n/a	n/a
Yemen	Low	940*	66	3.8	13.5	150 000

Source: World Bank. 2020a.
n/a: Data not available.
* 2018 data.

1.1.5 Status of aquaculture in national economies

The overall value of aquaculture production from NENA region was estimated at USD 2.3 billion in 2018, including USD 1.5 billion from Egypt, USD 0.6 billion from Saudi Arabia, USD 136 million from Iraq, USD 92 million from Tunisia, USD 27 million from the United Arab Emirates and USD 16 million from Algeria, while the value for each of the other

NENA countries was less than USD 10 million (FAO, 2020c). Aquaculture production trends and the role aquaculture plays in the region and each country are discussed in more detail in subsequent chapters of this review. Trends in the value of aquaculture production are presented in section 2.1.5.

In 2018, aquaculture production contributed 0.59 percent of total GDP in Egypt, 0.23 percent of GDP in Tunisia, 0.07 percent in Saudi Arabia, 0.06 percent in Iraq, 0.05 percent in the Syrian Arab Republic, 0.04 percent in Palestine and 0.02 percent in Jordan, while in other countries the contribution of aquaculture towards total GDP was less than 0.01 percent.

Although the current economic contribution of aquaculture is modest, the potential for its development is significant, and the sector is receiving strong support in several countries of the region as they strive to diversify their economies and move towards food self-sufficiency. Aquaculture is often seen as an important sector for the revitalization of rural and coastal areas while supporting complementary businesses related to input supply, processing, transport, marketing and trade of farmed products, as well as catering, research, technological development and innovation, education and training (FOESA, 2011; FAO, 2017a; FAO, 2019a).

1.2 SALIENT ISSUES AND SUCCESS STORIES

1.2.1 Economies

The World Bank (2020b) states that the Coronavirus disease (COVID-19) pandemic compounded by a simultaneous oil price shock is having a devastating impact on already vulnerable economies across the region. Growing public health challenges and effects on economic activity are both exacerbating and being amplified by longstanding structural challenges in NENA economies, including large and inefficient public sectors, uncompetitive business environments, high youth and female unemployment and poor governance. The result is an increase in the already high rate of unemployment, especially for youth and females, and widespread economic insecurity in a region where two-thirds of the population is under 35 years old. However, the departure of many foreign workers from the Gulf region may actually increase opportunities for local employment. It is difficult to predict how economies will react as the COVID-19 pandemic develops. The impact of COVID-19 on aquaculture is discussed more fully in Section 7.1.3 of this review but it appears that initial impacts have been limited and that domestic demand has remained strong despite lock-downs and movement restrictions. However, supply chain disruption is inevitable and may cause problems with imported raw materials and exports of seafood products (Dabbadie, 2020).

In April 2020, the World Bank forecast that GDP in the Middle East and North Africa would contract by 1.1 percent in 2020 due to the spread of the coronavirus and associated collapse in global oil prices following low growth in 2019. Low demand for goods and services from the region, notably oil and tourism, and social distancing measures in the region also triggered domestic supply and demand shocks (Arezki *et al.*, 2020).

The Egyptian economy is expected to have grown by 5.5 percent in 2019 as the country embarked on a series of mega-projects over the last five years with the aim of creating employment and attracting investment. These included the New Suez Canal and economic zone in 2015, new cities, including the New Administrative Capital, New Ismailia, and New Alamein, and energy infrastructure, including the world's largest solar array near Aswan, new roads, expansion of irrigated agriculture and large state-owned aquaculture projects (for example the Ghalioun Project and Aquaculture Suez Canal Company).

Iraq's recovery and reconstruction efforts are moving forward while Jordan and Lebanon are still bearing the costs of millions of Syrian Arab Republic refugees while preparing to embark on domestic economic reforms. Tunisia launched economic reforms in 2018. Morocco has implemented a series of long-term plans to diversify its economy and remains stable though with slow growth. The Algerian economy has shown growth in recent years driven by expansion of agriculture, and growth in the construction and service sectors. Libya returned to a state of civil war in April 2019.

In the Gulf Cooperation Council (GCC) countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates) economic growth is around two percent with reforms in many countries, most notably in Saudi Arabia which in 2018 launched the Saudi Vision 2030. This is a strategic framework designed to diversify the economy and develop public sector services. Bahrain, Saudi Arabia and the United Arab Emirates implemented a five percent rate of value-added tax as part of a 2016 regional agreement to reform government finances. In July 2020, Saudi Arabia increased sales tax from 5 percent to 15 percent. Oman has launched the Oman Vision 2040 with the aim of building a competitive, productive and diverse economy (Diwakar, 2020) while also reducing government spending in the 2020 budget.

1.2.2 Food policies

The FAO RNE considers that countries in the NENA region face numerous challenges in achieving improved food security, nutrition and inclusive agricultural development. This is due to persistently high rates of population growth, averaging over 2.2 percent for the whole region, increasing urbanization, low growth in food production and declining productivity. Increasingly scarcity and fragility of natural resources are affecting food production, which is already quite low, while water scarcity and large areas of arid land make the region's agricultural production susceptible to the negative impacts of climate change. Limitations in the supply of food increasingly make the region a large and growing importer of basic foodstuffs, which heightens its vulnerability to volatility in international food prices. For example, the United Arab Emirates imports up to 90 percent of its domestic food consumption and the gap between domestic fish supply and demand is expanding. Statistics show that the United Arab Emirates consumes 220 000 tonnes of fish per year, over 75 percent of this is imported, while aquaculture provides only two percent of the fish consumed locally (Food Security, 2020). In addition to the long-standing structural challenges, several countries in the region remain under civil insecurity and many others are facing protracted crises. In those countries, chronic undernourishment is significantly increasing, greatly affecting capacities of FAO Member states to eradicate food insecurity and malnutrition (FAO, 2020a).

A recent overview of food security and nutrition in the NENA region noted that hunger is worsening in the region because of the situation in conflict-affected countries (Iraq, Libya, Syrian Arab Republic and Yemen). Undernourishment rose from 23 percent in 2011–2013 to 26 percent in 2015–2017 in those countries whereas it remained stable at around five percent in non-conflict countries (FAO, 2019b). The report stressed the importance of rural transformation promoting sustainable agricultural production, improvement of rural infrastructure and services and the reduction of food insecurity and rural poverty as accelerators for achievement of Sustainable Development Goals (SDG) targets. However, many governments have focused more on food security through support for cereal production and staple food subsidies that keep undernourishment low but do not improve the nutritional status of populations. The report also notes that unemployment, particularly for young people and women across all age groups is a significant challenge in the NENA region and is often higher than in other regions of the world. This is aggravated by

significant disparities in living standards and poverty rates between rural and urban areas and differences in labour productivity between traditional agriculture, industry and services. This gap is widened by differences in access to education, health as well as other public services and housing.

On average, prevalence of rural poverty is about twice that in urban areas. Although the NENA region has fallen short of halving hunger by 2015, 15 of 17 countries achieved Millennium Development Goal (MDG) hunger targets, a significant success story even though protracted crises in some places pushed malnutrition rates up. The successful countries include: Algeria, Bahrain, Egypt, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi Arabia and the United Arab Emirates (FAO, 2019b).

1.3 THE WAY FORWARD

Key message: ***Local food production, including aquaculture, must be prioritised to build diverse, resilient NENA economies, reduce dependence on imports, create employment and support food security and nutrition while enabling recovery from the COVID-19 pandemic.***

The spread of the COVID-19 virus and the actions taken by individual governments to control it are likely to have far-reaching impacts on economic prospects in the NENA region. While most governments reacted rapidly and contagion has been limited, so far there have already been dramatic economic and social consequences, particularly for the most vulnerable (OECD, 2020a; OECD, 2020b). The impact of COVID-19 combined with the rapid fall in crude oil prices could exacerbate regional differences and structural imbalances. The Organisation for Economic Co-operation and Development (OECD) calls for a comprehensive reform agenda to address some of the region's underlying structural issues (decentralisation, private sector development, social protection) to design a new growth model based on economic diversification, health and education spending, industrial innovation and participation in regional value chains.

A forthcoming report from the World Bank will argue that changing the economic outlook for the region requires reforms around three main goals: job creation, modernization and wide social inclusion. Countries need to reduce employment barriers and allow more workers, including women, to join the workforce while embracing technologies such as digital platforms that can lower transaction costs for businesses (Saliola, 2019).

The FAO (2019b) envisages that, at the NENA regional level, there are significant opportunities for transforming agriculture in a sustainable way, starting with the provision of improved access to markets for farmers, promoting investments in agriculture (including aquaculture), transfer of technology and other innovations, more efficient and effective management of water resources, as well as key policy changes that support the shift from subsistence farming to commercial, diversified and sustainable production systems.

In addition, FAO RNE sets the fisheries and aquaculture sector as one of its priorities in the region. The sustainability of both capture fisheries and the aquaculture sectors must become a top priority throughout the region, which remains plagued by challenges including illegal, unreported and unregulated fishing (IUU), scarce water resources, as well as vulnerability to climate change (FAO, 2020a). FAO RNE adds that the agreed priorities for fisheries and aquaculture in the region and sub-regions of NENA include an increase of fisheries and aquaculture production in a sustainable manner, implementation of policies for effective and sustainable management, promotion of stakeholder participation in planning and managing fishery resources, optimization and rationalization of the exploitation of fisheries and natural resources for aquaculture and the implementation of product valorisation throughout the

fish value chain. Moreover, FAO has been working on a number of programmes on regional cooperation and management, supporting the development of freshwater aquaculture technology as well as integrated agriculture-aquaculture (IAA) systems, and promoting the importance of reducing food losses and waste in the fisheries sector (Corner, Fersoy and Crespi, 2020). In the GCC countries, FAO is currently implementing two projects, one in Bahrain on upgrading of the National Mariculture Centre (NMC) marine fish hatchery, and a second one in the United Arab Emirates on biosecurity, monitoring of seafood consumption, assessment of markets and consumers' expectation, recirculated aquaculture systems and the potential of offshore aquaculture.

2. General characteristics of the aquaculture sector

2.1 STATUS AND TRENDS

2.1.1 Overview

Total aquaculture production in the NENA region has grown rapidly since the 1980s, more than doubling in the ten-year period 2009–2018 and increasing by almost 50 percent over the five years from 2013 to 2018. However, growth rates varied widely from country to country. Egyptian aquaculture dominates production statistics as it has become a 'top ten' global aquaculture producer, responsible for more finfish aquaculture production than any other non-Asian country (FAO, 2020c). Several NENA countries, notably Algeria, Bahrain, Morocco, Oman, Saudi Arabia, Tunisia, and the United Arab Emirates are attempting to expand production while aquaculture remains a limited activity in others.

The main driver for growth of NENA aquaculture has been supply for the domestic market while providing employment and income, particularly in rural communities with few alternative jobs. Food self-sufficiency and reduction of food imports has recently become an important focus for many countries in the region particularly in the Arabian Peninsula. Aquaculture is often viewed as an alternative production system to agriculture, which is constrained in many NENA countries by shortages of freshwater, harsh weather and unsuitable soils. It also offers an opportunity to complement yields from capture fisheries.

2.1.2 Aquaculture production

Total 2018 aquaculture production in NENA region was 1.70 million tonnes (Table 4). This compares to 2013 production (five years earlier) of 1.14 million tonnes and 2009 production (ten years earlier) of only 0.77 million tonnes, equivalent to increases of 48.3 percent and 120.4 percent, respectively (FAO, 2020c). This is faster growth than seen in global aquaculture and global capture fisheries. Despite this strong growth, the NENA contribution still only represents 1.5 percent of global aquaculture production, which was 114 million tonnes in 2018.

Egyptian fish farms were responsible for 92 percent of 2018 aquaculture production in the NENA region (FAO, 2020c). This means that the regional statistics are heavily influenced by what happens in Egypt, where pond-based aquaculture of tilapia and mullet has demonstrated consistent growth since the 1980s, making farmed fish an important commodity for the economy and food security.

Saudi Arabia has the second largest aquaculture industry in the region (4.2 percent of total NENA aquaculture) with production increasing rapidly in recent years following declines when a thriving shrimp sector was impacted by disease problems in the early to mid-2010s. One of the main aquaculture operators (National Prawn Company, now called National Aquaculture Group (NAQUA)) diversified into finfish (for example barramundi) and other aquaculture products (for example sea cucumber) and upgraded their shrimp farming system by applying strict biosecurity protocols. Meanwhile other companies have also expanded, encouraged by government support, incentives and strong market demand.

TABLE 4. Aquaculture production by countries and territories in the Near East and North Africa from 2009–2018 (tonnes)

Country/ territory	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Algeria	2 163	1 759	2 246	2 644	2 193	2 411	1 333	1 376	1 416	5 100
Bahrain	2	3	3	2	0	6	0	14	0	0
Egypt	705 490	919 585	986 820	1 017 738	1 097 544	1 137 091	1 174 831	1 370 660	1 451 841	1 561 457
Iraq	18 732	20 320	16 290	25 040	14 060	26 625	24 803	28 835	31 814	25 737
Jordan	440	541	575	600	720	885	885	885	885	900
Kuwait	272	310	319	309	303	297	262	196	195	198
Lebanon	1 080	1 180	1 280	1 280	1 180	1 125	1 025	1 025	1 025	1 031
Libya	110	110	10	10	10	10	10	10	10	10
Morocco	657	742	617	693	988	1 189	1 050	1 150	1 270	1 267
Oman	118	127	157	168	353	282	170	103	77	451
Palestine	115	280	189	269	284	184	256	280	500	749
Qatar	36	36	36	36	56	56	10	10	10	10
Saudi Arabia	26 442	26 374	16 076	12 737	9 266	23 880	30 000	39 920	55 000	72 000
Syrian Arab Republic	8 697	8 610	7 500	6 200	4 000	3 000	2 500	2 500	2 350	2 350
Tunisia	4 907	5 424	8 126	8 577	12 184	11 279	14 425	16 183	21 930	21 826
United Arab Emirates	130	198	415	420	780	788	790	2 685	3 255	3 350
Western Sahara	0	0	0	0	0	0	0	0	0	0
Yemen	150	150	150	100	0	0	0	0	0	0
Total	769 541	985 749	1 040 809	1 076 822	1 143 921	1 209 108	1 252 350	1 465 832	1 571 578	1 696 436

Source: FAO, 2020c.

Iraq and the Syrian Arab Republic's productive freshwater aquaculture systems have been constrained by conflict. The Iraqi industry was showing signs of recovery in recent years, although production dropped in 2018. The conflict in Syrian Arab Republic has also resulted into reduced demand for Lebanese rainbow trout in cross-border markets.

Production in Bahrain, Oman and the United Arab Emirates is set for expansion through a diverse range of projects. The National Food Security Strategy of the United Arab Emirates includes an initiative to launch a National Aquaculture Roadmap while the Sheikh Khalifa Hatchery in Umm Al Quwain has been upgraded to triple its production capacity (from 10 to 30 million fry/year) and will be operated by a private company. A Marine Innovation Park has been established on the same site to serve as an aquaculture research base, an enabler for the local community and a tool to raise the social acceptability and image of aquaculture. In Abu Dhabi and other Emirates, five commercial farms (Aquaculture and Marine Studies Center – Abu Al Abyad, Al Jaraf Fisheries LLC, Fish Farm LLC, Emirates Fish Farms owned by Al Wathba Investment LLC and Dibba Bay Farm), the largest with a production capacity of over 2 000 tonnes, are being established along with a plan to build a feed factory and develop a sustainable aquaculture policy.

Bahrain also intends to develop its aquaculture sector. Commercial marine aquaculture began in 2014, when Asmak Bahrain Company started producing marine finfish. The company also plans to produce 1 500 tonnes of fish in floating cages in Gumais area within a marine concession area of 240 000 m^2. In 2015, the Ministry of Works, Municipalities Affairs and Urban Planning allocated six investment land plots in the area of Ras Hayan, to support private sector aquaculture investment as a component of its national food security plan. Each plot has a surface of 6 000 m^2 with the aim of producing

a minimum 250 to 300 tonnes of fish in recirculating aquaculture systems (RAS). The current priority is to modernize the National Mariculture Centre of Ras Hayan and upgrade its capacity to supply fry and fingerlings of endemic fish species to local and regional aquaculture farms.

Aquaculture has been identified as a promising industry for Oman and in 2006, the Ministry of Agriculture and Fisheries established an Aquaculture Centre to carry out scientific research in order to provide the basis for commercial growth of the sector. Suitable sites have been allocated for investments, while Best Aquaculture Practices (BAP) guidelines were developed for investors. There are currently 23 tilapia farms, one shrimp farm and a marine cage farm producing European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*).

Aquaculture is showing steady growth in Palestine based on marine and freshwater species in Gaza Strip and freshwater fish in West Bank, as a result of various regional and international assistance programmes and private-sector investment. In 2012, with technical assistance from Brazil, demonstration fish farms were established in Jericho and Tulkarm to provide technical and training support resulting in the construction of 21 tilapia ponds for farmers. Due to the shortage of freshwater, filtered irrigation water was used and local non-government organizations (NGOs) received help from Cooperation for Development (United Kingdom of Great Britain and Northern Ireland), the Near East Foundation (United States of America) and the United Nations Development Programme (UNDP). With more than a third of Palestinian agricultural land in the Gaza Strip taken out of production to form a buffer zone, rooftop aquaponics gardening systems were developed, providing much-needed supplies of fish as the security situation made it difficult to source marine fish. A freshwater experimental aquaculture project was established in Gaza to take advantage of water from irrigation ponds. Fish farms were also established by private investors encouraged by local authorities in an attempt to increase fish supplies. Cage-based farming of high value species (for example gilthead seabream and European seabass) along the coastline of the Gaza Strip has also been considered as a means to increase fish supplies. The first offshore fish cage farm is currently being established off the coast of Gaza with the financial support of the Italian Government, technical support from FAO and in close partnership with the local private sector.

The aquaculture sector is also growing in several other countries, although from a relatively small base. Tunisia has built significant production capacity for marine cage-based aquaculture of European seabass and gilthead seabream, including the leading marine fish hatchery in North Africa, Tunisian Aquaculture (Aquaculture Tunisienne), producing around 20 million fingerlings annually for domestic and export markets. Tunisia also has a long association with grooved carpet shell clam (*Ruditapes decussatus*) production in Monastir Lagoon while freshwater species are produced in inland areas (Gennari, 2019). Algeria prioritised inland aquaculture of species such as tilapia in irrigation systems and carps in ponds, lakes and reservoirs, but is now expanding marine aquaculture, including gilthead seabream and Mediterranean mussels (*Mytilus galloprovincialis*) under a strategy called Plan Aquapeche 2020 (Corner, Fersoy and Crespi, 2020). The promising technology of year-round culture of tilapia in geothermally heated water is in need of revitalization. Morocco has been pursuing a policy of aquaculture expansion since the establishment of an agency to promote the sector in 2011, the National Agency for the Development of Aquaculture (ANDA), along with an ambitious production target of 200 000 tonnes by 2020. Current production is limited and is based on Pacific cupped oysters (*Crassostrea gigas*), European seabass, seaweed and grooved carpet shell clams, while more than 256 investment projects have been planned as part of the national Halieutis Plan (Dabbadie, Beveridge and Ababouch, 2017; Van der Meer, 2018).

Meanwhile, aquaculture production in Jordan and Lebanon has remained static and other NENA countries, including Libya and Qatar, have very small aquaculture sectors comprised of just a few individual farms or research facilities. After the closing down of the only commercial marine shrimp farm in Yemen in 2013, there has been no aquaculture production in the country and the state-run Aquaculture Research Centre, in need of full-scale repair, has remained idle.

2.1.3 Species

Forty-three species of finfish, shellfish and aquatic plants were produced through aquaculture in the NENA region in 2018 (Figure 1). Tilapia was the most commonly farmed fish in the region (1 061 321 tonnes in 2018) and was produced in 14 countries. Tilapia represented 62.6 percent of total NENA aquaculture production in 2018 compared to 51.9 percent (565 163 tonnes) in the region in 2009. The main species grown was Nile tilapia, *Oreochromis niloticus*. However, several countries did not report which species of tilapia was farmed, while *Oreochromis aureus* was reported from Syrian Arab Republic and *Oreochromis spilurus* and *Oreochromis mossambicus* from Saudi Arabia.

The second-ranked farmed species group in 2018 was mullets (mainly flathead grey mullet, *Mugil cephalus* and thinlip grey mullet, *Chelon ramada*), totalling 242 383 tonnes and equivalent to 14.3 percent of total NENA 2018 aquaculture production. This compares to total production of 117 033 tonnes and 27.4 percent of total production in 2009. Almost all (99 percent) of regional mullet aquaculture production came from Egypt, although production was also recorded from Algeria, Saudi Arabia, and Tunisia (from natural breeding in dams). Egyptian fish farmers usually grow mullet in polyculture with tilapia at a ratio of one mullet to ten tilapia; mullet seed comes from fry and fingerlings caught in the Mediterranean (Saleh, 2008). The lower percentage contribution of mullet to total NENA production in recent years could be due to the relative abundance and low cost of stocking tilapia seed compared to mullet.

The third largest species group was carps, totalling 211 085 tonnes (12.4 percent of total production) in 2018. This compares to 97 396 tonnes (12.7 percent of total production) in 2009. Egypt and Iraq were the largest producers. Egyptian carp production was split between unidentified species, common carp (*Cyprinus carpio*) and silver/big-head carp (*Hypophthalmichthys molitrix/ Hypophthalmichthys nobilis*). Carp is less favoured by Egyptian consumers than tilapia and is mainly produced by government-owned fish farms as well as a few rice-fish farms. Silver carp has been grown in cages with little or no feeding in plankton-rich waters of the lower Nile. Grass carp (*Ctenopharyngodon idella*) has been produced in Algeria, Iraq and Syrian Arab Republic. In Tunisia, carp larvae are produced by the Technical Center of Aquaculture and released into dams and reservoirs. Although most of the farmed carp species originate in Asia and several are considered invasive in other regions of the world, with the exceptions of Iraq and Jordan there appears to be little concern in NENA countries about their use in aquaculture.

The other main species grown in inland pond-based systems was the African catfish, *Clarias gariepinus*. Although this is a very popular fish in sub-Saharan Africa and is indigenous to North Africa, relatively small amounts are grown in the NENA region (7 747 tonnes in 2018, compared to 19 027 tonnes in 2009). Very few Egyptian fish farmers culture African catfish but the fish finds its way into aquaculture ponds and spawns naturally in irrigation ditches and drains. *Clarias* is also grown in many Syrian Arab Republic fish farms (I. Krouma, personal communication, 2018) and has an advantage in the market as it is air-breathing and can be sold alive if transported and held in a small amount of water. Egypt also recorded 2 tonnes of Bayad catfish (*Bagrus bajad*) which was probably a by-catch from aquaculture ponds.

Temperate freshwater finfish species were grown in Lebanon (rainbow trout, *Oncorhynchus mykiss*), Morocco (rainbow trout), Algeria (pike-perch *Sander lucioperca*, barbel *Barbus* spp., large-mouth bass *Micropterus salmoides*) and Tunisia (pike-perch, wels catfish *Silurus glanis*, rudd *Scardinius erythrophthalmus*, roach *Rutilus rutilus*). Tunisia also produced 78 tonnes of Algerian barb (*Luciobarbus callensis*).

European eel (*Anguilla anguilla*) aquaculture was recorded from Morocco (260 tonnes – mostly from an indoor Recirculated Aquaculture System facility), Algeria (27 tonnes), Egypt (11 tonnes) and Tunisia (6 tonnes) in 2018. This is a critically endangered species on the Red List of the International Union for Conservation of Nature (IUCN) and cannot yet be bred in captivity. The collection of juvenile eels (elvers) as well as commercial fishing for eels is subject to strict controls in Europe (Bevacqua *et al*., 2015).

The United Arab Emirates operates a farm with a recirculating aquaculture system producing Siberian sturgeon (*Acipenser baeri*) for caviar. Recorded production in 2018 was 220 tonnes, which presumably was the meat yield from the fish after they had been harvested for caviar (FAO, 2005–2020a). The starlet sturgeon, *Acipenser ruthenus*, is produced in the Eastern Province of Saudi Arabia. In 2017, three tonnes of caviar were produced and traded along with 35 tonnes of meat.

The three main species of marine finfish produced by NENA fish farms in 2018 were gilthead seabream (*Sparus aurata*), European seabass (*Dicentrarchus labrax*) and meagre (*Argyrosomus regius*) totalling 108 518 tonnes (51 percent seabream, 26 percent seabass, 23 percent meagre). Gilthead seabream aquaculture production was recorded from eight NENA countries in 2018, European seabass from seven countries and meagre from three (Egypt, Saudi Arabia and Tunisia). Farming of meagre in the region only started in the last decade and is still at pilot scale in Tunisia. Kuwait grew a small amount of sobaity seabream (*Sparidentex hasta*) in 2018. Most Egyptian European seabass and gilthead seabream farms are pond-based using water pumped from the Mediterranean whereas marine finfish farms in other NENA countries are usually floating cage-based.

Other species of marine finfish produced in 2018 included the Asian seabass also known as barramundi (*Lates calcarifer*) in Saudi Arabia and United Arab Emirates (total 5 532 tonnes) and a small amount of striped bass (*Morone saxatilis*) in Palestine. The roots of barramundi aquaculture are in Australia and the practice was introduced to Saudi Arabia as part of a diversification strategy for the NAQUA that had previously focused on pond-based shrimp farming.

A total of 400 tonnes of high-value tropical marine finfish were grown in the United Arab Emirates and Saudi Arabia in 2018 including grouper (*Epinephelus* spp.), amberjack (*Seriola* spp.) and rabbitfish (*Siganus* spp.). These are relatively new species to aquaculture in the region and require specialist expertise during the early rearing stages. However, market prices are high and production is rising rapidly in Asia due to market demand (Rimmer and Glamuzina, 2017). Demand for these species, especially groupers, remains high in all Gulf countries.

Shrimp farming in the NENA region is concentrated in Saudi Arabia which was responsible for 99 percent of the 56 496 tonnes produced in 2018. Shrimp represented 3.3 percent of total NENA aquaculture production in 2018 compared to 21 446 tonnes (2.8 percent of total production) in 2009. The main shrimp farming company in Saudi Arabia, NAQUA, was severely impacted by disease when farming the Indian white prawn, *Fenneropenaeus indicus* and switched production around 2013 to whiteleg shrimp, *Litopenaeus vannamei* as well as diversifying into barramundi and sea cucumber *Holothuria scabra*. Shrimp was also

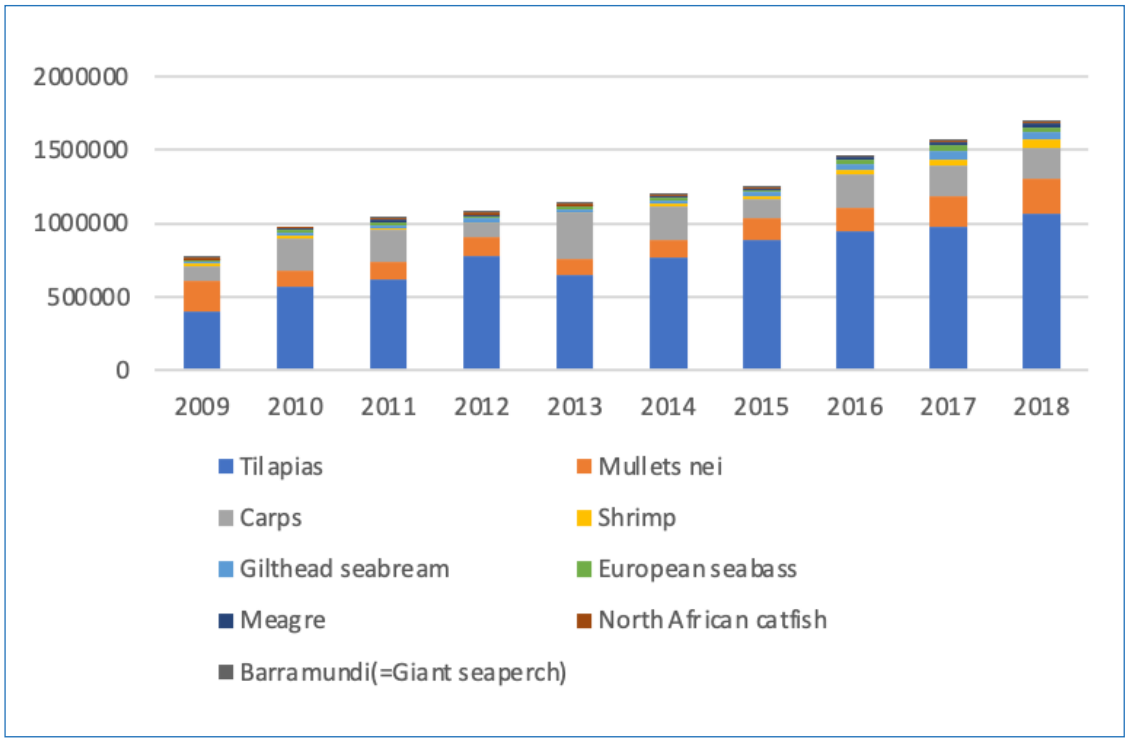
produced by the United Arab Emirates (225 tonnes of Indian white prawn in 2018), Egypt and Lebanon as well as Tunisia and Algeria. The whiteleg shrimp has rapidly taken over from the giant tiger prawn *Penaeus monodon* and Indian white prawn as the most important global shrimp aquaculture species. Domesticated breeding lines have been established for whiteleg shrimp that can be certified as disease-free whereas most other shrimp hatcheries still rely on wild-caught broodstock. However, shrimp farms in NENA region import broodstock or post-larvae from established hatcheries in other regions of the world.

Relatively small amounts (total 703 tonnes in 2018) of bivalve shellfish are grown in NENA countries. Pacific cupped oyster (*Crassostrea gigas*) was grown in Morocco (349 tonnes in 2018) and smaller amounts in Algeria, Tunisia and United Arab Emirates. The Mediterranean mussel (*Mytilus galloprovincialis*) is grown in Algeria and Tunisia while grooved carpet shell clams (*Ruditapes decussatus*) were grown or harvested in Morocco.

In stark contrast to other regions of the world, the only records for farmed aquatic plants in NENA in 2018 were 130 tonnes of slender wart weed (*Gracilaria gracilis*) in Morocco and 70 tonnes of Spirulina (*Arthrospira* spp.) in Tunisia. *Gracilaria* is a red seaweed grown in Africa, Asia, Oceania and South America mainly for production of agar as well as for direct consumption. Spirulina is a filamentous cyanobacterium that is consumed as a health food. It is grown in specialist facilities where pH and alkalinity can be controlled.

Several other species have been grown in NENA in recent years but not recorded in the 2018 statistics presumably because the relevant farms have closed or now focus on other species. These include bluefin tuna (*Thunnus thynnus*) in Libya, Morocco and Tunisia, yellowfin tuna (*Thunnus albacares*) in Oman, giant tiger prawn and Nile perch (*Lates niloticus*) in Egypt, and marine finfish including sandfish (Trichodontidae), snappers (Lutjanidae), croakers (*Micropogonias undulatus*), yellowfin seabream (*Acanthopagrus* spp.) and gold-lined seabream (*Rhabdosargus sarba*) in a range of NENA countries.

FIGURE 1. Production of the major farmed species groups in the Near East and North Africa region (2009–2018)



Source: FAO, 2020c.

Although no freshwater crustaceans are recorded in official aquaculture data for NENA, a commercial fish farm in Morocco produces a small quantity of Australian redclaw crayfish (*Cherax quadricarinatus*) while the invasive red swamp crayfish (*Procambarus clarkii*) is established in Egypt and Morocco. Although wild caught red swamp crayfish has been exported from Egypt to China and Northern Europe in recent years, there has been no promotion of it as a potential aquaculture species in the region. This is in sharp contrast to its favoured status in China where 1.6 million tonnes were produced in 2018, mainly in integrated rice-crayfish farms.

2.1.4 Production environment

Aquaculture production environments are categorized as freshwater, brackishwater and marine. Most freshwater production in the NENA region is in ponds and cages for carp, African catfish and tilapia, although there are also farms using intensive tanks. Commercial marine aquaculture systems in NENA are mainly used to grow barramundi, European seabass, gilthead seabream, meagre, sobaity seabream, and shrimp.

The FAO Coordinating Working Party on Fishery Statistics (CWP) defines brackishwater culture as "the cultivation of aquatic organisms where the end product is raised in brackishwater, such as estuaries, coves, bays, lagoons and fjords, in which the salinity may fluctuate between 0.5 parts per thousand (ppt) and full-strength seawater". In Egypt, the main aquaculture production zones for tilapia and mullet are categorized as brackishwater because the salinity is above 0.5 ppt but they are inland and not connected to the sea. The salinity of water supplied to these pond-based systems is commonly up to 4 ppt as a result of evaporation as the water passes along the Nile and through the addition of salts from fertilisers and soils as the water passes through multiple irrigation systems. Meanwhile, European seabass is produced in cages in Egypt in an inland brackishwater lake as well as in intensive tanks fed by a salt-water aquifer.

Because most Egyptian fish farms are in areas classified as brackishwater, this is the leading aquaculture production environment in NENA, representing 77.5 percent of total aquaculture production in 2018 (Table 5). This compares to 78.3 percent of total NENA aquaculture production in 2009. Egypt's production accounts for more than 98 percent of brackishwater aquaculture in the region (FAO, 2020c). Brackishwater aquaculture was also practiced in eight other NENA countries in 2018.

Freshwater aquaculture is practiced by 14 countries in the region and represents 18.5 percent of total production in 2018 (Table 5), the same percentage as in 2009. Egyptian freshwater aquaculture production in 2018 accounted for 86 percent of total freshwater aquaculture production in NENA region in 2018 (FAO, 2020c).

Marine aquaculture was recorded from six countries and accounted for only four percent of total aquaculture production in 2018 (Table 5), 94.5 percent of which came from Saudi Arabia (FAO, 2020c). The relative contribution of marine aquaculture production in NENA region was 3 percent in 2009.

Separating production into inland waters and marine areas shows that 79 percent came from inland areas in 2018 and 21 percent from marine areas. This is difficult to reconcile with the information on environment where only four percent was classified as coming from marine environments and may reflect uncertainty over classification of environments by the reporting authorities in some of the countries.

TABLE 5. Aquaculture production in 2018 by environment in the Near East and North Africa countries/territories (tonnes)

Country/Territory	Production environment		
	Freshwater	Brackishwater	Marine
Algeria	3 016	2 084	0
Bahrain	0	0	0
Egypt	271 384	1 290 073	0
Iraq	25 737	0	0
Jordan	695	205	0
Kuwait	0	187	11
Lebanon	1 015	16	0
Libya	10	0	0
Morocco	660	356	251
Oman	101	0	350
Palestine	279	470	0
Qatar	10	0	0
Saudi Arabia	7 600	280	64 120
Syrian Arab Republic	2 350	0	0
Tunisia	881	20 935	10
United Arab Emirates	258	0	3 092
Western Sahara	0	0	0
Yemen	0	0	0
TOTAL	313 996	1 314 607	67 833

Source: FAO, 2020c.

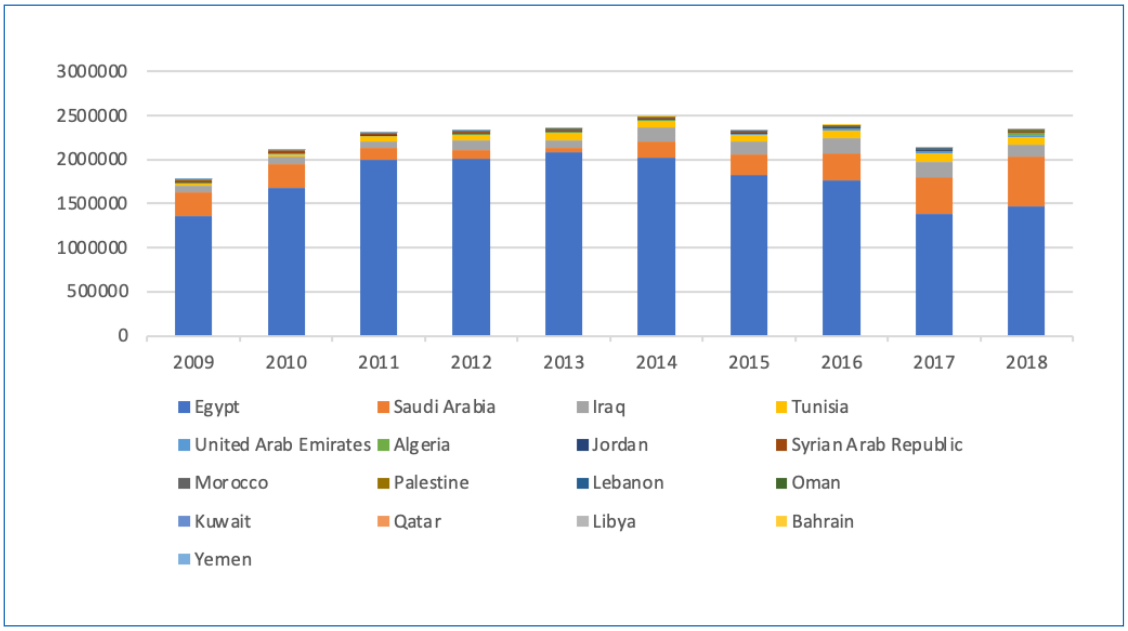
2.1.5 Aquaculture production value

The total value of aquaculture production in the NENA region was estimated at USD 2.343 billion in 2018, equivalent to 0.9 percent of the value of world aquaculture production (FAO, 2020c). Although there has been a steady upward trend in aquaculture production in the region, the value of production has fluctuated over the last decade, mainly due to exchange rate fluctuations between the Egyptian pound and the US dollar (Figure 2). The Egyptian pound fell after the 'Arab Spring' revolution and lost further value when it was floated against other currencies in 2016/2017. While there were local price rises for the main farmed fish products, these did not compensate for the loss in US dollar value.

Aquaculture made a contribution of USD 1.47 billion to the national economy of Egypt in 2018, while the contribution to Saudi Arabia was USD 558 million, Iraq was USD 136 million, Tunisia was USD 92 million, the United Arab Emirates was USD 27 million and Algeria was USD 16 million (FAO, 2020c). For the other countries in the region, the value of aquaculture production ranged between USD 9.5 million for Jordan and USD 20 000 for Libya, while Yemen had no production.

The average unit value of aquaculture products in 2018 varied across the region from USD 0.94/kg in Egypt to USD 3.7/kg in Qatar, USD 4.9/kg in Oman, USD 5.9/kg in Kuwait, USD 7.7/kg in Saudi Arabia and USD 8.0/kg in the United Arab Emirates. This reflects the value of the species being grown and the strength of markets. In Egypt, the majority of farmed fish is sold in domestic markets and production is dominated by tilapia, which is a relatively cheap species. In contrast, aquaculture in Saudi Arabia and the United Arab Emirates is predominantly marine finfish and shrimp, some of which are destined for high value export markets.

FIGURE 2. Aquaculture production value in the Near East and North Africa countries (thousand USD)



Source: FAO, 2020c.

2.1.6 Production systems and technologies

The main production systems in the NENA region are ponds and cages. However, there is increasing use of intensive tanks, including RAS, while IAA, integrated multi-trophic aquaculture (IMTA) systems and culture-based fisheries in lagoons are also practiced.

Egyptian pond-based aquaculture infrastructure was established in the 1980s, when large aquaculture zones were developed. Land on the margins of lakes near the Mediterranean coast that flooded on a seasonal basis before the construction of the High Aswan Dam came under the management of the General Authority for Fisheries Resources Development (GAFRD), who leased the land in blocks to fish farmers. The water supply for the fish farms was from nearby agricultural drainage canals.

Fish farmers built ponds, usually around half to one hectare in area and 0.5 to 1.5 m in depth. In the most common management system, ponds are stocked when water temperatures increase in late March or early April, using tilapia fry sourced from hatcheries and wild mullet fry from nurseries. Few farmers use aeration systems as most do not have access to electricity. Farmers have upgraded their feeding strategies over the years away from farm-made compound feeds. At present, nearly all fish farmers use factory-produced compound feeds including extruded floating feeds from specialist fish feed mills. Fish are not graded or sorted during the production cycle and most farms harvest a single crop of fish from each pond. Some fish are farmed overwinter period to take advantage of higher market prices when fish is scarce. Improved fish genetics and higher quality feeds have allowed average annual production levels to increase to around eight tonnes per hectare. Despite the lack of sophisticated infrastructure and technology, this has been a very successful production system that has only changed a little over the last 30 years (Dickson *et al.*, 2016; Eltholth *et al.*, 2015; Nasr-Allah *et al.*, 2019).

Using similar methods to Egypt, earth ponds are used to grow tilapia in several other NENA countries including Iraq, Palestine and Syrian Arab Republic. Ponds fed with seawater are used for marine finfish and shrimp in Egypt and ponds are also used for farming shrimp in Saudi Arabia. Smaller units such as shrimp nursery ponds can be lined with concrete or polyethylene to improve water retention. It also makes them easier to clean, which can be important for biosecurity and facilitates harvesting.

Integrated agriculture-aquaculture systems have been tested in Egypt and it has also been adopted in several countries including Algeria where an FAO project developed integrated tilapia farming in palm groves at Wilaya de Ouargla (FAO, 2018a). The pilot project helped farmers develop tilapia ponds based on water used for irrigation of palms and accompanying crops. It demonstrated that farmers could increase their revenue by adding fish farming to their activities and recommended that integrated systems are included in the national agriculture investment programme.

A recent FAO project resulted in a key report on the potential for development of IAA systems in NENA region (Corner, Fersoy and Crespi, 2020). The report 'Integrated agri-aquaculture in desert and arid lands: Learning from case studies from Algeria, Egypt and Oman' summarizes evidence of current IAA activity in the three countries participating in the project that provided an opportunity for farmers from ten countries to visit others to learn more on techniques being employed in IAA systems, and share expertise and experiences. The case studies report that approximately 600 farmers are operating IAA systems in Algeria, producing around 5 000 tonnes of carps, catfish and tilapia with date palm, cereals and market gardens. Integration was reported to produce more benefits than conventional agriculture, reducing or eliminating the need for fertilization of crops and increasing the productivity of water. Most IAA systems in Egypt are desert farms producing Nile tilapia in flow-through tanks or balancing ponds with the water re-used to irrigate agricultural land for vegetables, arable crops and Egyptian clover. Fish production from IAA systems in Egypt was estimated at 2 200 tonnes in 2017 from around 100 farms. In Oman there are an estimated 18 integrated fish farms producing 70 tonnes in 2017. The report includes a roadmap for upscaling IAA in arid lands, developed by the experts who attended a final workshop in Cairo that should provide a basis for future development of IAA within the NENA region. The report recommended establishing demonstration IAA units and centres of excellence, promoting best practices and marketing while also increasing funding for IAA (Corner, Fersoy and Crespi, 2020).

Culture-based fisheries in coastal lagoons are widespread across North African countries where shellfish harvesting is the primary aquaculture activity. A recent study identified 22 lagoons, four along the Atlantic shore of Morocco and 18 along the Mediterranean coastline (El Mahrad *et al.*, 2020). North African lagoons are commonly used for small-scale fishing while shellfish production is practiced in Oualidia and other lagoons further south in Morocco, in Bizerte in Tunisia and in Farwa in Libya. The sustainability of aquaculture in lagoons is threatened by climate change resulting in the invasion of species such as jellyfish as well as sea level rise and the development of tourism (Cataudella, Crosetti and Massa, 2015).

Egypt also has cage farming of tilapia, carp and mullet, mainly in the lower reaches of the Nile tributaries where the legal status of cages is uncertain and at various times they have been removed or production halted because of concerns about their impact on the aquatic environment. Fish held in the cages have been used as a buffer stock of tilapia that can be harvested easily during the winter when access to the main pond areas is difficult. Cages in the Nile have also been used to produce silver carp, a filter-feeding species that does not need feeding when there are high plankton levels. Egyptian freshwater cages are relatively small (around 10 m x 10 m), square or rectangular wooden or metal structures with shallow cage nets and tend to be densely packed together.

More recently constructed cage-based aquaculture systems in Egypt and other NENA countries are in the sea or large lakes so they must be able to withstand prevailing weather conditions. In very sheltered inshore sites, small wooden cages can be used, similar to those used by Egyptian fish farmers in the Nile. However, high density polyethylene (HDPE)

circular cages originally designed for use in salmon farms are more usual in exposed environments. These range in size from 20 m to 60 m diameter with varying pipe sizes, number of pipes, designs of handrails and depths of net depending on the exposure and depth of the farm site. Floating HDPE European seabass and gilthead seabream cage fish farms are common in the Mediterranean and the system has been used in, Algeria, Morocco, Oman, Saudi Arabia and in Tunisia. Marine cages are also used for barramundi and grouper in Saudi Arabia and the United Arab Emirates. There is also a cage-based European seabass fish farm at Fayoum in Egypt with HDPE circular cages and new HDPE circular cages installed on the Egyptian Mediterranean coastline as part of the Ghalioun Project, a joint-venture between a Chinese company and the Egyptian government. Marine fish farms usually stock fingerlings from land-based hatcheries. Marine fish fingerlings are relatively expensive and must be fed high protein feeds. As the fish grow, they are moved to larger cages with larger mesh nets to ensure adequate water flow and oxygen.

Tank-based aquaculture systems have been constructed in most NENA countries. The main advantage is that less space is used when compared to earth ponds and the system can be built almost anywhere, whereas ponds or cages require specific conditions. However, they are relatively expensive and have higher operating costs as water needs to be pumped and aerated.

There are two main types of tank system: flow-through and recirculating (RAS). A flow-through system can work well in NENA when the water passes through aquaculture tanks before being used for irrigation. Small-scale tank-based aquaculture systems (including aquaponics systems) have been used in most NENA countries for research or small-scale production, while RAS has been used at a commercial scale (at least 100 tonnes per year) by farms in Egypt, Saudi Arabia and the United Arab Emirates.

In RAS, the aim is to minimise the use and discharge of water by recirculating most of it after treatment. As only a small amount of ambient temperature water is added to the system, it is easier to maintain constant water temperatures so warm water species, such as shrimp, can be grown in temperate environments and cold water species (salmon, sturgeon) can be grown in insulated buildings in hot climates. While RAS allows more flexibility over farm location, capital and operating costs are higher than for cage-based aquaculture. For this reason, RAS has mainly been used for high-value species. In the United Arab Emirates, a farm using RAS technology was established to grow sturgeon but has stopped operating. A similar RAS Atlantic salmon (*Salmo salar*) project has been developed more recently (Waycott, 2020). RAS-based investments have also taken place in Saudi Arabia including a sturgeon farm that produces high quality caviar and more recently a shrimp farm started pilot-scale operation, with the aim of achieving consistent production through the improved biosecurity offered by RAS. There is also a new Atlantic salmon RAS farm being developed in Saudi Arabia and several tilapia RAS farms are under construction and expected to start operating in 2021.

Environmental NGOs favour RAS because it addresses the spread of disease from farmed to wild fish, the deposition of wastes under cages and the impacts of fish escapes. However, high costs and a history of system failures caused by build-up of toxic metabolites, electrical problems and difficulties in containing disease outbreaks have limited the widespread deployment of RAS systems. Nevertheless, there appears to be unprecedented global interest and financing for new RAS developments while increased experience has led to improved performance and reliability and offers the prospect of aquaculture development with greater biosecurity and fewer locational constraints so that farms can be located closer to key markets.

Variations on RAS include aquaponics, where hydroponically grown plants act as the main biofilter, and in-pond raceway systems (IPRS) where a pond acts as the biological filter (FAO, 2019c). Aquaponics is a very attractive concept that has been tested and operated in many NENA countries but has failed to develop at scale. It usually results in more vegetable production than fish and it is difficult to maintain a balance between plants and fish. Successful systems need to focus on marketing to consumers who will pay a premium for aquaponic fish and vegetables as they cannot compete on price with conventional production systems (Palm *et al.*, 2018; FAO, 2019c). However, the market situation and opportunities for alternative production systems will vary from country-to-country and results from Oman appear to be promising. IPRS are also promising as they offer multiple benefits to pond-based fish farmers who can double or triple the overall productivity of their ponds while dramatically reducing water consumption. Oxygen in the production cells is maintained at optimum levels so fish performance is better than in open ponds while easier feed management leads to improved feed conversion efficiency. Harvesting is easier in IPRS than in open ponds and less water inflow to the system should reduce the risk of disease. WorldFish has tested IPRS in Egypt where it is also being deployed by private-sector fish farms (Nasr-Allah, Al-Kenawy and Karisa, 2019). In Egypt, the first IPRS production of 18 tonnes was recorded in 2018 using four raceway cells measuring 1.5 × 3 × 12 m (GAFRD, 2020). However, IPRS systems have constraints as they require capital investment that is unlikely to take place unless fish farmers own their ponds or have sufficiently long leases and stable electricity supply.

2.2 SALIENT ISSUES AND SUCCESS STORIES

2.2.1 Factors leading to Egyptian aquaculture success

Egypt has emerged as "top–ten" global aquaculture producer and per capita availability of fish has increased despite rapid population growth. Around two-thirds of the fish eaten in the country comes from Egyptian fish farms, a remarkable success when the only secure water supply is the Nile and so much of the country is covered by desert.

Success was built on commitments made by the Egyptian government in the 1980s to set aside large areas of land (now over 120 000 hectares) for aquaculture production and to establish institutional and legal frameworks. The government also built hatcheries, feed mills and research stations as well as trained key personnel to manage and guide the new activity. The second success factor has been the profitability of the value chain, which has led to large-scale investment by the private sector in aquaculture and associated services such as feed mills, hatcheries, transport and markets.

No other country in the region made such large aquaculture investments at that time. Investment by the private sector has now largely overtaken public investment as Egyptian aquaculture is almost wholly operated by private businesses, without any need for sector-specific subsidies. However, the General Authority for Fisheries Resources Development (GAFRD) still owns most of the land in aquaculture zones, which it leases (originally for a maximum of 5 years which was usually renewed but now extended to 25 years) at low cost to fish farmers and until recently all fuel in Egypt was heavily subsidised.

Egyptian fish farmers have consistently been able to make profits. They operate a simple farming system, producing relatively low-cost fish for consumption by rural and urban Egyptians, most of whom live within 100 km of the fish farming zones. Although many Egyptians prefer wild-caught fish, demand for farmed fish from the majority of the population remains strong. Most farmers have been able to maintain profitability despite rising input costs by increasing the efficiency of their farming processes through stocking faster growing fish, using better quality feeds and improving feed management (Dickson *et al.*, 2016).

2.2.2 Diversification and expansion of aquaculture

Aquaculture production in the NENA region shows relatively little species diversity and is currently dominated by freshwater finfish. However, there are efforts across many countries to diversify aquaculture production, particularly in the marine environment and by adopting alternative farming systems such as aquaponics, IAA and biofloc-based systems.

Saudi Arabia has been the leading shrimp farming country in NENA region with significant capital investment over several decades in large companies such as NAQUA. Aquaculture has been identified as a key component of its food security strategy with the goal of increasing aquaculture production to 0.6 million tonnes by 2030. Fifteen aquaculture development zones have been identified in the Red Sea and generous support packages are available for a range of systems. These include the Fish Farming Support Programme of the Agricultural Development Fund (ADF) that will provide 70 percent of the total cost of new aquaculture projects. The Ministry of Environment, Water and Agriculture (MEWA) has also simplified investment license application processes and shortened the period within which permits should be issued. Saudi Arabia has also implemented a national biosecurity surveillance programme and introduced a Saudi Arabia Mark of Aquaculture Quality (SAMAQ), an aquaculture product certification and label based on international guidelines and responsible aquaculture practices (MEWA, 2020a; MEWA, 2020b; NordOest, 2016).

European seabass and gilthead seabream have a long history of cultivation in the Mediterranean but there have been market challenges. In the main production centres of Turkey and Greece, poor economic conditions and weak markets coupled with a failure to diversify products has led to stagnating prices and consolidation of the industry. This has left little room for imports from other non-European countries, including from the NENA region. Tunisia has the largest seabass and seabream hatchery in North Africa although many of its cage-based growout farms are struggling to make profits (L. Gennari, personal communication, 2019). Most Egyptian gilthead seabream and European seabass are produced in ponds rather than cages, and many farmers switched to meagre as an alternative in 2015. However, local Egyptian markets were quickly saturated and farmers were unable to export enough meagre to other markets to prevent prices collapsing.

Both Algeria and Egypt plan to access aquifers beneath the Sahara Desert as they seek to improve food security (Win, 2018). Some of this water could be used for fish production in IAA projects. In Algeria, the strategy has been oriented towards the development of whiteleg shrimp farming using biofloc technology. Algeria has an aquaculture strategy called Plan Aquapeche 2020 that aims to reach annual seafood production of 100 000 tonnes (Adamowski, 2018; MPRH, 2014).

In Egypt, it is unclear whether aquaculture will be added to the activities promoted in new or expanded groundwater-based desert settlements, although it is encouraged when there are saline aquifers not suited to agriculture. The Egyptian government has also developed new government-owned marine fish farms along the Suez Canal and Mediterranean coastline for marine finfish, tilapia and shrimp (Feidi, 2018). The developments will cover around 10 000 hectares and include ponds, marine cages, feed mills and fish processing facilities.

Morocco has been implementing a diversified fisheries and aquaculture strategy called Halieutis since 2009 and established a National Agency for Aquaculture Development (Agence Nationale pour le Développement de l'Aquaculture – ANDA) in 2011. It has been difficult for Moroccan seabass and seabream producers to compete with European producers while oyster production has remained competitive over the years (Van der Meer, 2018).

The Al Amal Fisheries Cooperative is developing an offshore mussel farm while another cooperative at Mar Chica lagoon has a red seaweed farm. After several years of technical studies, some 150 projects are now being launched with private investment (Rafih and Pons, 2019).

In Oman, the Ministry of Agriculture and Fisheries Wealth has actively encouraged commercial aquaculture projects, initiating an Agriculture and Fisheries Fund that awarded 24 projects by 2018 and five initial projects actively under development at that time. The government has also issued a by-law on aquaculture, published an atlas on suitable aquaculture sites along the entire coastline, and released aquaculture investment guidelines to attract both home and foreign investments (MAFW, 2011; Lund, 2019).

In Bahrain, the NMC successfully achieved mass propagation of rabbit fish (*Siganus canaliculatus*), sobaity seabream (*Sparidentex hasta*), gilthead seabream (*Sparus aurata*), mangrove red snapper (*Lutjanus argentimaculatus*) and brown-spotted grouper (*Epinephelus coioides*) becoming a regional finfish seed supply hub for the GCC countries and other Regional Commission of Fisheries (RECOFI) Member countries. The hatchery facilities are currently being renovated to accommodate production of a larger number of fingerlings throughout the course of the year including setting up a modern and efficient broodstock photoperiod conditioning and maintenance system. Bahrain also has a tilapia fish farm that has been developed as a tourist attraction.

In the United Arab Emirates, the Aquaculture and Marine Studies Centre (AMSC) in Abu Al Abyad was tasked in 2015 to support the growing aquaculture industry in the country, by supplying commercial aquafarms with high quality fingerlings of local fish species. Based on current industry demand, the hatchery is capable of producing 3 million fingerlings annually including white-spotted rabbitfish *(Siganus canaliculatus*), cobia (*Rachycentron canadum*), spangled emperor (*Lethrinus nebulosus*) and orange spotted grouper known locally as hamour (*Epinephelus coioides*). In addition, the centre is producing 2 million fingerlings of sobaity seabream (*Sparidentex hasta*), yellowfin seabream (*Acanthupagrus latus*), bluespot mullet (*Valamugil seheli*) and gold-lined seabream (*Rhabdosargus sarba*). Another hatchery, the Sheikh Khalifa hatchery has been renovated and upgraded to triple its production capacity (from 10 to 30 million fry/year) and is now operated by a private-sector company. A Marine Innovation Park has been established to serve as a research base on aquaculture. It aims to promote regional and global leadership, and advanced research and development in the field of marine resources including the development and operation of commercial hatcheries using environmentally responsible approaches (Food Security, 2020). Five commercial farms are currently producing the bulk of the national production.

Meanwhile, Tunisia has adopted three National Aquaculture Development Strategies starting in 2006 when the objective was to reach a production target of 15 000 tonnes by 2016, followed in 2015 by a new strategy focused on production of 27 000 tonnes by 2020 and in 2019 by the Strategic Study of Fisheries and Aquaculture by 2030 with the objective of reaching 60 000 tonnes by 2030.

2.2.3 Production data collection

Accurate and timely data play a key role in management and policy formulation for sustainable aquaculture development. However, not all the NENA countries have effective data collection systems as inconsistencies, including no reporting are common, resulting in FAO having to estimate production based on past performance, information obtained from alternative sources and indirectly cross-referenced information. The estimates also involve disaggregation of data received by FAO in aggregated form by species and by culture environment. As noted above, Egypt classifies inland ponds fed with water from irrigation

schemes (agricultural drainage water) as brackishwater, although this would normally mean coastal systems where there is mixing between freshwater and seawater.

Many NENA countries do not have a systematically established framework aligned with internationally and regionally accepted standards for data collection from fish farms. In Egypt, there are 6 000 to 10 000 fish farms, many of which are unlicensed or operate as informal businesses. Fish farms are not required to report production data to the competent authority, and in the absence of direct reports, production data are estimated by extrapolation, i.e. multiplying the area under fish culture by an estimate of average productivity and adjusting according to advice from key contacts in the industry. This issue can only be solved by resolving issues with the fish farm licensing process and devising a system for direct reporting of production coupled with validation through sample surveys by trained enumerators.

In several countries the staff responsible for reporting production estimates lack the knowledge, support or relevant mechanisms such as specifically designed databases to develop accurate production estimates and improve monitoring and control of the industry. The RECOFI includes seven countries from the NENA region (Bahrain, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates) as well as Iran (Islamic Republic of), and has committed to addressing this issue by adopting a binding recommendation in 2015 on reporting aquaculture data and information to the Regional Aquaculture Information System (RAIS) in parallel to the reporting to FAO. All NENA countries with a Mediterranean coastline are obliged to report national aquaculture data to the General Fisheries Commission for the Mediterranean (GFCM) through its Information System for the Promotion of Aquaculture in the Mediterranean (SIPAM) with data coverage wider than FAO's minimum required national data reporting. However, regular annual reporting to RAIS by these countries has yet to be achieved, while the data reports to SIPAM remain confidential to non-GFCM organizations, including FAO.

2.3 THE WAY FORWARD

2.3.1 Key Message: Aquaculture is growing and has good potential for further growth

Many countries in the NENA region have struggled to establish economically sustainable aquaculture. Most countries have now addressed the institutional and legal issues, but allocating space for aquaculture is often challenging as there are many competing interests. Space means both physical space (land, water) and a conducive operating environment for large-scale development.

The other factor that leads to upscaling of aquaculture is profitability. If aquaculture is not profitable, there will only be limited private-sector investment and the sector will not grow beyond pilot-scale or research projects. This is a complex issue but, too often, when decisions are being made to diversify aquaculture development strategies, developers choose species or systems that are unlikely to be profitable. It is tempting to focus just on market value whereas the whole value chain needs to be profitable. Input costs and the efficiency of the system are just as important while larger enterprises also benefit from significant economies of scale.

The main operating cost for finfish farms in NENA region is usually feed, followed by the cost of fingerlings and labour. However, energy costs are also significant in the case of intensive tank systems or RAS. While it may be worth subsidizing importation of feeds and/or fish fingerlings or shrimp postlarvae for stocking in the short-term during the development phase of the industry, long-term subsidization is unsustainable.

Efficiency of feed use is often overlooked but is within the control of the farmer. Simple changes such as checking that feed rations have been consumed before applying the next feed ration can be the difference between loss and profit. Through a programme of best management practice training in Egypt, several thousand fish farmers were able to improve their feed conversion ratios from an average of 1.8:1 to 1.4:1 over a period of 3 years (Dickson *et al*., 2016; A.M. Nasr-Allah, personal communication, 2020). Many fish farms in NENA do not use equipment that could improve the efficiency of feed use such as automatic feeders or aeration systems, yet part of the capital and operating costs could be recouped from savings in feed costs. Other investments such as improved genetics or using a more efficient farm system could also make significant contributions to cost saving.

Aquaculture planners and developers in NENA region need to have a clear understanding of market options for their products and be realistic about the market prices that they can expect in both domestic and export markets. Egyptian fish farms supply most of the fish being consumed in the country so they can, at least to some extent, set their own prices. If, as is the case in most NENA countries, the majority of supply comes from wild-caught fish or imports, these will tend to set benchmark prices and have a strong influence on the price being offered for farmed product. Export markets may seem attractive but entail higher costs and potential hurdles such as sanitary and phytosanitary controls, processing factory inspections and welfare standards. Exports also usually face strong competition from other regions of the world meaning that exporters have to really understand global market supply and demand for their product and closely related products.

Aquaculture will not work everywhere, and if there is insufficient space for aquaculture, or aquaculture is very unlikely to be profitable it may be better to look to other sectors for economic growth. However, these are complex issues and detailed analysis and modelling is required to determine the likelihood of success for a range of options while it is also important to share best practice and experience between countries in the region and beyond.

Environmental conditions in areas such as the Red Sea are different from those where marine finfish species, such as European seabass and gilthead seabream are usually farmed with higher water temperatures and salinities. This means it is important to investigate optimal feed requirements and protocols for these conditions as they are likely to be quite different to those developed in the Mediterranean. There has been significant progress over the years in the development of specific feeds for different species, fish sizes and seasons in the Mediterranean and this needs to be replicated in the new high-temperature, high-salinity environment as well as for other finfish species including sobaity seabream, pompano and grouper that are currently being fed general seabass/seabream feeds.

The customisation of feed formulations is a good example of the need to adapt and innovate aquaculture technologies to suit the unique circumstances in each part of the region. For example, inshore cages may not suit the coastline of Oman, where there is a history of algal blooms, but offshore cages could work well. Novel feed raw materials such as single cell protein, insects and algae need to be evaluated, particularly when there are opportunities to produce locally and replace imported ingredients. This means that investment in aquaculture research and innovation is extremely important for continued growth of the sector.

Effective reporting systems require investment by regulatory authorities in sector management. All aquaculture farms should be licensed and a condition of that license should be to report production and harvest (sales) data on a regular basis. Where there is insufficient staff in the regulatory authority this could involve representative organizations such as aquaculture associations or even feed companies as intermediaries.

3. Resources, services and technologies

3.1 STATUS AND TRENDS

3.1.1 Land and water for aquaculture

Most NENA region states are arid or semi-arid, with low or intermittent rainfall, limited freshwater resources, large areas of desert and extensive coastlines. Freshwater resources such as the major rivers or groundwater have long been harnessed for irrigation, while many natural inland lakes are saline or highly seasonal. Marginal land is readily available in several NENA countries but land with easily available water is in very short supply and expensive.

The NENA region has 19 000 km of coastline (Table 6). The shortest coastline is in Jordan which has access to 26 km of the Gulf of Aqaba. In contrast, Saudi Arabia has 2 640 km of coastline. However, possession of a long coastline does not necessarily mean that there is high potential for marine aquaculture. For example, conditions in the Gulf are particularly challenging for aquaculture, because of high temperatures, high salinity and low depth, not to mention competition from other important resource users. Cage-based fish farms are usually located in sheltered areas deep enough for cage nets to be clear of the seabed but not too deep for mooring. They also need to have good tidal exchange and protection from extreme weather. Most shrimp farms are now located away from exposed coasts and the preference is to use brackishwater rather than full strength seawater to reduce the amount of water that needs to be brought in to replace evaporation. Saudi Arabian shrimp aquaculture is an exception to this principle where high-salinity Red Sea water is the only source. Other factors are also important, such as the prevalence of red tides (toxic dinoflagellate algae) which can be devastating for cage-based or pump-ashore aquaculture systems during extensive harmful algal blooms (HABs). Furthermore, coastlines are often occupied by other activities such as tourism, fishing or ports that are mostly incompatible with aquaculture development. This highlights the need for marine spatial planning and has led to a campaign coordinated by the GFCM advocating for the establishment of Allocated Zones for Aquaculture (AZA) (Macias *et al.*, 2019). However, some aquaculture activities, including bivalve shellfish or seaweed, may be more acceptable to other stakeholders than finfish aquaculture.

Designated zones for aquaculture have also been identified along the Red Sea coastline of Saudi Arabia. This is largely an oligotrophic water body as there are no river run-offs or major inputs from anthropogenic activities so there is minimal risk of HABs and less potential for conflict with tourism than many other coastlines in the region. Development zones also minimise risks and delays for investors because environmental impact assessments (EIA) have usually been carried out for the entire zone rather than at the enterprise level.

The NENA countries with the largest areas of inland surface water are Egypt and Tunisia, while ten have no permanent inland water bodies (Table 6). Total renewable water resources (RWR) include rainfall, groundwater and water entering the country from beyond the border, such as the Nile River in Egypt and the Tigris and Euphrates rivers in Iraq and the Syrian Arab Republic. The region has 244 km^3/year of RWR with the largest average amounts in Egypt and Iraq. In stark contrast are the RWR estimates for Bahrain, Kuwait, Libya and the United Arab Emirates. In countries where freshwater is available it is used for agriculture, industry and domestic water supply; in high-income, water-scarce countries, desalination has become an important source of water for domestic and industrial supply. Several North African countries plan to expand groundwater extraction for agriculture, although the dangers of over-extraction have already been experienced in many Gulf countries.

TABLE 6. Coastlines and water capacities for the Near East and North Africa countries/territories

Country/territory	Land area (km^2)	Coastline (km)	Inland water area (km^2)	Total renewable water resources (km^3/yr)
Algeria	2 381 740	998	0	11.67
Bahrain	778	161	0	0.17
Egypt	995 450	2 450	6 000	57.60
Iraq	434 128	58	950	89.86
Jordan	88 780	26	540	0.94
Kuwait	17 820	499	0	0.02
Lebanon	10 230	225	170	4.50
Libya	1 759 540	1 770	0	0.70
Morocco	446 300	1 835	250	29.00
Oman	309 500	3 165	0	1.40
Palestine	6 220	40	220	0.84
Qatar	11 610	563	0	0.06
Saudi Arabia	2 149 690	2 640	0	24.00
Syrian Arab Republic	183 630	193	1 550	16.80
Tunisia	155 360	1 148	8 250	4.62
United Arab Emirates	71 020	1 318	0	0.15
Western Sahara	266 000	1 100	0	n/a
Yemen	527 970	1 960	0	2.10
TOTAL	9 815 766	20 159	17930	244.37

Sources: FAO, 2020d; CIA, 2020.

In Egypt, the Nile has been the primary source of water that is re-used through an intricate system of irrigation supply canals, drainage canals and pump stations. When an aquaculture development strategy was designed in the 1980s, there was a pre-condition that it should not place additional pressure on water already allocated for other uses. This was possible because large amounts of water that had already passed through irrigation was being discharged via the agricultural drainage system to the Mediterranean and could be intercepted for fish farming.

Re-use of agricultural drainage water has been efficient and a key success factor for the sector in Egypt. However, the negative side is that the water contains high levels of fertilisers and other soluble chemicals applied to crops as well as industrial and sewage effluent discharged into irrigation drains. The impact on quality of fish has been a subject for debate and research. According to WorldFish research, farmed tilapia in ponds supplied with agricultural irrigation drainage water did not accumulate toxins such as heavy metals, polychlorinated biphenyls (PCBs) and pesticides. The levels in fish flesh were either not detectable or well below levels that would cause concern (D.A.R. Kenawy, personal communication, 2017). However, a more extensive research programme is needed to establish whether this is the case across all farming zones and at all times of year. Apart from the potential for bio-accumulation of toxins, the re-use of agricultural drainage water adds to biological oxygen demand which may exacerbate fish health issues. However, the greatest practical impact is that it detracts from the image of farmed fish as a healthy product.

Syrian Arab Republic also made rational use of scarce water resources by leasing seasonal surface water retention lakes for culture-based fisheries and using drainage canals for grass, silver and common carp farming thereby reducing maintenance costs. Aquaculture was also

used to rehabilitate salinized land by flushing with water and alternating agriculture with aquaculture in rotation. Syrian Arab Republic also promoted aquaculture in small water reservoirs as family fish ponds and disseminated fingerlings to fish farmers (I. Krouma, personal communication, 2019).

3.1.2 Seed

In Egypt, the supply of tilapia seed has grown to match sector demand. Over 400 tilapia hatcheries were in operation in 2013 producing an estimated 3.5 billion fry and fingerlings (Nasr-Allah *et al.*, 2014a) while 13 state-owned hatcheries and around 600 private hatcheries were reported in 2014 (FAO, 2017a). Private-sector hatcheries concentrate on tilapia whereas several government-owned hatcheries also produce carp species. Nearly all the hatcheries produce all-male Nile tilapia using hormonal (methyltestosterone) sex-reversal. The average hatchery produced around 10 million fry or fingerlings per year. The simplest hatcheries used fine mesh enclosures (hapas) in open ponds while many hatcheries covered their breeding ponds with greenhouses to raise the water temperature and initiate breeding earlier in the year to take advantage of higher early season prices. A few hatcheries also added heating systems to raise water temperature even earlier in the year.

All mullet seed in Egypt comes from wild-caught fry and fingerlings in the Mediterranean meaning that the mullet subsector is entirely based on capture-based aquaculture (CBA). The practice started with the establishment of government-operated mullet fry-catching stations when every licensed fish farm was entitled to a quota of mullet fingerlings. However, it is now a private-sector business with little or no control by the authorities. Fry are caught in the latter part of the year and over-wintered in nurseries before being stocked into grow-out ponds with tilapia, usually at a ratio of one mullet to ten tilapia. It is not known if the fishery for fry and fingerlings is sustainable; high mortalities in nurseries mean that many more are caught than are actually stocked in ponds. Research has demonstrated that polyculture of tilapia with mullet is a significant risk factor in the incidence of 'summer mortality' of tilapia, which suggests that wild-sourced mullet fingerlings could be carriers of disease (Ali *et al.*, 2020). It would be preferable if mullet seed came from hatcheries. However, this has not been commercially viable as long as there has been a plentiful supply of wild-caught mullet seed (Saleh, 2008).

Marine species such as seabass and seabream are also caught and distributed from fry-catching stations in Egypt, some illegally, while marine fish farms also buy seed from commercial hatcheries in Europe. Marine finfish and shrimp hatcheries have operated intermittently in Egypt although their production only makes a small contribution to total demand and the supply of juveniles has been recognised as a serious constraint on development. A large marine finfish hatchery will operate as part of the Ghalion Fish Farm investment by the government in Northern Kafr-el-Sheikh Governorate (Feidi, 2018).

Tunisia has the largest European seabass and gilthead seabream hatchery in North Africa, Aquaculture Tunisienne, with a capacity of around 20 million fingerlings per year supplying seed for domestic and international markets (Gennari, 2019). Algeria has a number of small-scale hatcheries for tilapia and catfish but imports other species while a marine hatchery (European seabass and gilthead seabream) has recently been established at the Centre for Fisheries and Aquaculture Research and Development in Bou Ismail district. Morocco has a shellfish hatchery (Azura) producing grooved carpet shell clams that was launched in 2016.

Most countries on the Arabian Peninsula have hatchery facilities for shrimp seed production and have developed or are developing finfish hatcheries for a range of species. In Saudi Arabia there are commercial hatcheries producing and supplying shrimp post-larvae

as well as barramundi, seabream and tilapia juveniles to local producers. Moreover, the Jeddah Fisheries Research Centre (JFRC) has research programmes focused on breeding a wide range of marine species such as the snubnose pompano (*Trachinotus blochii*), the sobaity seabream (*Sparidentex hasta*) and the marine-tolerant tilapia (*Oreochromis spilurus*). NAQUA operates a shrimp hatchery with an annual capacity to produce over one billion post-larvae of whiteleg shrimp. The Aqua Bridge Farms Company project in Saudi Arabia located in Al-Lith, Makkah Province, is developing a new hatchery to produce three million juvenile gilthead seabream and European seabass annually with an eventual target of ten million juveniles.

The NMC in Bahrain used to be a regional finfish seed supply hub for the GCC countries and other RECOFI Member countries and is currently modernizing its facility to increase its production capacity. The freshwater Issa hatchery in Oman produces around 1.5 million tilapia fry per month.

In the United Arab Emirates two hatcheries, the Aquaculture and Marine Studies Center, Abu Al Abyad and the Sheikh Khalifa Hatchery, have a production capacity of 30–35 million fry/year (Food Security, 2020). This includes a wide range of species (see Section 2.2.2).

In Syrian Arab Republic, the main hatchery supplying carp to fish farms was demolished at the start of the civil war in 2012. This has encouraged fish farmers to produce their own fingerlings through natural spawning of common carp while the government has recently launched a programme to supply fingerlings to stock reservoirs in agricultural properties.

3.1.3 Feed

Egypt has the largest aquaculture feed industry in the region and it has grown rapidly in scale and sophistication. Whereas feed mills used to operate pressure pelleting mills, where feed raw material is pushed through a rotating die by rollers and cut to size, Egypt installed the first extruded pellet lines for aquafeeds around 10 years ago. Extruders operate at much higher pressures than conventional pelleting, rapidly cooking the feed material, which increases its digestibility and allows the operator to control the density of the pellet. Although operating and investment costs are higher, floating extruded feeds have gained market share because it is easier for the farmer to see whether the feed has been eaten. Together with increased digestibility, this makes it easier to achieve lower cost of production. Feed formulations are based on internationally sourced materials such as soya, fish meal, and vitamin and mineral premixes, as well as locally sourced materials such as cereal by-products.

Many new extrusion processing lines have been installed in Egypt over the last five years, and the capacity for extruded feeds now exceeds that for conventionally processed feeds. Overall feed production capacity has grown from around 20 000 tonnes/year in 2010 to a current capacity of 1.4 million tonnes/year with major investments by international aquafeed companies (Skretting, Aller Aqua, De Heus and New Hope) as well as local companies (El-Sayed, Dickson and El-Naggar, 2015; Nutreco, 2015; A.F.M. El-Sayed, personal communication, 2020).

Saudi Arabia has also developed a modern fish feed industry based on vertically integrated companies such as NAQUA supplying their own growout operations and feed companies selling to farmers (the Arabian Agricultural Services Company [ARASCO], Maram Feeds). These well-equipped feed mills produce international-standard aquafeeds for Saudi Arabian shrimp, tilapia and marine finfish farms while also exporting to neighbouring countries.

In Tunisia, a single company, Tunisian Company for the Production of Farmed Fish Feed (SOTUPAP), produces aquaculture feeds, manufacturing 1 000 tonnes per month using raw materials approved by local authorities. Another two companies are also operating.

There has been less investment in other countries because their aquaculture industries have not reached sufficient scale. However, there is a plan to establish a private-sector aquaculture feed plant in the United Arab Emirates. Fish farms in Iraq do not have access to high quality feeds and depend on fertilisation and feeds based on locally available cereal by-products (Al-Tameemi, 2015).

Other Gulf States and Oman import their feeds from Saudi Arabia, Iran (Islamic Republic of) and Europe while North African countries either use locally produced feeds or import feeds from Europe (FAO, 2017a; Corner, Fersoy and Crespi, 2020).

3.1.4 Aquaculture health management and biosecurity

Aquaculture health management becomes increasingly important as production expands and intensifies. Until recently, freshwater finfish species such as tilapia, mullet and carp were said to have low susceptibility to disease. Any outbreak caused by parasites or bacteria could be traced to husbandry practices such as poor water quality, overfeeding, overstocking and/or poor handling. In contrast, shrimp and marine finfish were more susceptible to disease as they are prone to viral pathogens as well as bacterial and fungal diseases. However, emerging diseases such as tilapia lake virus (TiLV) demonstrate that all species are susceptible to serious disease and sustainable aquaculture must take that into account.

In recent years, FAO has embarked on the adoption and dissemination of the Progressive Management Pathway (PMP) approach to improve aquaculture biosecurity and aquatic animal health (Bondad-Reantaso *et al.*, 2018; FAO, 2019d). This is a four-stage approach focusing on building management capacity through both bottom-up and top-down approaches with strong stakeholder engagement to promote application of risk management at the producer level as part of a national approach. Stage one focusses on creation of a national strategy that has the confidence and support of the national stakeholders and addresses the principal hazards and risks that affect national aquaculture health and production. Stage two deals with implementation of a Biosecurity Action Plan in specific sectors where co-management is expected to continue and strengthen implementation and improvement. Stage three aims to establish sufficient management capacity to safeguard investments and to manage disease and other risks through a combination of public efforts, policies, legislation, and producer interest and engagement. Stage four aims to build a sustainable and resilient national aquaculture system to maintain stakeholder confidence, biosecure systems, emergency preparedness and preventive measures.

The NENA region has examples of countries and regions at different stages of the aquaculture biosecurity and aquatic animal health pathway. Countries such as Bahrain, Jordan, Libya, and Qatar have not yet developed an aquaculture biosecurity strategy or a National Strategy on Aquatic Animal Health (NSAAH) but are initiating or have had aquaculture developments. Several other countries have a NSAAH already in place, often as a result of FAO projects but these need to be revised or expanded to fit the wider PMP context. Examples are Algeria, Iraq, Kuwait, Lebanon, Morocco, Oman, the Syrian Arab Republic, Tunisia and the United Arab Emirates. Egypt and Saudi Arabia have advanced biosecurity strategies and NSAAH that can be further enhanced and used as examples of bottlenecks or good practices for other countries in the region, while regional biosecurity strategies are needed for transboundary shared watersheds (M. Bondad-Reantaso, personal communication, 2020).

The Saudi Arabian shrimp aquaculture sector provides a good example of an industry that responded effectively to aquatic animal health problems following an outbreak of white spot syndrome virus (WSSV) between 2010 and 2012. A new biosecurity strategy at national and enterprise level was developed which included the switch from Indian white prawn (*F. indicus*) to specific pathogen free (SPF) and specific pathogen tolerant (SPT) whiteleg shrimp (*L. vannamei*). This involved the development of biosecure facilities up to postlarval stages and risk mitigation measures during the rest of the production cycle. From an industry that was struggling, Saudi Arabian shrimp production is now expanding rapidly. This has been achieved with the support of the government which, noting the negative consequences of the WSSV crisis, designed and put in place a very tight national aquaculture biosecurity surveillance programme, which includes regular (monthly) sampling and analysis for all possible farmed shrimp and fish pathogens. This programme also includes Ministry-approved standard operating procedures, rapid alert systems and contingency plans in case of emergency. Compliance with its rules and guidelines is mandatory and a pre-requisite for the renewal of licences.

Egyptian shrimp farming has also been impacted by disease problems with production peaking in 2014 at 7 235 tonnes, after the introduction of Indian white prawn in 2010, but dropping to only 12 tonnes in 2015 due to bacterial infection (*Vibrio harveyi*) and WSSV. After the introduction of whiteleg shrimp SPF postlarvae in 2016, shrimp farming production increased to 135 tonnes in 2017 (Sadek, 2019).

Egyptian fish farmers have suffered significant losses from "summer mortality" of tilapia since 2013 and, while this has been linked to husbandry issues, further research may confirm that an infectious agent is the primary cause (Ali *et al.*, 2020; Fathi *et al.*, 2017; FAO, 2017b). In 2017, Tunisia adopted a legislative text on aquatic animal health which instructed 14 marine aquaculture farms to obtain zoosanitary approval as a condition of their aquaculture licence.

3.1.5 Education and training

Specialist aquaculture education and training is one of the cornerstones for a successful aquaculture sector. In Egypt, key personnel received training in United States of America universities in the 1980s and most have played their part either in the public or private sector as aquaculture specialists and advocates. Aquaculture is a relatively new subject, so even though the sector employs at least 0.25 million people in Egypt, specialist courses are offered by relatively few universities (Kafr-el-Sheikh University, Suez Canal University, Aswan University, University of Alexandria and Arish University). Aquaculture has not yet been included in the school curriculum.

Egypt also hosts the Africa Aquaculture Research and Training Center (AARTC) at WorldFish, Abbassa, that has been offering short courses in aquaculture subjects since the late 1990s (WorldFish, 2020). Specific courses have been offered for Palestinian fish farmers and for farmers from North Africa and Iraq with support from donors including FAO, United States Soybean Export Council (USSEC) and Japan through the Japan International Cooperation Agency (JICA). Courses have also been supported by the Egyptian International Centre for Agriculture (EICA), the Arab Organization for Agricultural Development (AOAD), and the Egyptian Fish Council (EFC).

Aquaculture feed companies are playing an increasing role in providing technical training to farmers. In Egypt, this is part of the extra services offered by many companies in order to secure sales and improve farm profitability.

Most aquaculture development projects in the region include training. In Morocco, a training centre is undergoing construction at Sidi Ifni as part of a recently launched marine aquaculture development project (Undercurrent News, 2020a), Algeria has a series of aquaculture training centres (ANDI, 2020) and support for aquaculture training from the Centre for Fisheries and Aquaculture Research and Development (Corner, Fersoy and Crespi, 2020). Tunisia has aquaculture courses at undergraduate and postgraduate levels at universities and specialized government training centres (écoles de pêche maritime)

Saudi Arabia benefitted from the FAO project "Strengthening and supporting further development of aquaculture in the Kingdom of Saudi Arabia" (Cardia and Lovatelli, 2016). To build on this foundation and to further support the industry, the government in Saudi Arabia, in collaboration with the Saudi Aquaculture Society, is organising technical workshops on an almost bi-monthly basis, with national and international specialists sharing their experience with relevant industry stakeholders, on key issues including new production techniques and protocols, environmental impact monitoring and control, animal health and welfare, and marketing. FAO is also providing technical and advisory training to build a cadre of aquaculture specialists.

The importance of field-based training for fish farmers was demonstrated by two Swiss-funded projects in Egypt, managed by WorldFish. Expert fish farmers helped develop a series of best management guidelines delivered in short, pond-side training sessions to groups of farmers by expert fish farmers. This participative process led to high adoption rates of more efficient management practices, resulting in significant savings and improved feed efficiency for 4 000 fish farmers (Dickson *et al*., 2016). This also underlined the importance of evaluating the impacts of training, something that is rarely done under project-based initiatives. Advanced aquaculture training for young investors is also being implemented in Bahrain (at the National Mariculture Center) and is under development in the United Arab Emirates (Food Security Office) and Kuwait. Oman has a specialized aquaculture training institute belonging to the Ministry of Manpower. It awards vocational diplomas in aquaculture while also providing short courses on ornamental fish culture and general aquaculture.

In GCC countries, university courses in aquaculture at the undergraduate and/or graduate levels are offered by universities in Kuwait, Oman, Saudi Arabia and in the United Arab Emirates. Course are also offered in higher education institutions in Lebanon. Courses are offered in general topics such as aquatic science, fisheries science, hydrobiology, marine biology and oceanography, and on specific topics such as aquaculture, aquaculture hygiene, disease, feeding, fish husbandry, food hygiene, genetics, and production.

In the Syrian Arab Republic, all universities introduced specialised courses on the main aquaculture, fisheries, biological and environmental topics. The Chinese carp hatchery had become a focal point for practical training of national fisheries officers and fish farmers on aquaculture and induced fish spawning before its destruction in 2012.

3.1.6 Research and development

As can be seen from Table 7, almost all countries in the region have national aquaculture research centres, universities that have aquaculture research programmes and aquaculture research supported by national and international funding and research linkages. Funding for these institutions varies widely, depending on the income-level of the country and priority of aquaculture in that country. Traditionally, research has been strongest in Egypt, Kuwait, Morocco, Saudi Arabia and Tunisia, although Algeria, Bahrain, Oman, Qatar and the United Arab Emirates have also built significant capacity. In Lebanon, the Aquaculture and Aquatic Science Centre at the American University of Beirut has also been active over the years.

TABLE 7. Aquaculture academic and research institutions in the Near East and North Africa region

Country	Institute
Algeria	National Centre of Research and Development of Fisheries and Aquaculture
	National School for Marine Science and Coastal Management
	Annaba University
	Shrimp Cultivation Research Center
Bahrain	National Mariculture Centre (Ras Hayan)
	Bahrain Centre for Studies and Research
	University of Bahrain (Manama)
Egypt	Arab Academy for Science and Technology, College of Fisheries Technology and Aquaculture
	Egyptian Academy of Scientific Research
	Ain Shams University
	Zagazig University
	Kafr el Sheikh University
	Cairo University
	Alexandria University
	Suez Canal University
	Arish University
	Aswan University
	Central Laboratory for Aquaculture Research
	National Institute for Oceanography and Fisheries (Hurghada)
	WorldFish Abbassa African Aquaculture Research and Training Center
Iraq	Fish Research Center (Zeafaraniyah, Baghdad)
	Marine Science Center (Basra)
	Agriculture Research Center
	Central Hatchery (Swairah)
	Fisheries and Marine Resources Department in College of Agriculture (Basra)
Jordan	National Agricultural Research Center
Kuwait	Kuwait Institute for Scientific Research (Ras Salmiya)
	Public Authority of Agriculture Affairs and Fish Resources (Kuwait City)
	University of Kuwait (Shuwaikh)
Lebanon	Marine Center - National Council for Scientific Research (Lebanon)
	American University of Beirut
Libya	Marine Biology Research Center (Tripoli)
Morocco	National Agency for Aquaculture Development (Rabat)
	National Institute of Fisheries Research (Casablanca)
	M'diq Aquaculture Centre
	University of Hassan II (Casablanca)
Oman	Oman Aquaculture Centre (Muscat)
	Sultan Qaboos University (Muscat)
	Vocational College for Marine Sciences (Al-Khaboura)
	Directorate General of Fisheries Research (Muscat)
Palestine	An Najah National University
	Islamic University of Gaza
Qatar	Qatar Aquaculture Centre (Doha)
	University of Qatar (Doha)
	Aquatic and Fisheries Research Centre (Al Khor)
Saudi Arabia	Fisheries Research Centre (Jeddah)
	King Abdul Aziz City for Science and Technology (Riyadh)
	King Abdullah University of Science and Technology / BEACON Development - Aquaculture Development Program, Jeddah

TABLE 7. (*continued*)

Country	Institute
Syrian Arab Republic	Aleppo University, Faculty of Agriculture
	Baath University, Faculty of Veterinary Sciences (Hamah)
	Damascus University, Faculty of Agricultural Engineering
	Deir Ez Zoor University, Faculty of Agriculture
	Tishreen University, Faculty of Agriculture
	Tishreen University, High Institute for Marine Research
Tunisia	National Agriculture Research Institute (Tunis)
	University of Carthage
	National Institute of Marine Sciences and Technology (Tunis)
	University of Manouba (Tunis)
	National Agronomic Institute of Tunisia (Tunis)
	Institut Supérieur de Pêche et d'Aquaculture de Bizerte
	Aquaculture Technical Center (Tunis)
	University of Monastir
	Institut supérieur de Biotechnologie de Monastir
United Arab Emirates	Marine Environment Research Centre (Dubai)
	Aquaculture and Marine Studies Center (Abu Al-Abyad)
	Marine Resources Research Centre (Umm Al-Quwain)
	Marine Environment Research Department (Umm Al-Quwain)
	United Arab Emirates University (Al Ain)
	Sheikh Khalifa Marine Environment Research Centre (Umm Al-Quwain)
	Khalifa University (Abu Dhabi)
Yemen	Aquaculture Research Centre (Aden)

Under the European Union's future of research on aquaculture in the Mediterranean region project (AQUAMED project), multi-stakeholder platforms were tasked with identifying research priorities for aquaculture in the Mediterranean (AQUAMED, 2013; CORDIS, 2020). The top five priorities were (1) to improve the transfer of research outputs to the industry: "Set up a group of economic interest involving industry, research, policy makers"; (2) "Find new alternative sources of material to replace fishmeal and fish oil in aqua feed composition" in order to define the technologies and systems that could contribute to reduce the feed cost; (3) improve communication and marketing strategies in order to improve the consumer perception and increase local consumption of aquaculture products: define "market intelligence" strategies; (4) "Collect laws and procedures in order to harmonize them and elaborate guides to administrative processes" in order to support the simplification of administrative process (time, costs, burden) for licensing; and (5) to contribute to support for territorial planning and to identify allocated zones for aquaculture: "Identification of criteria for site selection and monitoring in aquaculture".

This analysis is appropriate not just for Mediterranean countries but across the region. There tends to be poor linkage between research centres and the commercial sector, so multi-stakeholder platforms can help to build understanding between researchers and industry. Feed is the largest cost for most finfish farms, so anything that can be done to identify cheaper or more efficient ingredients is important. Aquaculture researchers often focus on technical research on feeds, breeds and disease, but understanding the market is also important for the industry, as are reducing the administrative burden and creating space for aquaculture.

The aquaculture sector has benefitted from research carried out at and managed from the WorldFish research centre at Abbassa in Egypt since 1997. WorldFish is one of the 15 Consultative Group on International Agricultural Research (CGIAR) international

agricultural research centres. The Egypt office was established as the regional research centre for Africa and Western Asia but has concentrated on research for Egyptian aquaculture and fisheries since 2012. This has focused on tilapia genetics (developing a genetically improved strain of tilapia), supporting the adoption of best management practices by Egyptian fish farmers, improving feeding practices, testing aquaculture systems (in-pond raceways, solar power) and fish processing and marketing by women retailers (WorldFish, 2017; WorldFish, 2019). The research centre also hosts the Skretting Egypt tilapia research programme.

In Saudi Arabia, there is continuous research towards improving the production efficiency of key marine fish species such as barramundi and gilthead seabream as well as experiments to adapt new species including grouper, pompano, sobaity and sabaki tilapia to local conditions. Research is financed by the Ministry of Environment, Water and Agriculture and is coordinated by the Aquaculture Development Programme (ADP/Beacon) of the King Abdullah University of Science and Technology (KAUST) in Jeddah, in collaboration with the Jeddah Fisheries Research Centre. A technical committee including government, academic and industry stakeholders has been established to identify research and development priorities, and to follow up and disseminate the results.

Kara *et al.* (2018) reviewed the dynamics of aquaculture research in North Africa (Algeria, Egypt, Morocco, and Tunisia) focusing on marine aquaculture. The study stressed the important supporting role of research helping to strengthen cooperation at a sub-regional level between Egypt and the three countries as well as stimulating innovation for sustainable aquaculture in the Mediterranean.

Since 1994, field research on areas related to aquaculture practices was conducted by the Department of Fisheries Resources (DoFR), in the Syrian Arab Republic Ministry of Agriculture and Agrarian Reform (MAAR) in collaboration with the German Agency for Technical Cooperation (GTZ). Research included fish farming technology in irrigation systems and in saline land.

In recent years the GFCM has launched two Aquaculture Demonstration Centre (ADC) units, in Romania and in Turkey that have been an effective means to share knowledge and research and technology development (RTD) innovations among countries. This concept could be replicated in other Mediterranean countries such as Egypt and Tunisia.

3.1.7 Finance and investment

Although it is frequently claimed that the development of aquaculture is curtailed by lack of investment, this is not necessarily the case across the NENA region. Taking the example of Egypt, there was initial investment by the government, allocating land and developing essential infrastructure and operating frameworks. After that, financing has almost entirely come from private-sector fish farmers, feed companies, wholesalers and retailers. Egyptian fish farming is a seasonal activity, so farmers need to be able to buy fish seed at the start of the season and fish feed throughout the season while harvest usually takes place at the end of the year. This raises cash flow problems and they find it difficult to raise finance from formal sources such as banks as fish farmers have little or no collateral. Feed companies usually offer credit on feed purchases while wholesalers also offer credit that is recovered when fish is sold at the end of the season. This means that credit control is extremely important for the feed companies who can, at times, pressure farmers into harvesting. Government-owned feed companies cannot offer credit so must sell their feeds through agents who can provide that service to fish farmers. However, this is not ideal: credit means farmers are tied to particular feed companies and wholesalers, leaving little room for negotiation on price or quality.

Formal finance institutions in Egypt have been very willing to provide finance for development of aquaculture feed companies who complain that they are left to act as the bankers for the sector. When formal finance for fish farms has been available, there has been very low uptake because many fish farms are unlicensed or do not operate as formal businesses, or finance terms do not fit the farming cycle (A.M. Nasr-Allah, personal communication, 2020).

In other middle-income countries in the NENA region, the situation is likely to be similar. Financing for small and medium-sized aquaculture businesses will tend to come from informal sources such as family, friends or other value chain actors rather than from banks or other institutions.In contrast, in high-income economies (Saudi Arabia, the United Arab Emirates, Oman), aquaculture is actively promoted for food security with subsidised inputs, soft loans and specified development zones. More development capital is available but aquaculture is a new activity and, compared to many other investments, it is considered of higher risk and/or lower returns, at least in the short-term. There is a need for clear understanding of aquaculture investment economics and risks before launching new ventures; failed ventures deter further investment. Also, investors often focus on infrastructure and disregard the need for skilled human resources to manage sophisticated systems. Donor financing for aquaculture has frequently been for training or research rather than the value chain itself but it can help to provide confidence to formal finance institutions.

All countries in NENA region have national strategic plans for aquaculture and investment development authorities. An example is the Investment Development Authority of Lebanon (IDAL) that works as a one-stop-shop to facilitate investments, particularly in cage aquaculture, as recommended by the Lebanon Economic Strategy of 2018. Investment promotion agencies for the countries of the NENA region are listed in Table 8

In Saudi Arabia, further development of the aquaculture industry is one of the pillars of VISION 2030, the national strategic plan to transform the country and its economy. In this respect, and to achieve the ambitious targets set for the industry, a number of government agencies such as SAGIA (Saudi Arabian General Investment Authority), MODON (Saudi Authority for Industrial Cities and Technology Zones), SIDF (The Saudi Industrial Development Fund) and ADF (Agricultural Development Fund) are working closely with the National Fisheries Development Programme (NFDP), an organization which has been set up as the executive arm of the Ministry of Environment, Water and Agriculture. A clear investment framework has already been established, while aquaculture licensing has also been simplified, making relevant investments more business friendly. As a result, there is already increased interest from local as well as international investors for expansion of existing aquaculture businesses or establishment of new projects. The focus has been on marine fish farming, while increased interest has been shown for shrimp aquaculture, as well as RAS-based projects.

The Arab Authority for Agricultural Investment and Development (AAAID) of the Arab League is a potential source of development funding for aquaculture development in NENA region to fulfil the vision of food security in the Arab World. While the majority of AAAID investments are in Sudan, there are also projects in Egypt, Saudi Arabia, the United Arab Emirates and other member states of the Arab League including Oman and Tunisia. The governments of Algeria, Morocco and Tunisia are very supportive as they see great potential for development while reducing fishing pressure on overexploited fisheries resources.

TABLE 8. List of key Near East and North African investment promotion agencies

Country	Agency	Website
Algeria	National Agency of Investment Development (ANDI)	http://www.andi.dz/index.php/en/
Bahrain	Bahrain Economic Development Board	https://bahrainedb.com/
	Bahrain Development Bank (BDB)	https://bdb-bh.com
	Tamkeen	https://www.tamkeen.bh
Egypt	General Authority for Investment and Free Zones (GAFI)	https://gafi.gov.eg/English/Pages/default.aspx
	Common Market for Eastern and Southern Africa (COMESA) Regional Investment Agency	http://www.comesaria.org/
Iraq	Iraq National Investment Commission	http://investpromo.gov.iq/
Jordan	Jordan Investment Commission (JIC)	https://www.jic.gov.jo/en/
Kuwait	Kuwait Direct Investment Promotion Authority (KDIPA)	https://www.kdipa.gov.kw/
	The Arab Investment and Export Credit Guarantee Corporation "Dhaman"	http://dhaman.net/en/
Lebanon	Investment Development Authority of Lebanon (IDAL)	https://investinlebanon.gov.lb/
Libya	Privatization and Investment board	http://investinlibya.ly/en/home/
Morocco	Moroccan Investment Development Agency	http://www.invest.gov.ma/
Oman	Ministry of Trade and Commerce and Investment Promotion (MOCI)	http://www.moci.gov.om
	Oman Investment Authority (OIA)	http://www.oia.gov.om
Palestine	Palestinian Investment Promotion Agency (PIPA)	http://www.pipa.ps/
Qatar	Investment Promotion Agency of Qatar (IPAQ)	http://www.ipaq.gov.qa/about
Saudi Arabia	Saudi Arabian General Investment Authority (SAGIA) Agriculture Development Fund (ADF)	https://www.sagia.gov.sa/en/ https://adf.gov.sa/
Syrian Arab Republic	Syrian Investment Agency (SIA)	http://sia.gov.sy/userfiles/reports/procedures_guide-_eng.pdf
Tunisia	Agence de Promotion de l'Investissement Exterieur (FIPA)	http://www.investintunisia.tn/
	Tunisia Investment Authority (TIA)	https://www.tia.gov.tn/en
	Agence de Promotion des Investissements Agricoles (APIA)	http://www.apia.com.tn/
United Arab Emirates	Invest in Sharjah	http://www.investinsharjah.ae/
	Abu Dhabi Investment Authority (ADIA)	https://www.adia.ae/En/home.aspx
	Dubai Foreign Direct Investment (FDI)	http://www.dubaifdi.gov.ae/English/Pages/default.aspx
	Khalifa Fund for Enterprise Development	https://www.khalifafund.ae/
Yemen	General Investment Authority	http://www.investinyemen.org/index.php?langid=2
Regional	Arab Authority for Agricultural Investment and Development (AAAID)	https://www.aaaid.org/en

Source: World Association of Investment Promotion Agencies (www.waipa.org).

3.2 SALIENT ISSUES AND SUCCESS STORIES

The NENA region will be exposed to further severe freshwater scarcity in coming decades, suitable land for development of pond-based systems will become harder to find and environmental constraints are likely to make it more difficult to develop cage-based aquaculture. If aquaculture is to expand there will need to be an increasing focus on sustainable intensification of production from existing sites as well as expansion to new sites. Intensification can be through technologies such as RAS or variations such as IPRS. The United Arab Emirates, Saudi Arabia and Kuwait have developed intensive RAS systems and the technology it is being tested in Lebanon. IPRS is being tested in Egypt.

The availability of water in Egypt is likely to be impacted by the filling and operation of the Grand Ethiopian Renaissance Dam in Ethiopia. This has been the subject of intense diplomatic efforts between Egypt, Ethiopia and Sudan with Ethiopia insisting that they aim to fill the dam in three years while Egypt and Sudan want a longer time period. The principal function of the dam is to generate electricity to relieve Ethiopia's acute energy shortages. However, the large surface area means that water will be lost to evaporation, even after the dam is filled, thereby reducing the amount of water available to Sudan and Egypt. While the impact is likely to be felt more on agriculture than aquaculture, increased evaporation and reduced flow could affect the salinity and availability of water to fish farming zones.

The reliable supply of affordable fish feed is an essential pre-condition for development of finfish and shrimp aquaculture (i.e. fed aquaculture). This has been a cornerstone in Egyptian aquaculture and has been consolidated through remarkable private-sector investment in recent years. Foreign investment has brought innovation that means Egyptian fish farmers have access to very high-quality extruded feeds. Further research will be required to fine-tune formulations for specific farming systems, ecological zones and species while farmers need to improve feed management to maximise productivity and efficiency.

Fish farms in Egypt still depend on wild-caught seed for several important species (mullet, gilthead seabream, and European seabass), leaving them vulnerable to disease and threatening the sustainability of wild fish stocks. Wild-caught seed has not benefitted from domestication or genetic improvement. Meanwhile the importation of fish seed also carries the threat of importing viral, bacterial or parasitic diseases. These practices continue because there are insufficient hatcheries in the region for species such as seabass, seabream, shrimp and mullet. Yet capacity cannot develop until wild collection is curtailed or adequately managed as recommended in the FAO capture-based aquaculture technical guidelines (FAO, 2011). The key may be to develop local genetic improvement programmes producing pathogen free, higher quality, better performing seed which are better adapted to the harsh environmental conditions experienced in many parts of the region.

As aquaculture industries develop and intensify, they usually face increasing challenges regarding fish health. The spread of diseases such as TiLV and WSSV demonstrates the importance of restricting and regulating fish movements between and within countries along with banning the use of wild broodstock or fry. Adequate quarantine systems and diagnostic capacity is needed at both country and farm level to reduce the spread of disease. However, it is impossible to treat new diseases until they have been characterised, which emphasises the need to take a precautionary approach. The most promising development has been international agreement on the PMP approach for aquaculture biosecurity advocated by FAO. This is based on practical global experience in aquatic animal health management and sets out the steps and required investments needed from farms to national governments (FAO, 2019d).

Many countries have insufficient fish disease diagnosis capacity because they lack facilities or trained personnel. In Egypt, fish health management falls within the remit of veterinary authorities who are more experienced in terrestrial animal health. In the absence of official support, the main source of advice is often agents for pharmaceutical companies. Aquatic animal health management requires access to specific treatments but the approval system often has significant delays; because few treatments are available, farmers use unapproved chemicals or apply approved ones wrongly. There are particular concerns about the misuse of antibiotics, which could lead to antimicrobial resistance (FAO, 2017b). Access to pathogen-free stocks and improvements in husbandry would significantly reduce the impact of diseases.

Meanwhile, there is an urgent need in several countries for measures to ensure food safety, including testing for veterinary chemical residues that would be required for exports to the European Union and regular testing for bio-accumulation of toxins in fish and shellfish reared in recycled irrigation water.

The majority of aquaculture-related research in the region is carried out by universities and institutes with a strictly national focus (AQUAMED, 2013; Joffre *et al*, 2017). The GFCM launched an aquaculture multi-stakeholder platform in 2013 with the objective of facilitating wider involvement of aquaculture stakeholders and contributing to the technical advice provided by the Commission on promoting sustainable aquaculture development in the Mediterranean (GFCM, 2013). This identified a series of thematic areas to start preparation of the GFCM strategy for the sustainable development of Mediterranean and Black Sea aquaculture, which was adopted in 2017. Meanwhile, aquaculture multi-stakeholder platforms (AMShP) can enhance communication, cooperation and knowledge-sharing among stakeholders and act as repositories for documents and training materials.

Lack of access to credit is among the major constraints to the development of aquaculture in NENA region. Both state-owned and private banks are reluctant to finance aquaculture enterprises because banks are not prepared or do not have the requisite expertise to carry out proper risk assessments and require feasibility studies or business plans (Naziri, 2011). Banks also ask for specific guarantees such as fixed assets, movable assets or savings certificates, which most small and medium-sized enterprises (SMEs) are not able to provide.

Investment in aquaculture is improving in some NENA countries. Gulf Cooperation Council and Maghreb countries have begun to provide easier access to loans for aquaculture expansion. Saudi Arabia has eased regulations by endorsing the "Foreign Investment Law" under which investment projects can be fully owned by foreign investors or owned jointly by Saudi Arabia and foreign investors. The ADF provides loans (with low interest and payable up to 25 years) for aquaculture projects while a flagship programme developed by FAO and Saudi Arabia has started to promote entrepreneurship for youth and women in aquaculture.

The high-risk nature of aquaculture constrains aquaculture insurance in the region. Although insurance is taken out by most salmon farming companies in Europe and the Americas, few other aquaculture sectors are considered insurable because they are either too risky or fragmented (Craze, 2020). No Egyptian fish farms are insured and the shrimp industry is considered uninsurable because of high levels of disease.

3.3 THE WAY FORWARD

Key message: ***It is important to allocate space, water, resources, services and technologies for sustainable development of aquaculture.***

Feed is the largest single operating cost for most fish farms, so even a small adjustment in cost or feed conversion will influence profitability. While it would be desirable to have more locally sourced feed ingredients, this can only be done if they can be produced in sufficient quantity and with reliable quality when compared with imported raw materials. The COVID-19 pandemic has exposed the weakness of depending on complex supply chains and should stimulate efforts to replace imported raw materials with locally produced feed ingredients. The most critical component in most fish feed formulations is protein so research on protein-rich materials should be prioritised. These include insect protein (for example crickets or black soldier fly fed on waste raw materials), marine worms (for example polychaetes) autotrophic (using sunlight) and heterotrophic production of algae

for protein and oils (for example *Schizochytrium* for omega-3 oils), halophyte plants (for example *Salicornia*), bacterial and yeast protein and the recovery of by-products from animal and fish processing. It will always be necessary to review feed formulations and carry out applied research to test new raw materials while research testing of improved feed processing methods and feeding systems is also important. Meanwhile, as aquaculture industries mature, feed companies usually consolidate because larger companies benefit from significant economies of scale. Feed companies can also act as aggregators of small-scale fish farmers, providing technical advice and extra services, such as credit, to their clients.

Fish farmers in Egypt still depend on wild-caught mullet and marine finfish seed while across the region there are few genetic selection programmes. Hatchery-produced seed is thus genetically very similar to wild seed. Yet fish performance can be significantly enhanced through genetic selection. Experience from tilapia shows around ten percent improvement in growth per generation of selection (Ibrahim, Nasr-Allah and Charo-Karisa, 2019) while many other traits, such as disease resistance can be enhanced through genetic selection. From the biodiversity point of view it may be desirable to use indigenous species and strains but a well-managed genetic selection programme will improve fish performance and farm profitability. It will also differentiate hatchery-raised seed from wild strains, thereby increasing demand for captive-bred seed and protecting wild stocks from overexploitation.

Health management issues have been addressed in shrimp aquaculture systems with the use of SPF stocks and biosecure management practices but have received insufficient attention for other species, including tilapia, where there are clear risks in stocking infected fry. There is an urgent need not only to upgrade capacity to diagnose and treat disease outbreaks but also to farm fish in more biosecure systems than flow-through ponds and cages. It is not possible to control disease transfer between farms if the outlet from one farm is the inlet for another. Farms need to consider operating zero discharge systems, such as in-pond raceways, or observe adequate spacing between production facilities. Meanwhile, widespread adoption of the FAO PMP approach to aquaculture biosecurity will help control fish disease.

Aquaculture skills need to be upgraded through hands-on training. WorldFish organised best management training in Egypt delivered by fish farmers to fish farmers in small-group, pond-side training sessions. This led to high uptake rates and improved profitability. This type of training can be shared between NENA countries through organizations such as FAO, while there may also be a role for representative organizations to coordinate and offer training as a key service for their members (for example GFCM, RECOFI).

Aquaculture research and development is usually carried out by universities, government research institutes and organizations such as WorldFish. Government-supported research is often under-funded so there is a need for researchers to look beyond this to apply for national or international research grants. This requires networking and building skills in writing compelling grant proposals. There is also an increasing role for private-sector research by feed and pharmaceutical companies. The research agenda needs to be tailored to the needs of each country and sector, which is best achieved through multi-stakeholder platforms bringing sector management authorities, researchers and aquaculture industry representatives together to decide on priority research topics.

Aquaculture is often viewed by formal finance institutions as a high-risk sector, so fish farmers may need to depend on other sources of finance such as credit from feed companies and wholesalers. This works when there are good profit margins but the cost of finance is factored into the feed price or the price paid by the wholesaler. Independent financing would improve the efficiency and profitability of aquaculture businesses because it allows them to choose their suppliers and market outlets based on service rather than the ability

to access credit. However, finance earmarked for aquaculture often remains unspent if the disbursement conditions do not match the requirements of the industry. There needs to be better understanding between finance institutions and the aquaculture sector so that the institutions can design products that fit the sector.

4. Aquaculture and environmental integrity

4.1 STATUS AND TRENDS

4.1.1 Background

Most forms of aquaculture are affected by environmental conditions and in turn have an impact on the surrounding environment. For example, the quality of incoming or surrounding water affects farming practices while the application of feeds and the metabolic processes of the aquaculture species may impact nearby lakes, rivers or surrounding water bodies. Unplanned or badly managed aquaculture development can lead to negative environmental impacts that can outweigh the long-term benefits of growing more aquatic products (Aguilar-Manjarrez, Soto and Brummett, 2017; FAO, 2017c). In order to address this, the FAO developed the ecosystem approach to aquaculture (EAA) that provides a planning and management framework for integrating the aquaculture sector into local planning (FAO, 2010; FAO, 2017b; FAO, 2018b; Soto *et al.*, 2012).

In the NENA region, the expansion of aquaculture poses important environmental threats while water pollution, such as that in the Nile Delta irrigation system, could threaten its own sustainability (FAO, 2014). Meanwhile there is concern about the potential impacts of increasing cage culture across NENA region (FAO, 2019a), especially in Egypt where thousands of small-scale cages concentrated in the lower reaches of the Nile have been blamed for oxygen depletion. Cage aquaculture has not been allowed in Lake Nasser (El-Ezaby, El-Sonbati and El-Sayed, 2010).

Environmental impact assessments are required as part of the approval process for new aquaculture projects in most NENA countries. Examples include Egypt's 1994 Egyptian Environment Law No. 4/1994 (Hebisha and Fathi, 2014), the United Arab Emirates' Federal Law No. 23 (1999) on aquaculture activities that features pollution control and regulations on alien species (Regunathan, 2012) and the Sustainable Aquaculture Policy for the Emirate of Abu Dhabi developed by the Environmental Agency – Abu Dhabi (EAD). Algeria and Morocco have recognized that environmental protection is a major concern and stress the importance of tackling all environmental aspects related to aquaculture at sea, in particular by carrying out EIAs and by identifying areas allocated for aquaculture (AZAs) along the marine coastline (FAO, 2017d). In Oman, the Ministry of Environment has taken great care during its approval process for EIAs for cage-based farms because of concerns about pollution (Prins, 2015).

4.1.2 Fish farms and water quality

Finfish aquaculture usually depends on artificial feed, some of which is not eaten, while the consumption of feed results in excretion of ammonia, faeces and other metabolites into the surrounding environment. Farmed fish also respire, consuming oxygen and emitting carbon dioxide. The impacts on the environment are most apparent in flow-through systems and cages, whereas the impacts in ponds are more complex as there are interactions with pond microbiota such as zooplankton and algae. Potential negative impacts include eutrophication and oxygen depletion. Significant amounts of hydrogen sulphide and nitrification have been noted in bluefin tuna culture in the western Mediterranean as well as in freshwater cages in the Nile (Potts *et al.*, 2016).

These impacts can be minimised by reducing stocking densities or the number of fish farm holding structures in a particular area or ecosystem, with the aim of causing minimal discernible damage. Most fish farm licensing systems require fish farms to apply for a discharge consent from the relevant regulatory authority (usually the Ministry of Environment), that has conditions such as the quantity of fish that can be held at a particular location, the amount of feed that can be fed or the permissible changes between incoming and effluent water in a flow-through system. Sophisticated modelling programmes have been developed to predict the impact of cage aquaculture effluents on aquatic environments. However, these are more advanced for temperate aquaculture than they are for warm water environments (Potts *et al.,* 2016; Keeley *et al*., 2013). In Saudi Arabia, technical guidelines and criteria for cage farms were developed by consultants under the FAO project "Strengthening and supporting further development of aquaculture in the Kingdom of Saudi Arabia". This helped to define selection for suitable sites in the Red Sea for deployment of offshore cages that led to the publication of an investment strategy for the sector (MEWA, 2020a; MEWA, 2020b; Cardia, Ciattaglia and Corner, 2017)

Integrated multi-trophic aquaculture systems aim to balance finfish aquaculture with shellfish, seaweeds and other organisms such as sea cucumbers that can take advantage of the higher levels of nutrients close to fish farming structures and reduce negative impacts of finfish aquaculture in marine environments. Aquaponics systems recirculate aquaculture water through hydroponically grown plants so that fish excreta and metabolites fertilize the plants and the plants remediate the water. Other systems such as IPRS or RAS result in low or no discharges to aquatic environments.

Fish farm effluents can contain more than just fish faeces and dissolved metabolites such as ammonia and phosphates. If chemicals are used in the fish farm these can end up in the environment and impact the health of other organisms. For example, residues from chemicals used to treat fish parasites or antibiotics used to treat bacterial infections may be deposited on the seabed or in a receiving waterbody. Most tilapia hatcheries in NENA countries, where it is permitted, use methyl testosterone in the first feed for fry to convert all the fish to male. The amounts used are very small and for a limited period so are not detectable in fully-grown farmed fish but the effluent from a hatchery could contain enough hormone to have unintended consequences for wild fish or affect the health of workers mixing and applying the feed. Alternative technologies such as the use of "genetically male tilapia" (produced from YY supermales) have been available for many years but have not gained widespread acceptance in the region. This may be because it is more expensive, or due to limitations in the strain that can be used. However, the proponents of the YY technology claim that hormonal sex reversal has negative impacts on the robustness of tilapia fry (Scott *et al.*, 1989; FAO, 2017a).

Fish farms are also affected by the quality of incoming or surrounding water. By law, Egyptian fish farms must use water from agricultural drainage canals or from drainage lakes. This is not necessarily as bad as it sounds because the main contaminants are nitrogen and phosphates that boost algal growth in the ponds, reducing the need for additional fertilisation. However, other waste streams also enter the canals, including industrial wastewater and domestic sewage. As explained in Section 3.1.1, a limited testing programme was carried out as part of an aquaculture certification project managed by WorldFish (WorldFish, 2018). This work, together with research carried out by Wageningen University investigating the use of reed beds to remediate agricultural drainage water, appears to indicate that tilapia, deriving most of their nutrition from compound feeds, do not bio-accumulate toxins found in the water (D.A.R. Kenawy, personal communication, 2020; Van der Heijden, Van Dien and El-Beshbishi, 2015). More research is required to establish whether this is the case across all aquaculture zones, at different times of year and for different species.

While Egyptian fish farmers have been calling for access to "clean" Nile water for decades, this is unlikely as there is insufficient Nile water in the areas around the main fish farming zones. However, a new project to remediate drainage water in Ismailia may point the way forward (Takouleo, 2020). The Al Mahsamma Project is designed to improve the quality of water being transferred from the Ismailia drainage canal to agriculture farms in the Sinai Peninsula while improving water quality in Temsah Lake that previously received large quantities of untreated drainage water. Similar projects could be used to remediate water from other agricultural drains such as those supplying water to the main fish farming zones. Research on water quality seasonality in marine fish ponds the Deeba Triangle Zone, near Lake Manzala, demonstrated that water quality parameters were influenced by the seasonality of activities in nearby petrochemicals plants which might affect fish yields (El-Mezayen *et al.*, 2018). It is also important to reduce the water demand of fish farms by using aeration and no-discharge systems such as in-pond raceways, thereby reducing the risk of exposure to contaminants.

4.1.3 Biodiversity impacts

Compared to other parts of the world, less attention has been paid to the potential impacts of aquaculture on biodiversity in NENA region. For example, carps (common carp, silver carp, grass carp) have been widely introduced across the region but are not recognised as invasive species in the same way as they are in countries such as Australia and the United States of America. Potential impacts might be escapes of invasive species, pollution from aquaculture, conversion of sensitive land areas, overexploitation of resources (for example for fishmeal), spread of disease from captive to wild stocks, alteration of the genetic composition of wild stocks through inter-breeding with escaped farmed fish, predator mortality (for example culling birds) and harmful release of chemicals (for example antibiotics and hormones) into the environment (Diana, 2009).

While the main fish species used for aquaculture in NENA region are indigenous (for example mullets, European seabass, gilthead and sobaity seabreams, etc.), several are not (for example whiteleg shrimp, barramundi, Chinese carps) or are only indigenous to some parts of NENA region (for example tilapias, African catfish). In addition, genetic improvement can mean that farm stocks have developed different characteristics to native wild strains so any escape of farm stocks into the ecosystem is undesirable.

It has been estimated that human activities including shipping, aquaculture and the opening of the Suez Canal have led to the introduction of nearly 1 000 alien species to the Mediterranean Sea, 64 of which (41 species of macrophytes and 14 species of invertebrates) were introduced, usually unintentionally, through aquaculture (Katsanevakis *et al.*, 2014). A recent publication estimates that the Arabian Peninsula has at least ten alien species of freshwater fish (Freyhof *et al.*, 2020) and, as aquaculture expands, negative interactions with native fauna are very likely (García *et al.*, 2015).

Fish farms in northern Egypt have been criticised for reducing the area available for wild fisheries in lakes such as Manzala and Burullus by expanding their ponds into the lakes and discharging nutrient-laden water. These are RAMSAR (Convention on Wetlands of International Importance especially as Waterfowl Habitat) sites that are particularly important for bird biodiversity and migration and should be protected from illegal encroachment by fish farms (Zingstra, 2013).

The use of wild species for broodstock or larvae such as the collection of wild mullet and marine finfish seed along the Mediterranean coastline of Egypt (see Section 3.1.2) could result in depletion of wild stocks.

One clear example of negative impacts of escapes in the region is the Louisiana red swamp crayfish (*Procambarus clarkii*) causing problems for fisheries in the Nile, in irrigation canals and in aquaculture ponds through its burrowing habit and predation on wild fish (Haubrock *et al.*, 2019). This highly invasive species is widely dispersed all along the Nile system and, as a result, a fishery has developed to target crayfish for export (FAO, 2017a; Fouly and Danni, 2019).

4.1.4 Certification systems

Although one of the major aims of aquaculture certification systems is to ensure that products are safe to eat, third-party certification also applies to the farming methods and can include criteria on environmental impacts, worker conditions, animal welfare and water quality. For example, the Aquaculture Stewardship Council (ASC) "promotes industry best practice to minimise the environmental and social footprint of commercial aquaculture" and the best aquaculture practices promoted by the Global Aquaculture Alliance (GAA) are "built on four pillars of sustainability: food safety, environmental, social welfare and animal health and welfare". The GLOBAL G.A.P. aquaculture standard "sets strict criteria for legal compliance, food safety, workers' occupational health and safety, the GLOBAL G.A.P. risk assessment on social practice, animal welfare and environmental and ecological care".

Oman and Saudi Arabia have committed to certification of their export-oriented aquaculture programmes. In 2015, NAQUA became the first company in the region to achieve GLOBAL G.A.P. aquaculture and compound feed manufacturing certification (Towers, 2015). Saudi Arabia signed a memorandum of understanding (MoU) committing all aquaculture facilities to achieve BAP certification (BAP, 2016). Around 9 percent of the Saudi Arabian output is currently BAP certified and the aim is for the industry to achieve 100 percent BAP certification compliance by the end of 2020. In addition, a "Saudi Arabian Code of Responsible Aquaculture Practices" was developed for certification and labelling of the national products of aquaculture under the SAMAQ logo (SAudi Mark of Aquaculture Quality). SAMAQ is based on international guidelines and compliance criteria and serves as the country's benchmark for responsible aquaculture practices.

Oman requires all new aquaculture projects to adhere to nationally developed "Better Management Practices" and secure and maintain certification to an international standard such as ASC. However, in other countries of the region there has been relatively low uptake of aquaculture certification as most production is consumed locally and certification confers little or no advantage in local markets. However, there are consumers in NENA markets who are very concerned about food safety and other sustainability issues, so locally managed certification systems may have a role to play.

4.2 SALIENT ISSUES AND SUCCESS STORIES

Environmental legislation designed to limit negative impacts of aquaculture has been enacted by most countries in the region but frequently appears insufficient. Where environmental legislation has not yet been developed, this needs to be done and existing legislation needs to be reviewed and revised to reflect what is happening on the ground as the sector develops. FAO has assisted several regulatory authorities to develop appropriate legislation, including Morocco in recent years (Dabbadie, Beveridge and Ababouch, 2017). Environmental legislation also needs to be enforced, which is easier in situations where there are relatively few, large farms but difficult when, as is the case in Egypt, there are many small, unlicensed fish farms.

The regulatory authority needs to have sufficient capacity to monitor the impacts of aquaculture and to implement enforcement measures when fish farms exceed their agreed

discharge consents or other agreed environmental practices. Particularly in marine environments, local level impacts may have wider consequences which call for a regional approach (Thompson *et al.*, 2016; FAO, 2017c; GFCM, 2018). Unfortunately, many countries in the region do not have a permanent environmental monitoring system in place for aquaculture and there can be a lack of cooperation among farmers and institutions for monitoring. Moreover, poor harmonization of norms and standards increases difficulties in monitoring (GFCM, 2018) which suggests a need for national capacity building. The Mediterranean countries managed to finalize guidelines on a harmonized environmental monitoring programme (EMP) for marine finfish cage farming, but some countries had implementation difficulties (FAO/GFCM, 2015; FAO, 2017d). A guide for establishment of coastal zones dedicated to aquaculture in the Mediterranean was prepared by GFCM in order to maximize and harmonize technical and scientific knowledge on AZA (Fourdain *et al.*, 2019; Macias *et al.*, 2019; FAO, 2019e).

Mediterranean countries of the NENA region adopted a strategy for development of aquaculture that aims to "enhance interactions between aquaculture and the environment while ensuring animal health and welfare" (GFCM, 2018; Massa, Demian and Bourdenet, 2018). Cooperation and participation, including multi-stakeholder platforms, were key to addressing aquaculture's environmental aspects (FAO/GFCM, 2015).

International certification systems are becoming the norm for export-oriented products, including shrimp and marine finfish, but local certification systems could also provide reassurance to domestic consumers. This is particularly important in markets such as in Egypt and Saudi Arabia where many consumers are concerned about the quality of farmed fish. Certification also drives adoption of best practices not just in farms but throughout the supply chain. Oman and Saudi Arabia have committed to mandatory certification of all aquaculture production systems through international or local certification.

Some aquaculture systems are more likely to threaten ecosystems than others. At one end of the spectrum is bluefin tuna production that threatens the sustainability of the species (Metian *et al.*, 2014) as well as the aquatic environment close to cages; at the other is bivalve shellfish and seaweed aquaculture where no feed is required and there are very low discharges to the surrounding environment. These low-input types of aquaculture system have been slower to develop in the NENA region than almost any other region of the world, perhaps because the products are not valued in local markets. However, growing international markets for mussels, oysters and seaweed should be explored. Experiences from Algeria, Morocco and more recently in the United Arab Emirates with oysters should be shared with other countries in the region.

A sound site selection process is needed that includes the use of AZA, site carrying capacity and vulnerability assessment (FAO, 2017c). Spatial planning could also be a means to improve negative public perception about environmental impacts (Aguilar-Manjarrez, Soto and Brummett, 2017).

4.3 THE WAY FORWARD

Key Message: ***Focus is needed on improved environmental management, aquaculture certification and low-input aquaculture systems***

Above and beyond national environmental management and permitting processes, two overarching approaches should guide the continued development of aquaculture in the region: the Ecosystem Approach to Aquaculture and aquaculture certification based on systems such as ASC, BAP or the GLOBAL G.A.P. aquaculture standard. Environmental management

is only one aspect of certification as its main aim is to differentiate certified products in the marketplace from products that have not attained the same standards. Organic certification is also potentially important as it has high levels of consumer recognition and immediately differentiates farmed product from wild-harvested that cannot be certified as organic.

The EAA, promoted by FAO as an extension of the ecosystem approach to fisheries (EAF) ensures that there are adequate consultations with other stakeholders and that aquaculture farms operate as responsible and "good neighbours". Fish farms need to consider their impacts on aquatic ecosystems and biodiversity as part of the EAA. This can be implemented as part of an overall system of marine spatial planning or integrated coastal zone management (ICZM) plan (Meaden *et al*., 2016).

Certification will help to raise standards throughout the value chain, not just in fish farms but also in feed mills, wholesalers, transporters and in retail, providing reassurance to consumers that farmed fish is being produced to international standards whether it is being sold locally or exported. However, aligning with international certification systems will identify practices that are not acceptable such as the unmanaged use of wild-caught seed and farming fish in recycled irrigation water. These are systemic problems that need to be addressed through updating and enforcing legislation as well as investment in infrastructure.

Fish farms in the region need to reduce their dependency on freshwater by becoming more efficient, producing more fish with less water. RAS, IAA and IPRS offer opportunities to do this, while aquaponics may be applicable in locations where there is a premium market for local, sustainable supply. Moving production to marine systems should be another option, but the cost of production for marine species such as seabass, seabream or shrimp is much higher than for freshwater species such as tilapia and mullet, so they target distinctly different markets.

More of the countries in the region should consider strategies to develop low-input aquaculture sectors, such as bivalve shellfish and seaweeds, as is currently being pursued by Morocco. Global markets are expanding and these systems offer multiple environmental benefits including carbon sequestration and providing habitat for wild juvenile marine fish.

5. Markets and Trade

5.1 STATUS AND TRENDS

5.1.1 Fish imports and exports

Almost all the fish produced through aquaculture in NENA countries is sold in local markets. The exceptions are a portion of the shrimp, tilapia, marine finfish and bivalve shellfish produced in Egypt, Morocco, Saudi Arabia and Tunisia. Fish trade statistics are not disaggregated into aquaculture or fisheries products. However, most countries in the region are net fish importers (Table 9). Only Morocco, Oman and Yemen export more fish and fish products than they import in both volume and value terms. However due to the rather low levels of their aquaculture production (combined total of 1 718 tonnes in 2018), the contribution that aquaculture makes towards their exports remains rather small. However, Morocco and Oman have ambitions to become significant aquaculture exporting countries. Tunisia is a net fish importer in volume terms, although it is a net exporter in terms of value.

Saudi Arabia exports the largest quantity of aquaculture produce in the NENA region – its total exports of 68 539 tonnes (net-product weight), valued at USD 0.3 million, in 2018 are mainly cultured shrimp. However, the country imported 234 282 tonnes of fish in the same year, creating a negative trade balance in fish and fish products. Egypt was also a net fish importer with a negative trade balance in 2018. Egypt currently has no processing plants approved for export of aquaculture-produced fish to the European Union although it has 22 plants approved for the export of fish from capture fisheries. Egypt exported tilapia to several countries in the NENA region, including Palestine and Saudi Arabia.

TABLE 9. Fish trade in the Near East and North Africa region in 2018

Country/territory	USD 1 000			Tonnes (net-product weight)		
	Exports	Imports	Net trade	Exports	Imports	Net trade
Algeria	13 538	125 719	- 112 181	3 377	33 291	- 29 914
Bahrain	69 057	72 470	- 3 413	26 693	30 352	- 3 659
Egypt	35 344	915 554	- 880 210	23 913	565 536	- 541 623
Iraq	54	139 614	- 139 560	172	43 604	- 43 432
Jordan	2 823	113 774	- 110 951	1 016	31 765	- 30 749
Kuwait	2 443	229 161	- 226 718	426	47 114	- 46 688
Lebanon	2 864	163 773	- 160 909	336	38 158	- 37 822
Libya*	35 811	213 691	- 177 880	2 541	48 915	- 46 374
Morocco**	2 355 904	244 324	2 111 580	714 254	99 000	615 254
Oman	331 744	66 645	265 099	286 605	32 284	254 321
Palestine	1 102	24 384	- 23 282	195	6 767	- 6 572
Qatar	735	104 080	- 103 345	525	31 769	- 31 244
Saudi Arabia	308 813	653 685	- 344 872	68 539	234 282	- 165 743
Syrian Arab Republic	691	47 219	- 46 528	69	16 329	- 16 260
Tunisia	187 646	71 675	115 971	23 355	31 487	- 8 132
United Arab Emirates	412 988	776 001	- 363 013	100 195	253 163	- 152 968
Yemen	123 530	48 410	75 120	52 723	13 929	38 794
Total	3 885 087	4 010 179	- 125 092	1 304 934	1 557 745	- 252 811

Source: FAO, 2020h.
* Libyan official figures may not reflect the actual situation as there is significant unregistered trade with neighbouring countries.
** Including the territory of Western Sahara.

However, this growing trade was disrupted around 2018, when export tariffs were imposed by the Egyptian Government with the aim of protecting supplies for the domestic market (A.M. Nasr-Allah, personal communication, 2020).

The countries that imported the largest quantities of fish products in 2018 were Egypt, the United Arab Emirates and Saudi Arabia, followed by Morocco, Libya and Kuwait. A significant proportion of these imports are likely to have been produced through aquaculture including *Pangasius* catfish, salmon and shrimp. Countries such as Egypt also import large quantities of lower value marine species such as frozen mackerel, herring, horse mackerel and sardines. These trade flows are likely to have been disrupted by the COVID-19 pandemic in 2020 (see Section.7.1.3.).

5.1.2 Domestic markets

Most of the aquaculture production in NENA region is sold in domestic markets and all countries in the region, apart from Morocco, Oman and Yemen, in both value and volume terms, and Tunisia in value terms only, imported more fish and fish products than they exported. This indicates that there is already significant demand for fisheries and aquaculture products in domestic markets while the relatively low per capita consumption rates in most countries of the region indicate potential for further expansion (see Section 6.1.1). However, the characteristics of markets vary widely across the region.

As the most populous country, Egypt has the largest domestic market for fish in the region and the majority of that fish comes from aquaculture (FAO, 2003–2020). Egyptian fish farmers do not assume responsibility for marketing their fish because wholesalers play this role. The wholesaler comes to the farm, usually in an open pickup truck when fish are ready for harvest. Wholesalers tend to have a pre-existing relationship with the farmer as they usually provide credit for operating expenses. Fish is sorted by the farmer, at the pond side, into plastic boxes according to species and grades, and prices are agreed. The fish is then transported to a wholesale market where it is auctioned and distributed to retailers in local markets or to shops and restaurants or distributed without going to auction (Hebisha and Fathi, 2014; Nasr-Allah and Dickson, 2017). Post-harvest handling practices in the market chain are very basic with insufficient ice used to chill the fish or maintain fish at chilled temperatures. Most wholesalers use uninsulated plastic boxes and auction markets operate at ambient temperatures. This means the shelf-life of the fish is very short, around two days, but fortunately good transport links and relatively short distances between farms and markets means that it is sold quickly. However, there is significant loss of value through the market chain that places pressure on small-scale retailers who must sell the fish quickly because most do not have facilities to preserve fish overnight (Kantor and Kruijssen, 2014). Many fish markets have fish fry shops that clean the fish and fry or grill it for home consumption. Egyptians usually grill tilapia without removing the viscera as the fish have gone through a fasting period (S. Sadek, personal communication, 2020). A limited amount of farmed fish in Egypt is sold through supermarkets, including some which is filleted and packaged (Macfadyen *et al.*, 2012; WorldFish, 2019).

Egyptian wholesalers and retailers have been slow to adopt improved handling practices because they find a ready market for their fish, but better practices could open up opportunities to expand into more quality-conscious markets including tourist hotels, processing and exports. Research has shown that if tilapia is chilled and maintained at chilled temperatures the effective shelf-life can be at least seven days (Moawad *et al.*, 2017). Other research indicated that domestic markets could be expanded as the availability of farmed tilapia and the frequency of tilapia consumption was higher at or near production areas; in non-producing areas, tilapia was usually available only on village market days (Eltholth *et al.*, 2015).

There has been an increasing trend in Egypt to sell live farmed fish, transporting it in plastic drums equipped with basic air blowers often over long distances from the Nile Delta to Upper Egypt. Customers pay a premium for live fish in retail markets but the transport and holding conditions are very poor so the fish die quickly (Macfadyen *et al*., 2012).

The marketing model in Egypt seems to be prevalent in other low and middle-income countries of the region, whereby the market is controlled by a limited number of large wholesalers who are linked to wholesale markets. Daily auctions determine farm-gate and retail market prices for fish that is then distributed to shops, restaurants and informal retailers. In Lebanon, local fish production is marketed to consumers through auctions, by licensed or unlicensed shops/supermarkets and fish stalls, directly by fishers or by street vendors (Pinello and Majdalani, 2018).

In high-income countries such as Kuwait, Oman, Qatar and the United Arab Emirates, dedicated, modern fish markets have been established (Feidi, 2019; AKDN, 2020; FAO, 2009–2020a) while the role of supermarkets has also increased. However, most aquaculture products are still sold fresh, mostly whole and in unprocessed form without any value added (FAO, 2017a). In Saudi Arabia, the development of export markets for shrimp and marine fish has helped aquaculture companies to apply total quality management systems, where the products are properly iced and packed in polystyrene boxes and transferred to wholesalers and/or retailers. This has been a key factor behind increasing sales of aquaculture products through major supermarket outlets and in regions of the Kingdom where seafood had not been part of the traditional diet. Online retailing is also becoming more important in several countries and its popularity appears to have increased during the COVID-19 crisis (Undercurrent News, 2020b). With the need to implement physical distancing and other regulations to face COVID-19, an integrated online platform for fish auctioning was launched by Oman's Ministry of Agriculture and Fisheries, in cooperation with the Oman Technology Fund. The Behar platform is currently being piloted in the country's second largest fish market, but there are plans to extend to aquaculture products.

Where aquaculture production is limited and a marketing system has not yet been established, local markets usually play a more important role. The majority of Saudi Arabian tilapia and catfish production in freshwater systems is sold in the domestic market either live or fresh to wholesalers at or near the farm site and the products are distributed to a chain of retail shops around the country (FAO, 2010–2020).

5.1.3 Export markets

According to official statistics, NENA countries exported around 1.3 million tonnes product weight of fish and fish products in 2018 worth around USD 3.9 billion. Saudi Arabia is the largest exporter of aquaculture products in the region and its largest aquaculture export is shrimp. Most of its aquaculture-produced shrimp is exported to Asia, the United States of America and the European Union while exports started to China in 2018 (FAO, 2010–2020).

Tunisia is a net exporter of fish and fish products in value terms, exporting European seabass and gilthead seabream to Europe and North America, in addition to local hotels, restaurants and wholesale markets. Bluefin tuna from Tunisia was sold to Europe and Japan before production shut down around 2018 (FAO, 2005–2020b; Gennari, 2019).

The main export market for Moroccan aquaculture products (mainly oysters, European seabass and eel) is Italy, which absorbs more than 60 percent of exports while France and Spain together account for about 30 percent. Reflecting its bilateral collaboration with the European Union and Japan, Morocco has engaged in promoting sustainable aquaculture

through technical collaboration projects including traceability practices and promotion of sanitary safety (UNCTAD, 2016).

Egypt has exported tilapia to regional markets, particularly Gaza and Saudi Arabia. However, the trade was curtailed following the imposition of an export tariff in August 2017 that was lifted in January 2019 (A.M. Nasr-Allah, personal communication, 2020). This has allowed trade to resume in limited quantities as concerns were raised over the quality of Egyptian farmed fish being exported to Saudi Arabia. Egypt has embarked on a series of major fish farming projects on the north coast and along the Suez Canal with dedicated processing facilities, targeting increased exports of high value products, including marine finfish and shrimp (Feidi, 2018).

Oman has identified aquaculture as one of the key pillars for diversifying its economy. The Ministry of Agriculture and Fisheries of Oman has estimated that aquaculture production in 2030–2040 could be as high as 220 000 tonnes with an estimated market value of USD 900 million. In 2011, Oman adopted a set of better management practices requiring all producers to have international accreditation in the future, a stipulation that should help the country develop export markets (UNCTAD, 2016; FAO, 2006–2020a).

5.1.4 Future prospects

In 2013 the World Bank developed a revised model for predicting global fish supply and demand. The model contemplated a range of scenarios such as faster growth rates of aquaculture and fisheries, fish disease and climate change. The overall conclusion was that aquaculture will continue to fill the growing supply-demand gap in the face of rapidly expanding global fish demand and relatively stable capture fisheries, predicting that 62 percent of global fish supply will be produced by aquaculture by 2030, so ensuring the successful and sustainable development of global aquaculture is an imperative agenda for the global economy. Under the baseline scenario of the 2013 IMPACT model, total fish supply in the Middle East and North Africa (including the Islamic Republic of Iran) was predicted to reach 4.68 million tonnes in 2030 while food fish consumption was 4.73 million tonnes. However, investments in aquaculture must be taken with consideration for the entire seafood value chain (World Bank, 2013).

More recently, a medium-term projection of fish supply and demand to 2030 was included in the 2020 FAO State of World Fisheries and Aquaculture report (FAO, 2020e). Based on the FAO fish model, the outlook foresees an expansion of total fish production (excluding aquatic plants) from 179 million tonnes in 2018 to 204 million tonnes in 2030, which represents a 15 percent increase compared to 27 percent growth in the period 2007 to 2018. Global aquaculture production is expected to reach 109 million tonnes in 2030, an increase of 32 percent over 2018 and within this, Egypt is expected to increase aquaculture production by 42 percent over the same period to reach 2.2 million tonnes by 2030. The global projection is based on an average annual growth rate of 2.3 percent compared to 4.6 percent in the previous time period. This relative slowdown is expected to result from broader adoption of environmental regulations, reduced availability of water and new aquaculture sites, increasing disease problems and decreased aquaculture productivity gains while reduced growth of Chinese aquaculture is also expected. Aquaculture is expected to fill the supply-demand gap and food fish supply will increase in all regions but per capita fish consumption is expected to decline in Africa. Meanwhile the proportion of fish that is traded will remain stable and reforms in China will have noticeable impacts at the world level as China will continue to dominate global production and consumption.

This supports a 2017 study published by FAO suggesting that income growth would drive world fish demand up by 47 million tonnes per year by the early 2020s but aquaculture production would only cover 40 percent of the projected demand growth, leaving a global fish demand-supply gap of 28 million tonnes (Cai and Leung, 2017). This study suggested that the demand-supply gap for shellfish would be greater than that for finfish. To fill the gap would require 9.9 percent annual growth of aquaculture whereas actual growth rates were expected to be 4.5 percent. The demand would occur across 170 countries; however, aquaculture growth is expected to come from only 17 countries. Projections in the 2018 FAO State of World Fisheries and Aquaculture Report (FAO, 2018c) highlighted similar trends suggesting that expanding world aquaculture production will grow more slowly than in the past but is expected to fill the supply-demand gap for fish.

These models concur that global demand for fish and fish products will increase and that aquaculture will be the main source to meet that demand. It also appears that aquaculture products will be traded across many nations from relatively few producing countries, which suggests that NENA countries must not only focus on domestic food security and reducing fish imports, but also prepare to meet demand for fish in other regions of the world.

5.2 SALIENT ISSUES AND SUCCESS STORIES

Until now, most NENA countries have focused on aquaculture for domestic markets. The exceptions are Saudi Arabia with shrimp and barramundi and also some of the North African countries with limited quantities of marine finfish and shellfish. A focus on food self-sufficiency and reducing fish imports makes sense but should not be the only strategy as seafood is a widely traded commodity and there may be opportunities to produce high value products for export while also growing more affordable or locally preferred products for domestic markets.

NENA aquaculture production is dominated by freshwater and brackishwater finfish species yet it is one of the regions of the world where freshwater is most scarce. While this presents a strong rationale to concentrate on marine aquaculture, it has to be recognised that markets for marine species such as European seabass, gilthead seabream and shrimp are quite different to those for freshwater and brackishwater species such as carp, tilapia and mullet. Marine species tend to be consumed by more affluent consumers within the region or need to be exported and national administrations may not have the systems in place to participate in international trade. Although traditional barriers to trade such as tariffs have been reduced, technical measures such as phytosanitary standards, traceability and aquatic animal welfare have become important factors for exports and the measures vary from market to market (Drakeford, Failler and Asche, 2014). Saudi Arabia is a good example of a country that has built its capacity to export aquaculture products, while good progress has also been made in Morocco, Oman and Tunisia. Both Oman and Saudi Arabia are demonstrating their ambition to build international trade through their adoption of certification (see Chapter 4). Organic standards for aquaculture have been developed for different aquaculture species and production systems and Morocco has taken the first steps in this regard (European Union, 2019; UNCTAD, 2016).

Certification systems could also have a role to play in domestic markets as consumers in many countries are concerned about the quality of farmed fish. In Saudi Arabia, the launch and promotion of SAMAQ as the national label for certification of aquaculture products was received very positively by major retailers. Already more than 120 branches of the five major supermarket chains are trading SAMAQ certified and labelled products in special displays within their fresh seafood sections. According to consumer surveys they prefer SAMAQ labelled products to non-labelled alternatives. An Egyptian tilapia standard was developed

by WorldFish and several of the main feed companies, with support from the Sustainable Trade Initiative (IDH). This project resulted in 50 fish farms producing fish that could carry an Egyptian Quality Tilapia label, demonstrating enthusiasm for quality certification from fish farmers and other value chain actors. However, the project was not sustained after the two years of IDH funding ran out, probably because there was insufficient time to build recognition of the quality label amongst fish buyers (D.A.R. Kenawy, personal communication, 2020).

It is also important to have a good understanding of what consumers want. As the quality of feeds, farming practices and fish genetics have improved in Egypt, there tend to be more of the larger tilapia grades in the market and these are sold at higher unit prices (EGP/kg). However, this may push prices beyond what is affordable by the majority of Egyptian tilapia consumers who prefer cheaper, smaller fish (Murphy *et al.*, 2020a). This presents an opportunity to adapt aquaculture systems to market needs; for example, by growing two crops of smaller fish in a season rather than one crop of large fish while other traits including colour, taste and market presentation may be equally important.

Aquaculture markets in NENA tend to deal in whole, fresh fish without any processing. As economies develop, demand for convenience products that can be sold through supermarkets and online tends to rise. Value added processing and packaging has the potential to open up new domestic and international markets, creating new businesses and employment, some of which will be for women.

5.3 THE WAY FORWARD

Key message: ***More investment is required to build resilient marketing systems***

In order to participate in international trade, there needs to be investment at all levels in the institutions and systems that will allow producers and processors to access the main international markets for seafood (China, European Union, Japan and the United States of America) while also opening up new market opportunities in regions such as sub-Saharan Africa where demand for fish is expected to grow. As well as necessary compliance with food safety and regulatory measures, countries in the region need to observe other market requirements including assurances of responsible farming practices, social responsibility, animal welfare and environmental sustainability as well as religious requirements such as halal while traceability along with proper naming and labelling of the products at both the business to business (B2B) and business to consumer (B2C) level are also important. Lessons can be learnt from Saudi Arabia and countries such as Viet Nam that have focused on building their capacity to export farmed seafood through trade promotion and investment in testing and certification. The increased focus on exports will almost certainly help to drive up quality in domestic markets. While this may increase costs and possibly market prices, at least some of the costs will be offset by reduced losses in the marketing system.

The development of effective marketing groups or organizations is important. Some NENA countries already have suitable organizations in place but many do not. Their main role is to lead in the implementation of certification systems, compliance with production standards, establishing quality and contaminant testing systems and developing trade contacts. They need to attend trade shows, organise local events, track global markets, and respond to trade enquiries and requests for information. This will preferably be led by a representative organization funded by the aquaculture value chain (Fezzardi *et al.*, 2013; Rad *et al.*, 2014; Barazi-Yeroulanas, 2010), for example, by applying a levy on feed sales.

Many aquaculture markets in NENA are missing out on economic activity and employment opportunities by only selling whole, fresh fish. Developing processing to supply packaged fish or fish fillets, as has been done in Saudi Arabia, will open up new domestic markets and opportunities for exports while also generating by-products that add further value. However, in addition to investment, this requires in-depth knowledge of markets and skills in product development and marketing. What works in one country or region may not work in another.

Many of the countries in the NENA region have extensive coastlines but are finding it difficult to build sustainable mariculture because of competition for space, competition on price from aquaculture in other countries and limited domestic demand (marine finfish are too expensive for many consumers). Aquaculture producers and planners in NENA need to think beyond familiar products and investigate global seafood markets where bivalve shellfish, seaweeds, sea cucumber and other less familiar products are in high demand. These are produced in low-input aquaculture systems that tend to face less opposition from other coastal stakeholders and can provide ecosystem benefits in terms of carbon capture, reduction in eutrophication and nursery habitat for other marine life.

Regional market observatories should be developed based on existing systems such as the European Market Observatory for Fishery and Aquaculture Products (EUMOFA) (www.eumofa.eu). These should provide useful, updated and more reliable market information on trade (imports/exports), domestic supplies, key species, product types, prices, and market share for different retail sectors (supermarkets, fish shops, informal retailers) and hotels, restaurants and catering.

Improper naming and labelling of products (both at B2B and B2C levels) undermines the transparency, rationalisation and further development of markets. It creates mistrust towards both the product and seller. This means there needs to be greater emphasis on traceability, correct species naming and labelling (including scientific and commercial names, method of production, country of origin, FAO area of production, etc.) to build seafood markets, gain consumer trust and shift consumption towards domestically produced food, thereby reducing imports.

During the COVID-19 pandemic, shortening of the supply chain by direct sales to customers and concentrating on local, rather than distant markets has benefitted consumers as well as producers. This has been a test of resilience for many producers and it will be interesting to see whether the trend will continue after pandemic restrictions are eased.

6. Contribution of aquaculture to food security, social and economic development

6.1 STATUS AND TRENDS

6.1.1 Food security and aquaculture

Global fish production is increasing and was estimated to have reached 179 million tonnes (excluding aquatic plants) in 2018 with a total first sale value of USD 401 billion, of which 82 million tonnes worth USD 250 billion came from aquaculture (FAO, 2020e).

Increased availability of fish is also evident in the NENA region. Total food fish supply in NENA countries based on FAO Food Balance Sheets (FAO, 2020i) is shown in Table 10. The figures in this table demonstrates great variation between countries from per capita availability of 28.5 kg/year in Oman to only 1.6 kg/year in the Syrian Arab Republic. For comparison, the global average per capita availability of fish was 20.3 kg/year in 2017 (preliminary estimate of 20.5 kg/year in 2018) and has risen by around 1.5 percent per year since 1961 (FAO, 2020c).

The aquaculture sector is now considered of strategic importance for the contribution it makes to food and nutrition security by providing high quality, nutritious and relatively inexpensive source of protein to many millions of people (FAO, 2017e; Béné *et al*, 2016). However, this promise has only come to fruition in a few NENA region countries (FAO, 2017f). The disparity between NENA countries in terms of fish availability needs to be addressed. In 2017 only Egypt, Morocco, Oman and the United Arab Emirates had per capita supplies above the global average while nine countries had less than half that level.

TABLE 10. Fish availability in countries/territories of the Near East and North Africa region in 2017

Country/territory	Food fish supply (tonnes)	2017 population (million persons)	Per capita fish availability (kg/yr)
Algeria	159 662	41.4	3.9
Bahrain	27 700	1.5	18.5
Egypt	2 285 151	96.4	23.7
Iraq	126 504	37.6	3.4
Jordan	52 355	9.8	5.4
Kuwait	59 682	4.1	14.7
Lebanon	59 528	6.8	8.7
Libya	98 016	6.6	14.9
Morocco*	692 674	35.6	19.5
Oman	133 145	4.7	28.5
Palestine	12 811	4.7	2.7
Qatar	60 688	2.7	22.3
Saudi Arabia	375 216	33.1	11.3
Syrian Arab Republic	27 137	17.1	1.6
Tunisia	147 342	11.4	12.9
United Arab Emirates	250 913	9.5	26.4
Yemen	88 275	27.8	3.2
Total NENA	4 656 799	350.8	13.3

Source: FAO, 2020i.
* Including Western Sahara.

However, it is important to distinguish between food self-sufficiency and food security. Food self-sufficiency is the goal of meeting food demand with production within the borders of a country. Food security is a much wider concept that does not discriminate between domestic production and imports. As defined by the United Nations' Committee on World Food Security (CFS) it means that all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their food preferences and dietary needs for an active and healthy life. This is a complex definition which is reflected in the indicators used to assess food security (prevalence of undernourishment, prevalence of moderate or severe food insecurity) and indicators assessing nutrition (wasting, stunting, overweight and obesity, anaemia in women of reproductive age, exclusive breastfeeding and low birthweight) (FAO *et al*., 2019).

Until recently the emphasis in food security has been on access to staple foods but in 2014, the CFS endorsed recommendations from a report that recognized the contribution fisheries and aquaculture make to food security and nutrition as a primary source of protein and essential nutrients and as a provider of income and livelihoods (CFS, 2014). CFS recommended the following actions:

- give fish the position it deserves in food security and nutrition strategies, policies and programmes;
- promote sustainable fisheries and aquaculture policies and management and design climate change adaptation strategies for food security and nutrition;
- seize the opportunities and address the challenges of aquaculture development;
- recognise the contribution of small scale fisheries;
- enhance fish market and trade contribution to food security and nutrition;
- improve social protection and labour rights;
- fully address the gender dimension of the fisheries and aquaculture sector;
- integrate food security and nutrition concerns into fisheries and aquaculture related policies and programmes.

These recommendations highlight growing recognition of the unique role that fish plays in nutrition and human health. Fish is a valuable source of nutrients including high quality protein, retinol (vitamin A), vitamin D, vitamin E, iodine and selenium. There is evidence that consumption of fish enhances brain development and learning in children, protects vision and eye health and offers protection from cardiovascular disease and some cancers. The fats and fatty acids in fish, particularly the long chain n-3 fatty acids are difficult to obtain from other food sources while combined with high quality protein, vitamins and minerals. Adding fish to bland, staple diets can also stimulate appetite and increase food consumption in vulnerable groups including young children, old people and the ill (Bogard *et al.*, 2017).

Child stunting is one of the key nutrition indicators that can be addressed by consumption of fish. Unless foetus and infant are supplied with sufficient micronutrients in the first 1 000 days of life their growth and development will be forever stunted. Statistics on stunting in NENA countries are incomplete but in 2018 the prevalence of stunting in children (under 5 years of age) in Yemen was 46.4 percent and in Egypt was 22.3 percent (dropping from 30.7 percent in 2012), while the 2012 stunting figures for Iraq and the Syrian Arab Republic were 22.1 percent and 27.6 percent, respectively (FAO, IFAD, UNICEF, WFP and WHO, 2019). These data provide a strong rationale to increase not just the availability of fish but also access to nutritious fish for priority groups, including pregnant mothers and young children, in NENA countries which implies that fish needs to be affordable and available in the right locations.

Countries that want to increase the supply of fish for consumers could implement a range of different strategies. They could attempt to increase fish supplies from capture fisheries but

this is often problematic and usually requires long-term investment in fisheries management. They could import more fish and fish products, as most of the countries in NENA region already do but that would further reduce their food self-sufficiency and harm their balance of payments. Compared to these options, investment in aquaculture is a more forward-looking approach that is likely to be more sustainable. This aquaculture-based strategy has been adopted in Saudi Arabia where apparent per capita consumption of seafood is only half of the global average. Population growth (~2 percent per year), along with social changes and emerging consumption trends towards more healthy eating, are expected to drive the domestic seafood market to around 0.7 million tonnes in 2030 and the domestic aquaculture sector aims to capture a significant proportion of this. A generic national marketing campaign is planned to increase public awareness on the health benefits of increased seafood consumption and to communicate to domestic consumers the positive attributes of local aquaculture products including location, freshness, safety and nutritional value.

It is important to note that while aquaculture is often promoted as a direct alternative to capture fisheries as a source of fish, employment and economic activity, the two activities differ in many ways. The species of fish being cultured or their sizes are usually different and they will usually be grown by different people or distributed through different value chains. The supply of fish from capture sources is usually seasonal and unpredictable whereas aquaculture harvests can be planned in advance. The presence of a productive capture fishery can constrain aquaculture development of the same or similar species because benchmark prices are often set by the capture fishery and fishers usually have fewer costs than fish farmers. Meanwhile, development of aquaculture has been shown in other regions of the world to have negative impacts on capture fisheries, particularly for poor fishers who are excluded from aquaculture zones or poor households who had access to cheap, small fish that becomes more valuable as a feed ingredient for aquaculture (Little *et al.*, 2012). It is also important to note that consumer preferences in key markets may differ from what is being offered by aquaculture (Murphy *et al.*, 2020a).

6.1.2 Aquaculture employment

Aquaculture provides employment, not just on fish farms but along value chains. Recent estimates of employment levels in aquaculture indicate that the total number of fish farmers in the NENA countries reached about 264 800 individuals (Table 11). The data are for employment in the primary sector of aquaculture and include sex-disaggregated data for countries when reported (FAO, 2020f).

A 2011 value chain assessment estimated that Egyptian aquaculture generated 13.8 full-time equivalent (FTE) jobs per 100 tonnes of production per year (McFadyen *et al.*, 2012), split between 8.3 FTE in fish farming, 0.9 FTE in trading and wholesaling and 4.6 FTE in retailing. All the fish farming jobs and 98 percent of the trading/wholesale jobs were taken by men while 31 percent of the retailing jobs were for women. The jobs were evenly split between people over or under 30. This analysis did not include input suppliers such as hatcheries and feed mills.

A more recent (2018) update of the aquaculture employment rate in Egypt estimates there are 19.56 FTE jobs per 100 tonnes of fish produced with a greater proportion of jobs in retailing than in other sub-sectors, including input supply (hatcheries and feed mills) and transport (Nasr-Allah *et al.*, 2019). With 2018 Egypt aquaculture production estimated at 1.45 million tonnes per year this is the equivalent of 0.28 million FTE jobs across the value chain. Despite the scale of the sector and the importance of aquaculture-produced fish in the diets of Egyptians, this only represents around one per cent of the total Egyptian workforce. However, the jobs are localised in rural locations where there are few other options for

TABLE 11. Number of fish farmers in the Near East and North Africa region in 2018

Country	2018		Flag	Country	2018		Flag
	Female	Male			Female	Male	
Algeria	2 166	2 321	E	Morocco	--	377	E
Egypt	24 724	223 801	E	Oman	--	53	E
Jordan	--	106	E	Saudi Arabia	--	8 461	E
Kuwait	--	104		Syrian Arab Republic	--	712	E
Lebanon	--	127	E	Tunisia	--	1 000	
Libya	232	248	E	United Arab Emirates	--	355	E
Total	**Males + Females**					**264 787**	**E**

Source: FAO, 2020f.
Flag E: FAO estimate.

secure employment. In villages close to fish farming zones such as Kafr-el-Sheikh, most households have family members involved in aquaculture.

Jobs on fish farms in Egypt are predominantly occupied by men. Fish farms are located in separate zones away from homesteads and villages where social and gender norms dictate women's right to access these locations. In this case, women cannot access them on a daily basis. Nevertheless, women could be more involved in Egyptian fish farms if aquaculture was practiced on land-holdings close to their homesteads using IAA approaches. There already are some fish farms in Egypt that operate in that way but they are not encouraged because they contravene regulations on zoning and the source of water. Few women are involved in fish wholesale and transport in Egypt but around one third of the people involved in retailing are female while processing is a potential opportunity for employment of women. Currently, relatively little farmed fish is processed.

The Egyptian women who are involved in fish retailing, often work as informal retailers purchasing fish from wholesalers and selling to their customers from street-side stalls or carrying fish from house-to-house. Research by WorldFish and CARE in Egypt demonstrated that the harsh lives of these women can be improved through forming groups that can advocate for their rights, such as secure markets to sell fish and store fish overnight (Murphy *et al.*, 2020b).

Aquaculture employment patterns in other NENA countries are less well documented because fewer people are involved.

6.1.3 Economic contribution of aquaculture

The macroeconomic contribution of aquaculture to the economies of NENA countries was discussed in Section 1.1.5 of this report. This ranges from 0.59 percent of GDP in Egypt to less than 0.01 percent of GDP in Algeria, Bahrain, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, the United Arab Emirates and Yemen. Nevertheless, the local contribution towards economic activity can be significant. Aquaculture was the second most important economic activity of the north eastern Beqaa Valley in Lebanon in 2015 and constituted an income generating activity linked especially with restaurants and tourism in the area (FAO, 2005–2020c). In Oman, small-scale aquaculture production also provided livelihood and income for local communities (FAO, 2006–2020a). Meanwhile in the United Arab Emirates, several hundred farms produce tilapia for household self-consumption.

The nature of fish farming businesses shows great variation between countries and along value chains. In the Egyptian aquaculture sector, feed supply is dominated by large companies, some of which are owned by foreign multi-nationals (Skretting, Aller Aqua, De Heus

and New Hope) or larger Egyptian multi-sectoral companies, while most fish hatcheries, fish farming, wholesale and retail is carried out by small, usually family-owned businesses (Macfadyen *et al.*, 2012; Nasr-Allah *et al.*, 2014b; El-Sayed, Dickson and El-Naggar, 2015). In Iraq and in the Syrian Arab Republic, aquaculture is also dominated by small, family-owned businesses (FAO, 2006–2020b; FAO, 2009–2020b). Egypt has also recently developed large, government-owned aquaculture businesses including new development projects such as the Aquaculture Suez Canal Company and the Ghalioun Project on the Mediterranean coast (Feidi, 2018).

Saudi Arabian aquaculture is dominated by a large company (NAQUA) and a number of emerging companies (Saudi Fisheries Company, Tabuk Fisheries, Tharawat Seas, Jazadco) as are the industries in most Gulf countries. In Tunisia, recent growth of the aquaculture sector has been through larger marine cage fish farms in the east of the country (FAO, 2005–2020b). Aquaculture in Morocco has involved some large operators but at present mostly consists of small-scale businesses (Van der Meer, 2018). Algeria is attempting to expand larger-scale marine businesses as well as small-scale inland fish farming (FAO, 2018d).

Other associated small businesses in aquaculture value chains include veterinary practices, consultants, pharmaceutical companies, aquaculture equipment suppliers and ice plants.

6.1.4 Social responsibility and gender

Relatively few women are directly engaged in fish farming in NENA countries and the home-based nature of the women engaged further restricts their visibility as they are often not captured in employment data. In Egypt, there are a few women who own fish farming businesses but a study by WorldFish in 2019 reported that none of the jobs in hatcheries, feed mills and fish farms were held by women (Nasr-Allah *et al.*, 2019). The authors suggest that the manual nature of the work and the need to stay onsite in remote locations was a constraint. Fish farming zones in Egypt are located some distance away from homesteads and it is culturally undesirable for most Egyptian women to work outside their homesteads, however, the situation may change in the future as females currently occupy a large proportion of the undergraduate positions in aquaculture at Egyptian universities.

In contrast, up to 40 percent of the fish retailers in some regions of Egypt are women, while the development of an aquaculture processing sector could increase female employment in the value chain (Nasr-Allah *et al.*, 2019). Fish retailers face numerous challenges and constraints while organizations for women have been shown to be an effective way to advocate for their rights in male-dominated sectors (Murphy *et al.*, 2020b; Kruijssen, McDougall and Asseldonk, 2018; Kantor and Kruijssen, 2014).

Concerted efforts have been taken to ensure that there are opportunities for employment of women in the Saudi Arabian aquaculture industry. In 2018, it was reported that 149 women were working in the NAQUA group where nearly 3 000 employees from 32 countries were employed (Al-Sulami, 2018). The Saudi Aquaculture Society also reported success in attracting female Saudi graduates to work in the sector (SAS, 2018) in line with an overall strategy to recruit a diverse work force (SAS, 2016). The seaweed and oyster sectors in Morocco are also providing opportunities for women (FAO, 2005–2020d).

Child labour is an issue that is often overlooked in small family-owned businesses such as fish farms and retail. In 2018, the International Labour Organization (ILO) reported that child labour is a big problem in Egypt; the latest National Child Labour Survey (www.capmas.gov.eg) indicated that 1.6 million children are engaged in hazardous or unlawful forms of work among the 1.8 million working children in Egypt. There are no clear statistics on the number

of children working in the Egyptian aquaculture sector, but many fish farming labourers are less than 18 years old (S. Sadek, personal communication, 2020). By taking a participatory approach while promoting the application of existing conventions, legislation and guidelines, child labour can be addressed directly and integrated into broader policies and programmes. Improvements are possible; available data show that the total number of child labourers in the world has declined since the year 2000 (FAO and ILO, 2013; FAO, 2020g).

Attention should be paid to the wider community, to stakeholder participation and to addressing gender issues during the planning phase of aquaculture development, to minimize potentially negative impacts on women and men and improve the public image of aquaculture. Efforts need to be made to include women as stakeholders so that their needs are captured in line with the principles of the ecosystem approach (FAO, 2010) as well as participation in certification programmes. A special role could be played by aquaculture farmers' organizations in promoting sustainable aquaculture including women's organizations (Stutzman *et al.*, 2017; Fezzardi *et al.*, 2013; Rad *et al.*, 2014). In addition, aquaculture also creates jobs, which is crucial in countries where opportunities for employment could reduce migration and provide social stability. AZA are thought to improve the social acceptability of aquaculture and help the sector contribute to food security (Massa, Onofri and Fezzardi, 2017; GFCM, 2018). Saudi Arabia and Oman published lists of suitable locations for aquaculture projects in 2016 and 2010, respectively, following extensive consultations with local communities (FAO, 2016; MOFW, 2010).

6.2 SALIENT ISSUES AND SUCCESS STORIES

Aquaculture planners and developers face difficult choices. They can focus on affordable fish for domestic markets or on export markets. In NENA, Egypt, Iraq and the Syrian Arab Republic have focused mainly on domestic markets while many other countries are following an export-oriented model. The two approaches are not mutually exclusive and countries such as Algeria and Saudi Arabia are doing both. Governments can also choose to support small-scale or industrial-scale systems, marine or freshwater, tilapia or marine finfish, shrimp or seaweed. The choices will depend on resource availability and the wider economic strategy being followed (Hall, 2015).

The most recent Egyptian aquaculture strategy aims to improve both food security and increase competitiveness in international markets by increasing total production to somewhere around 1 950 000 tonnes by 2030 in order to satisfy demand from a fast-growing population (FAO, 2017c). The National Aquaculture Development Program for Algeria was developed to foster the role of aquaculture as a key sector for socio-economic development (FAO, 2017c; FAO, 2006–2020c). The Saudi Arabian top development priority, in support of its food security programme, is aquaculture, particularly mariculture (FAO, 2018c).

Aquaculture value chains can create employment in rural areas, helping to address issues such as poverty and migration (Nasr-Allah *et al.*, 2019). The FAO sub-regional initiative "Sustainable Small-scale Agriculture for Inclusive Development" addressed increased income and employment for small-scale fishers in Gaza Strip through improved fish aquaculture and marine culture value chains (FAO, 2017g). The FAO and the ILO collaborated on the publication of guidance materials including the "FAO-ILO guidance on child labour in fisheries and aquaculture" and "Guidance materials on occupational safety and health in aquaculture" (FAO, 2017h). However, employment generation differs between aquaculture systems and is poorly understood. It can be difficult to document because of informal or seasonal labour and employment in upstream or downstream activities including feed production, ice factories, transport and fish shops. Home-based work such as fish retailing or processing is often not recorded as employment. Poor salaries, tough working conditions

and weak enforcement of health and safety legislation in many NENA countries mean that aquaculture is often not seen as an opportunity for young people.

With the exception of Saudi Arabia, where the Saudi Aquaculture Society has played a key role in promoting sustainable growth, sector organizations, including fish farmers' organizations, need strengthening in most NENA countries. Most are not very active and play a limited role in providing assistance and services to the sector (Rad *et al*., 2014; FAO, 2017a). In 2014, Tunisia established a local platform involving all the relevant stakeholders to study and review aquaculture project applications, and to enable reconciliation between decision-making stakeholders at the national level (GFCM, 2018). The Saudi Aquaculture Society could be used as an inspirational model for similar organisations in other countries of the region.

Quantitative information on the role of fisheries and aquaculture in food security and nutrient supplies is generally lacking. When available, it tends to be scattered, leading to underutilization and misuse. FAO has an important role in addressing information gaps (FAO, 2020e).

6.3 THE WAY FORWARD

Key message: ***With better planning, aquaculture can enhance food security, incomes and employment in NENA region***

Aquaculture can provide food security, help to achieve food self-sufficiency, reduce imports, create employment and provide economic activity for countries in the NENA region. Different strategies have been employed but they are not mutually exclusive. The most successful so far has been aquaculture for food security and many countries see potential for increasing food self-sufficiency. With respect to food security it is important for products to be affordable for the majority of the population, not just for high-earners. At present, this means concentrating on species such as tilapia, carp and mullet rather than seabass, seabream and shrimp. Research should focus on developing low-cost aquaculture of marine species to provide another option for NENA countries where freshwater is in short supply.

A strategy is needed to address the relative shortage of aquaculture employment opportunities for women in the region starting with gender studies to make fact-based recommendations. In Egypt, a relaxation of rules over the development of homestead aquaculture systems would allow women to participate in aquaculture to generate income and improve household nutrition, as has been experienced in many countries in Asia. Networks such as Genderaquafish.org, Aquaculture without Frontiers, Women's Network and Women in Seafood have been established and need to become more visible in the region. Researchers and developers can contribute by the collection and dissemination of sex disaggregated data, making sure that aquaculture developments are gender responsive, by mainstreaming gender in policies, toolkits and guidance and by documenting the causes of gender inequality to develop gender transformative approaches (Brugere and Williams, 2017).

As recommended in Section 5.3 of this review, countries that want to develop export-oriented aquaculture sectors need to invest in the systems, operating frameworks and linkages. This needs to include promotional activities, supported by the government or preferably through representative organizations funded by the aquaculture value chain.

Most NENA governments provide incentives or support including aquaculture development grants for specific activities like research and development, or sometimes special tax or rates allowances. It can be more attractive to concentrate on large-scale developments rather than

small-scale businesses and diversification of agriculture farmers into aquaculture. However, these approaches can be complementary if the whole value chain is considered. In Egypt, large commercial companies have invested in aquaculture feed while farming is in the hands of many thousands of small-scale businesses. Large businesses can also provide essential services such as marketing or export-oriented aquaculture could be promoted through large companies that can participate in certification programmes and provide traceability while domestic production is in the hands of smaller producers.

7. External pressures on the sector

7.1 STATUS AND TRENDS

7.1.1 Climate change

Following the adoption of the Paris Agreement in 2015, during the Twenty First session of the Conference of Parties (COP21) all nations were required to commit to Nationally Determined Contributions (NDCs) detailing actions that would be taken to mitigate and adapt to climate change from 2020 to 2025. This started with the submission of Intended Nationally Determined Contribution (INDC) documents. All NENA countries except Palestine and the Syrian Arab Republic submitted INDC documents in 2015. The first NDC documents were submitted by Algeria, Bahrain, Jordan, Morocco, Saudi Arabia and the United Arab Emirates in 2016, by Egypt, Palestine, Qatar and Tunisia in 2017, by Kuwait in 2018, by Oman and the Syrian Arab Republic in 2019 and Lebanon in 2020. No NDC documents have been submitted by Iraq and Yemen. Revised NDCs are to be submitted in 2020 and every five years thereafter.

A comprehensive review of the likely interactions between climate change, fisheries and aquaculture published by FAO in 2018 stated that short-term impacts on aquaculture could include damage to infrastructure and loss of fish through flooding, increased risk of disease and increased incidence of HABs (Barange *et al.*, 2018). Longer term impacts might include reduced availability of wild seed as well as increasing competition for freshwater. The review goes into detail with tables listing climate change drivers, possible impacts and essential adaptations. Drivers are listed as: warming, acidification (in marine ecosystems), hypoxia, distributional shifts, sea level rise, water currents, circulation and winds, extreme events (droughts, floods), disease and harmful algae blooms, gaps in knowledge and uncertainties on specific impacts, water shortage, climate change impacts on fisheries (availability of fishmeal and fish oil), climate change impacts on agriculture, distal drivers and National Adaptation Plans. The tables feature a traffic light system to highlight positive, neutral and negative impacts.

Climate change is likely to have severe impacts on marine organisms and associated fisheries in the region. A study on The Gulf predicts a high rate of local extinction by 2090, particularly off the coasts of Qatar, Saudi Arabia and the United Arab Emirates with a reduction in fish catches of at least a 26 percent (Wabnitz *et al.*, 2018).

The greatest impact of warming on aquaculture in the region is likely to be on pond-based aquaculture systems, such as those in Egypt. On the positive side, warmer temperatures should extend the growing season, allowing farmers to grow more than one crop per year. However, peak summer temperatures in these pond systems are already above 30 °C, so fish farmers will have to provide aeration during critical periods. Surface temperatures are projected to increase by about 1.5 °C to 5 °C throughout the entire Euphrates-Tigris Basin (FAO, 2014), predicted to be one of the most vulnerable to drought and extreme heat (Bozkurt and Sen, 2013). Warmer temperatures could lead to increased risk of disease or proliferation of aquatic fauna such as jellyfish or toxic microalgae (red tides) that could threaten cage-based fish farms or other marine farming systems. Tunisian fish farmers did not take any countermeasures against previous jellyfish blooms and one of their facilities nearly went bankrupt due to jellyfish-related mortality (Bosch-Belmar *et al.*, 2017).

Sea level rise will threaten low-lying coastal zones in NENA, including heavily populated areas such as the northern edge of the Nile delta. Pond-based aquaculture could be impacted,

although rising sea levels could be counteracted in most cases by raising the pond banks. On the positive side, flooding of land in coastal zones could also increase the availability of land for brackishwater or marine pond-based aquaculture.

Extreme weather events such as unseasonal flooding in pond-based aquaculture could cause damage to infrastructure including pond banks and feeder roads. Rain is a regular occurrence in winter in areas of northern Egypt such as Kafr-el-Sheikh and Behera, where many fish farms are located, but is highly disruptive if it takes place during the main growing season. Flooding could be exacerbated by sea level rise in the Mediterranean. Marine cage-based aquaculture could also be impacted by strong winds or turbidity caused by run-off.

Changing rainfall patterns in the catchments of major river systems and changes to agricultural practices could result in decreased water supplies for aquaculture. This is likely to be exacerbated by the construction of dams and increased irrigation, industry and domestic demand. In aquaculture systems such as Egypt, where water comes through the agricultural irrigation system, the quality of water could also decline (Soliman, 2017).

As aquaculture production expands, it has to be recognised that it will increasingly contribute to climate change impacts. Most analyses show that emissions from aquaculture are much less than from ruminant animals such as beef, sheep or goats and are similar to or lower than other non-ruminants such as chickens or pigs (Robb *et al.*, 2017; Henriksson *et al.*, 2016). The largest component in greenhouse gas (GHG) emissions from finfish aquaculture is from feeds, so anything that can be done to improve the efficiency of feed use, such as the adoption of best management practices, will significantly reduce overall impacts. Plant based feeds such as soya will result in lower GHG impacts than feeds based on fishmeal (Henriksson, Mohan and Phillips, 2017) while another significant source of GHG is the energy used to pump water. Egyptian fish farms could reduce emissions by switching to electrically powered pumps instead of using diesel and reducing water requirements by aerating rather than using flow-through water to provide oxygen. Emissions could be further reduced by using solar power to generate electricity.

Aquaculture also offers opportunities to promote climate-smart technologies or even carbon sequestration. IPRS or other types of RAS use minimal amounts of water compared to flow-through systems, and shellfish and seaweed farming absorb carbon dioxide (CO_2).

7.1.2 Geopolitical and economic threats

Military conflicts, civil wars and economic and political instability have limited the development of agricultural sectors, including aquaculture, in Iraq, Lebanon, Libya, Palestine, the Syrian Arab Republic and Yemen. They also threaten the economic viability of existing aquaculture enterprises and security of investment. Aquaculture production in Libya, the Syrian Arab Republic and Yemen fell dramatically between 2005 and 2014, for this reason (FAO, 2017a).

Conflicts in the NENA region threaten to reverse the gains in nutrition and poverty reduction that the region made in the last decade, disrupting food production and trade and leading to loss of existing food stocks, increases in food prices, loss of employment and eventually reducing production of food (FAO, 2015). Moreover, several countries of the region, including Egypt, Libya, Tunisia and Yemen, have undergone political transitions that have adversely impacted investor confidence and economic and social development. In Egypt and Tunisia, GDP declined by two percent during the period 2011–2013 due to shrinking economic activities and tourism caused by political instability (FAO, 2015). The World Bank has calculated that it takes 15 to 25 years to recover from protracted crises and

that the effects of major refugee situations last on average 20 years. Impacts of protracted crises on food security tend to be intergenerational (FAO, 2015; FAO, 2017h).

7.1.3 COVID-19

Rapid spread of the newly identified coronavirus COVID-19 in 2020 has had severe impacts around the world. In relation to aquaculture and markets for seafood products, the main initial impact has been through the disruption of markets due to measures taken by different governments to contain the virus (FAO, 2020j). Most countries brought in lock-downs, asking people to reduce contacts with other households and maintain a safe distance from one-another. They also closed schools, universities, clubs, hotels, restaurants and other food service businesses and halted international travel. This severely disrupted international trade, first to China, one of the largest markets for seafood products, and afterwards, markets in Europe and the United States of America due to insufficient airfreight capacity and the closure of food service businesses in importing countries. However, demand for seafood for home consumption in most markets has remained high, so producers that have been able to increase their supplies to domestic markets or market directly to customers have been able to maintain sales.

The Egyptian market for aquaculture-produced fish has been affected. While the main market for tilapia and mullet is through shops, markets and informal retailers for home consumption, reduced demand from the food service sector led to falling market prices that resulted in farmers holding onto their stock for longer than they usually would. This reduced demand for feed and fish seed, affecting the profitability of feed companies and hatcheries, while market prices were depressed even further when large amounts of fish eventually came onto the market. Meanwhile, curfews and lock-downs affected the ability of workers such as informal retailers to travel and carry out their normal activities (A. Nasr-Allah, personal communication, 2020). The impacts were amplified because there is little or no flexibility in the Egyptian farmed fish supply chain as nearly all the fish is sold fresh with no facilities for storage or processing. In the medium-to-longer term it seems likely that the closure of many businesses, the contraction of tourism and the repatriation of Egyptians working abroad will have major impacts on the economy in general and may well reduce the spending power of households so it may take some time for the market to recover.

Impacts on aquaculture in other NENA countries will depend on their experience with the pandemic and the role that aquaculture plays in their economy. Domestic seafood markets should not be impacted too greatly as seafood is seen as a healthy food that can be prepared and eaten at home. In countries that normally import most of their fish, the reduced capacity for air freight may lead to increased market opportunities for local production. However, high-income countries have organised specific trips to fish-producing countries in order to import aquatic products and local production has also been considered strategic and benefitted from support measures. For example, in the United Arab Emirates, fishers have been granted an exemption from a fishing ban on particular species, to ensure they could maintain an income while contributing to the fish supply in local markets. The local aquaculture industry, heavily impacted by the closure of restaurants and hotels, also exhibited resilience by re-orienting production to the supermarkets and retail channels. In the meantime, the fish markets that were initially closed, progressively resumed their operations, after implementing preventive measures such as the mandatory wearing of gloves and masks, the monitoring of temperature of all people entering the market, the provision of hand sanitizer, regular cleaning of the market and good ventilation.

The most visible innovation has probably been the emergence of digital technologies to replace broken links in the supply chains. In the United Arab Emirates, online ordering and

home delivery became popular during the lockdown. In Oman, the authorities launched the Behar platform, which allows fish auctions to take place remotely at the central fish market of Al-Fulaij, with the aim of reducing crowding while maintaining its operation and the national supply and in Kuwait, customers can now register online to get a barcode that allows them to safely enter the fish markets.

This does not mean that maintaining aquatic food supplies during the crisis has not had a huge financial cost, nor that the pandemic will not have a lasting impact on fish value chains across the GCC countries. Some aquaculture companies, especially the large operators that have not been able to reorient their production to local markets, not only lost their income, but have also incurred additional expenses to feed and maintain their stocks. They will also have to cope with many uncertainties and the global economic slow-down that may follow.

All NENA countries with a Mediterranean coastline have been affected by depressed demand resulting from the closure of export markets and the hotel, restaurant and catering sector as well as the tourism industry. While there were gradual increases in demand by mid-May 2020 and a stabilization of prices, markets face continued uncertainty (GFCM, 2020). Aquaculture companies may react by holding onto their fish longer in the expectation of improved market prices in the future. Exports will be difficult until capacity increases and food service markets return to normal which will impact markets for shrimp from Saudi Arabia and marine finfish and shellfish from several NENA countries.

Meanwhile, several governments have developed support packages for sectors affected by market disruption such as expansion of conditional cash transfers in Egypt, postponing payment of taxes and import duties in Saudi Arabia, accelerating social safety net reforms in Tunisia and support for small business owners and private sector employees in Kuwait. In many cases, governments have been supported by international donors and finance institutions including the World Bank, the International Monetary Fund (IMF) and the European Bank for Reconstruction and Development (EBRD).

At this time, direct impacts on human health and death rates have been limited in NENA countries, at least when compared to Europe and the Americas. However, Bahrain, Kuwait Oman and Qatar have relatively high rates of infection placing them in the top twenty countries ranked by the number of infected persons per million of population in mid-October 2020. The longer-term situation in aquaculture markets is likely to remain uncertain if many more people become infected with COVID-19 and control measures have to remain in place for many months or have to be re-introduced because of second waves of infection. It has become clear that the post-pandemic future will have to be different and most countries now understood the importance of local production as imports cannot be taken for granted anymore.

7.1.4 Other external pressures

The space for mariculture development using the current technologies in coastal zones is becoming seriously limited, particularly in Mediterranean countries where tourism, environmentally protected areas, small-scale fisheries, transport and navigation and the oil and gas industry compete for it (Fezzardi *et al.*, 2013; Cataudella, Crosetti and Massa, 2015; FAO, 2017d). Moreover, there is heavy maritime traffic in the Mediterranean, Red Sea and the Gulf and it is an important region for oil and gas exploration and production, so coastal aquaculture is constantly at risk from oil spills. Toxic spills, land-based pollutants and wilful discharge of oil, petroleum products and chemicals can impact fisheries heavily, and may affect the health of the entire aquatic ecosystem.

Earthquakes, besides causing damage and destruction of aquaculture facilities, laboratories, hatcheries, ice plants, etc., can trigger tsunamis that damage aquaculture facilities (ponds, cages, shellfish rafts and longlines), buildings and infrastructure. Historical records show that tsunamis are frequent in the Mediterranean, with 23 large ones occurring throughout recorded history (Samaras, Karambas and Archetti, 2015).

7.2 SALIENT ISSUES AND SUCCESS STORIES

Climate change is high on the policy agenda for most countries in the region as indicated by their engagement in national planning processes. However, there is little regard for aquaculture in most of the INDC and NDC documents, apart from mentioning that aquaculture could be used to reduce impacts on capture fisheries and many aquaculture development plans and strategies fail to mention climate change. Aquaculture has considerable merits as a low-carbon technology (compared to ruminant animal systems) producing nutritious food. Simple measures need to be taken to climate-proof aquaculture systems in NENA region. This means more investment in infrastructure and equipment to secure water supplies, provide aeration and increase productivity of aquaculture systems because open-pond flow-through systems cannot be relied on in the future.

Higher temperatures, more extreme weather events, greater disease threats, less water and poorer water quality all demand adaptation of existing systems. A potential solution is in-pond raceways which result in higher productivity per unit of pond area, less water use and improved food efficiency while also facilitating fish handling. Marine cage-based aquaculture systems are less susceptible to climate change impacts. However, they also have little control over their environment so more care needs to be taken over farm location to reduce exposure to extreme weather and harmful blooms of jellyfish or toxic algae. It is also necessary to increase our knowledge base, focusing on regional priorities and demands.

COVID-19 has exposed the fragility of the globalised economic system and it may take many years to recover. However, it has demonstrated the benefits of local markets and may provide opportunities for producers to build these further. Many businesses have turned to social media to promote their products and sell directly to customers rather than supplying through normal market channels. Whether this is sustained will depend on the shopping and eating habits of people after the pandemic has passed; for now, the direct interchange between producer and customer should result in greater understanding of the needs of customers and could stimulate diversification by producers.

The League of Arab States has adopted a disaster risk reduction (DRR) strategy and launched a regional platform. Remote sensing, climate modelling and risk assessment methodologies are being used to develop a monitoring and early warning system. Other NENA countries need to adopt national DRR frameworks, build reliable early warning systems, strengthen the response capacity of the institutions in charge of the DRR and implement long-term mitigation and adaptation measures (FAO, 2015). There is a crucial need to strengthen the work on fisheries and aquaculture emergency response to reinforce the resilience of the fishing and aquaculture communities all along the NENA region (FAO, 2017e; FAO, 2018e).

7.3 THE WAY FORWARD

Key message: ***Build resilience to meet challenges including COVID-19, climate change and conflict***

Aquaculture producers and regulatory organizations need to become more involved in climate change planning and the first step is to ensure that aquaculture is included in

the development or revision of INDC documents. This will require inter-ministerial collaboration as climate change often falls within the remit of environment ministries or national planning authorities rather than departments of fisheries or agriculture. Climate change adaptation will require partnerships between governments, NGOs, civil society and private business (Barange *et al*., 2018). The impacts of climate change are already being felt by aquaculture producers in many countries so they need to plan for a situation where they have greater resilience and are prepared to face impacts which will require investment. Many countries have programmes to help with this adaptation process, and aquaculture producers should access these.

Marine spatial planning and/or ICZM is necessary to solve the issues around the selection of aquaculture sites, perhaps combined with the establishment of AZA in order to ensure the full integration of aquaculture with other coastal activities and thus prevent and minimize possible conflicts (Fezzardi *et al*., 2013; Sanchez-Jerez *et al*., 2016; Macias *et al*., 2019; Corner *et al*., 2020). Public consultation must be undertaken with local communities and with capture fisheries producers and other key stakeholders so that potential conflicts can be identified, avoided, minimized and mitigated through negotiation based on an assessment of risks and impacts on the surrounding communities and environment.

COVID-19 has demonstrated the importance of contingency planning. Countries that were best prepared were able to respond immediately and contain the spread of the virus. FAO has organised emergency planning for fisheries and aquaculture sectors in NENA region and this should continue to receive support. COVID-19 has also exposed weaknesses in supply chains when the rapid shut-down of food service outlets and international transport links coupled with increased demand from local retailers and consumers meant that aquaculture producers and market chains had to suddenly shift their focus. Assistance should be provided to help value chain actors adapt to changing market conditions through direct marketing, online retailing and supermarket-compatible processing and packaging. These investments will help to build sustainable and more diverse aquaculture markets for the future.

8. Governance and management of the sector

8.1 STATUS AND TRENDS

8.1.1 Background

Good governance is key to sustainable economic, institutional, environmental and social development and is critical to successful aquaculture and the formulation of aquaculture policies, strategies and plans (FAO, 2017b; GFCM, 2018). Aquaculture management should be based on sound and effective regulatory frameworks (Cataudella, Crosetti and Massa, 2015; FAO, 2017d). Four governance principles – accountability, effectiveness and efficiency of governments, equity and predictability of the rule of law – are suggested as necessary for sustainable development of the aquaculture industry (Hishamunda, Ridler and Martone, 2014).

Governance must foster an enabling environment, such as secure property rights, political stability, infrastructure (for example roads, utilities) and research and development, in order to reduce costs and risks to entrepreneurs and to protect the interests of the community at large. Business-friendly enabling policies are also important to stimulate entrepreneurship.

In practice, an aquaculture management system has to have a planning and licensing system that includes permissions to access water, to establish necessary buildings and facilities, to ensure that fish farms do not harm the environment (for example. EIA), to discharge wastewater from tanks or ponds or effluent from cage sites and to move fish from place to place (both fish seed and fish for the market). Farms also need rules to minimise the risk of spreading disease, on the use of drugs and feeds and on food safety, particularly for processed products. This means aquaculture businesses need to take note of a wide range of legislation, rules and regulations in order to start and operate a fish farm and these may involve a wide range of organizations.

8.1.2 Legislative and regulatory aquaculture frameworks in the region

Table 12 summarizes a selection of pertinent aquaculture legislation, where available, in the NENA countries and related competent authorities. Management of the aquaculture sector can be through a specialized entity within the ministries that are responsible for agriculture or environment (Jordan, Morocco and United Arab Emirates), an independent entity like an authority or directorate (Bahrain, Egypt, Iraq and Syrian Arab Republic) or within a Ministry of Fisheries (Algeria, Oman and Yemen).

Almost all the countries in the region have aquaculture legislation and strategies in place or being drafted.

In Algeria, executive decrees governing aquaculture were introduced recently, along with a national spatial planning scheme. Moreover, 29 priority aquaculture activity zones have been identified and initiatives like the IAA are being promoted (FAO, 2017c; GFCM, 2018).

In Bahrain, the lead agency for management and development of the aquaculture sector is the Directorate of Fisheries (DoF) within the Agriculture and Marine Resources Division of the Ministry of Works, Municipalities Affairs and Urban Planning. The DoF liaises with other government bodies on issues relating to quality control and provides the private sector with the opportunity to invest in fish farming projects while also launching an aquaculture training programme.

TABLE 12. Selected aquaculture legislation and competent authorities in the Near East and North Africa region

Country	Basic Legislation	Competent authority	Other actors
Algeria	Law No. 01–11 of 2001 relating to Fisheries and Aquaculture	Ministry for Fisheries and Fishing Resources	National chamber of fisheries and aquaculture. National consultative council for fisheries and aquaculture. National research centre of fisheries and aquaculture.
Bahrain	Royal Decree Law No. (20) of 2002 on Exploitation and Utilization of the Marine Resources	Directorate of Fisheries	--
Egypt	Law No. 124/1983 on fishing, aquatic life and the regulation of fish farms (Due to be revised but not yet approved) and Law No. 4/1994 for the Protection of the environment amended by law 9/2009	General Authority for Fisheries Resources Development	Central Laboratory for Aquaculture Research Ministry of Environment Egyptian Environmental Affairs Agency
Iraq	Law No. 48 of 1976	General Board for Fish Resource Development	Fishery Department
Jordan	Agriculture Law No. 13 of 2015	Ministry of Agriculture	Aquaculture Division
Kuwait	Law No. 46 of 1980 Resolution No. 293 for aquaculture of 2005	Public Authority for Agriculture Affairs and Fish Resources	Aquaculture Division
Lebanon	No licensing requirement	Ministry of Agriculture	Batroun Oceanography and Fishing Institute Fisheries and aquaculture Advisory Committee
Libya	Law No. (14) of 1989	National Marine Investment Institute	Aquaculture Development Administration
Morocco	Law No. 1–73–255 of 27 chaoual 1393 (23 November 1973) on the regulation of fisheries (A draft law on mariculture was submitted to the general secretariat of the government in September 2019)	Mariculture: Department of Marine Fisheries (DPM) in the Ministry of Agriculture and Marine Fisheries Inland: High Commission for Water and Forests and the Fight against Desertification	National Agency for the Development of Aquaculture The National Research Institute for Fisheries The National Food Safety Authority (ONSSA) The Maritime Fisheries Chambers
Oman	By-law for Aquaculture and Quality Control of the Cultured Organisms (MD 177/2012).	Ministry of Agriculture, Fisheries Wealth and Water	Aquaculture Centre Directorate of Aquaculture Development Fish Quality Control Centre Aquaculture Committee
Palestine	No specific legislation	Ministry of Agriculture	Department of Aquaculture
Qatar	Legislation under development	Ministry of Municipalities and Environment	Aquaculture Unit, Fisheries Department
Saudi Arabia	Royal Decree (No. M/9) of 18 November 1987 Law of Fishing, Investment and Preservation of Live Aquatic Resources within Territorial Waters of the Kingdom of Saudi Arabia issued by the Council of Ministers No. 14, dated 21/01/1408 H, crowned by the Royal Decree No. M/9 dated 27/3/1408 H. Implementing Regulation of the Law of Fishing, Investment and Preservation of Live Aquatic Resources within Territorial Waters of the Kingdom of Saudi Arabia issued upon the decision of H.E the Minister of Environment, Water and Agriculture No. 21911, dated 27/3/1409 H.	Ministry of Environment, Water and Agriculture	General Administration of Fisheries Resources

TABLE 12. (*continued*)

Country	Basic Legislation	Competent authority	Other actors
Syrian Arab Republic	Resolution No. 12/T of 1991 Resolution No. 8/T of 2003	Ministry of Agriculture and Agrarian Reform	General Authority for Fisheries Resources and Aquatic Life
Tunisia	Act of Law 94–13 31 January 1994 (aquaculture framework law) By law of 28 September 1995	Directorate General for Aquaculture Administration and Development (DGPA), Ministry of Agriculture, Water Resources and Fisheries	Technical Center of Aquaculture, Ministry of Agriculture, Water Resources and Fisheries National Environment Protection Agency Ministry of Environment and Sustainable Development
United Arab Emirates	Federal Law No. 23 of 1999	Ministry of Climate Change and Environment Food Security Office	Fisheries Sustainability Department Emirates authorities such as the Environmental Agency – Abu Dhabi
Yemen	Law No. 2 of 2006 concerning Organization and Exploitation of Marine Creatures and their Conservation	Ministry of Fish Wealth	--

In Egypt, the GAFRD of the Ministry of Agriculture and Land Reclamation (MoALR) is the competent authority for the development of inland and marine fisheries and aquaculture. It is responsible for monitoring and controlling fish farms through GAFRD branches in each Governorate. GAFRD also oversees the aquaculture cooperatives as it sits on the board of the Union of Aquatic Cooperatives (UAC) that acts as an umbrella organization representing several thousand fish farmers across the country. Responsibility for fish health management and food safety certification falls under the General Organization for Veterinary Services (GOVS). The Central Laboratory for Aquaculture Research (CLAR) is a division of the Agricultural Research Center. The Ministry of Environment, through the Egyptian Environmental Affairs Agency has a role to play in licensing of aquaculture: fish farmers have to obtain its approval following submission of an EIA study and also have to abide by conditions related to discharge of water. The Ministry of Water Resources and Irrigation (MoWRI) is also involved in licensing of fish farms as they need approval from its National Water Research Center (NWRC) for abstraction of water. Other authorities may be involved including the Ministry of Archaeology, Ministry of Tourism, Authority for Shore Protection, and Border Guard depending on the circumstances. A 2013 study concluded that while there is a clear legal and institutional framework for aquaculture there is a need to update the legislation regarding allocation of land and water resources and to streamline registration and approval procedures (Goulding and Kamel, 2013). Since then, draft legislation has been developed that would see major changes in the way Egyptian aquaculture and fisheries are managed. However, the necessary legislation has not yet been enacted.

In Iraq, the General Board of Fish Research and Development (GBFRD) of the Ministry of Agriculture is the authority responsible for regulating the aquaculture sector, through a framework for inland and marine aquaculture. The enforcement of Iraqi aquaculture regulations is currently weak, mainly due to the change of governments and political instability (FAO, 2017a).

In Kuwait, the Public Authority for Agriculture Affairs and Fish Resources (PAAFR) is the responsible authority and supports tank-based integrated tilapia farming on agricultural land as well as cage-based aquaculture through issuing licences and subsidies.

Lebanon currently has a draft Fisheries and Aquaculture Law and a Strategic Roadmap in Support of Fisheries and Aquaculture, both drafted in collaboration with FAO and GFCM, while Egypt has draft legislation to revise the overall management system for aquaculture.

In Morocco, the National Aquaculture Development Agency (ANDA) is the key regulatory organization in the aquaculture sector created in 2011 as a public institution mandated to support the development of marine aquaculture. The Halieutis Plan (see Section 2.2.2) is based on spatial planning for the identification of AZA, a specific and clear legal framework to ensure farmers' investments at sea, and market initiatives and studies to promote aquaculture and aquaculture products and raise awareness. There are five aquaculture development plans and associated AZA being prepared through spatial planning and a participatory approach in eight regions.

In Oman, the Ministry of Agriculture and Fisheries developed a Strategy for Aquaculture Development 2011–2030 based on a 2007 Aquaculture Development Master Plan. This covers legislation, environmental and disease monitoring, exotic species introduction, guidelines related to role of government and private sector in management of sector and best management practices. A Directorate of Aquaculture Development was established in 2013 with the aim of providing a "one-stop-shop" for aquaculture to receive applications, liaise with different government authorities and monitor projects.

In Qatar, aquaculture comes under the Aquaculture Unit of the Department of Fisheries in the Ministry of Environment. An Aquaculture Research Centre was opened in 2020 with finfish and shrimp hatcheries and laboratories.

In Saudi Arabia, the General Directorate of Fisheries, under the Undersecretary for Agriculture, is actively promoting investment in aquaculture by identifying suitable sites. The Department also publishes an atlas for aquaculture sites in the Red Sea (FAO, 2016) and conducts market analyses for aquaculture products, which are made available to the private sector (FAO, 2017a). The Saudi Aquaculture Society helps the General Administration of Fisheries Resources develop the necessary plans, regulations and legislation to ensure success of the aquaculture industry.

In the Syrian Arab Republic, the General Authority for Fisheries Resources and Aquatic Life (GAFRAL) has the full mandate for the fisheries and aquaculture sector. GAFRAL is expected to put into practice the aquaculture development plans and strategy set previously by the Department of Fisheries. GAFRAL is also expected to become familiar with the new global aquaculture management concepts and be more active at international and regional levels.

In Tunisia, the relevant authority for aquaculture is the General Directorate of Fisheries and Aquaculture (DGPAq) of the Ministry of Agriculture. Other ministerial departments and professional and civil society organizations have collaborated with the DGPAq for the planning and management of the sector. In line with a policy of decentralization and to improve the social acceptability and management of aquaculture, a local platform involving relevant stakeholders was established in 2014, in order to study and review aquaculture project applications, expand existing projects in line with local needs and priorities, reduce interactions between different activities using the same space and enable the reconciliation of decision-making stakeholders at the national level. Nevertheless, institutional and legal frameworks have not been updated or adapted, thus requiring by-laws and ministerial decisions. Interaction with other activities using the same spaces also has to be improved, including through the multi-stakeholder platform (FAO, 2017c).

In the United Arab Emirates, the Environmental Agency – Abu Dhabi in collaboration with the Ministry of Climate Change and Environment (MOCCAE), Ministry of Food Security, the Abu Dhabi Department of Economic Development (DED), the Abu Dhabi Agriculture and Food Safety Authority (ADAFSA) and stakeholders, is pursuing a policy aim for the

aquaculture sector of: "A sustainable and competitive aquaculture industry for Abu Dhabi which contributes towards economic growth, food security, the provision of meaningful employment and the generation of wealth for its citizens by producing safe, wholesome and high-quality seafood products to satisfy market demand through the use of sustainable technologies that preserve biodiversity and to ensure the protection of healthy, productive and resilient ecosystems." (EAD, 2019).

8.1.3 Regional and international contexts and instruments

The current challenges in governance, spatial planning, economic and market issues, ecological and environmental concerns as well as the globalization of aquaculture have highlighted the importance of regional strategies (FAO, 2017d). Furthermore, there is a need to continue facilitating communication between countries by taking stock of existing aquaculture regulatory and administrative frameworks throughout the region (GFCM, 2018). The GFCM Aquaculture Strategy aims at helping Mediterranean countries achieve improved regulatory frameworks, streamlined administrative and public sector management, and participatory, transparent and accountable policy-making. The strategy also aims for improved and sustainable integration of aquaculture in coastal and marine zones and enhanced compatibility of the sector with other existing and future human activities as well as the establishment of a regional network on aquaculture governance.

The Regional Commission for Fisheries (RECOFI) and the Regional Organization for the Protection of the Marine Environment (ROPME) signed a MoU in 2018 to strengthen cooperation between the parties with a view to benefiting from each other's work in relation to the management, conservation and sustainable exploitation of the marine environment and its ecosystems. The MoU also covers aquaculture.

Experience in the NENA region, in particular in Jordan and Morocco, points to the importance of key governance reforms for management of groundwater resources. Such reforms need to encompass water rights-based regulations involving all stakeholders, decentralization of management, incentives, and monitoring and information sharing (FAO, 2017i).

A regional cooperation framework for the Tigris-Euphrates basin has been agreed upon. It focuses on resource sustainability, comprehensive and participatory management, regional technical cooperation in establishing regionally harmonized fisheries and aquaculture management plans and actions (FAO, 2014). Furthermore, to improve marine governance through marine spatial planning, governance should operate at both regional and national levels (FAO/RECOFI, 2011; Corner *et al.*, 2020).

8.2 SALIENT ISSUES AND SUCCESS STORIES

Countries have implemented a range of management systems for aquaculture under different ministries with different degrees of decentralisation or autonomy. In some countries there are too many agencies concerned with permission and management of aquaculture. This can be streamlined, as has happened in Oman with their one-stop-shop approach and in Morocco through the National Aquaculture Development Agency (ANDA).

In Egypt, GAFRD was established as a management body that also had commercial activities including renting ponds and operating hatcheries and feed mills. However, the private sector now produces the feed, seed and fish, leaving GAFRD mainly concerned with regulation. The initial arrangements were designed to kick-start the sector and were successful but need to be revised to reflect GAFRD's current role. Too many fish farms cannot be licensed

because detailed specifications over fish farm designs, layout and management do not reflect what happens on the ground, and the industry faces a web of rules and ministerial decisions that have been interpreted in different ways by different stakeholders. This highlights the need to review and revise current legislation.

The allocation of space for aquaculture is an important issue. Environmental and social barriers appear to be placing increasing constraints on aquaculture development. Initiatives such as the GFCM programme of AZA and the identification of aquaculture development zones in the Saudi Arabia and Oman are welcome and reduce the uncertainty for entrepreneurs as well as reduce the potential for conflict over space and resource use in the future.

Even in Egypt, where aquaculture supplies two-thirds of the country's fish supply, fish farmers find it difficult to make themselves heard in policy and strategy discussions. Very large aquaculture developments have taken place in recent years (near the Suez Canal and Birket Ghalion near the Rashid branch of Nile on the north coast) but these have been driven by the production divisions of government rather than the private sector, and they operate independently from established value chains.

Aquaculture needs to be recognised and promoted as a real opportunity for economic growth, employment, food security and nutrition, as well as knowledge creation. Organizations such as FAO and WorldFish can help but they can only support local advocacy in the region. In other parts of the world, representative or producer organizations provide this advocacy whereas in the NENA region, the well-resourced and influential Saudi Aquaculture Society is perhaps the only good example of an effective sector organisation. Egypt has governorate-level aquaculture associations and an umbrella organization with an official advisory role with government, but these are poorly supported and key positions are often filled by people from outside the aquaculture community. In the absence of clear industry leadership, the feed companies probably form the strongest voice for the sector in Egypt; in other countries, exporters might be able to play this role.

Foreign investment in aquaculture development is encouraged in many countries but this has an economic cost. Investors expect tax exemptions and other incentives. There are also social costs. Foreign investment can generate resentment, particularly if it is managed as an estate-type development, with managers hired from abroad who do not interact with the local population (Hishamunda, Ridler and Martone, 2014).

8.3 THE WAY FORWARD

Key message: ***Aquaculture sectors in NENA region need stronger representation***

National regulatory frameworks should be regularly reviewed by governments to guarantee the quality, biosecurity, traceability and safety of farmed and fish products and fish feeds. The development of representative organizations should be supported as they can share responsibilities for promotion, regulation and reporting, while private sector companies such as feed companies can also play a role. The thirteen Egyptian aquaculture associations could play an important role in the development of the aquaculture industry but are currently not active (S. Sadek, personal communication, 2020).

Collaborative allocation of space for aquaculture should be supported. This makes it easier for private sector to commit to invest by providing some certainty of active support for development rather than a lengthy series of barriers and hurdles. Successes need to be acknowledged, even if they are small-scale and used as the starting points for upscaling of

sustainable aquaculture businesses. Large-scale and small-scale aquaculture-based businesses can work together to build a sustainable sector as has happened in Egypt.

There is a need to continue empowering local communities in aquaculture governance and to improve collaborative or participatory management. In many places, dialogue between the public and the production sectors is poor and, when it occurs, often biased towards big businesses at the expense of small-scale farmers and the rest of the community. It is therefore important to improve dialogue among farmers themselves, especially the resource-poor small-scale farmers, and to empower them to compete in the market.

Significant progress has been made through a range of approaches that include FAO's Blue Growth Initiative (BGI), ICZM, AZA and the EAA. These approaches can contribute to good governance in aquaculture because they place emphasis on stakeholder participation, which reduces the likelihood of conflicts in coastal area management and provides an effective approach to selecting zones for aquaculture development (FAO, 2017c; FAO, 2018b; Sanchez-Jerez *et al.*, 2016; GFCM, 2018).

9. Contribution of aquaculture to the FAO strategic objectives, the Sustainable Development Goals, and the Blue Growth Initiative

9.1 STATUS AND TRENDS

9.1.1 FAO Strategic Objectives

The FAO has identified five key priorities where it is best placed to intervene. These Strategic Objectives (SOs) are:

- Help eliminate hunger, food insecurity and malnutrition
- Make agriculture, forestry and fisheries more productive and sustainable
- Reduce rural poverty
- Enable inclusive and efficient agricultural and food systems
- Increase the resilience of livelihoods to threats and crises

These objectives align with the SDGs and aim to help countries implement the 2030 Agenda and ensure that no one is left behind (FAO, 2019f). The strategy also includes cross-cutting themes of gender, governance, nutrition and climate change, and is underpinned by FAO's technical knowledge and expertise.

All of the SOs have some relevance to aquaculture development in NENA region (FAO, 2018e). Increased production of fish and other aquatic food through sustainable aquaculture systems (SO 2) will help eliminate hunger, reduce food insecurity and malnutrition (SO 1) while reducing rural poverty (SO 3). A good example is the promotion of small-scale aquaculture systems growing fish for domestic consumption across North Africa and in Iraq and Syrian Arab Republic; these have the potential to produce relatively low-cost fish while generating rural employment. Meanwhile, initiatives to improve the efficiency of aquaculture and encourage new entrants (SO 4) while building their resilience to threats such as climate change or economic shocks (SO 5) are taking place across the region, such as the development of intensive shrimp and marine finfish aquaculture systems in the Gulf countries and Oman. The SOs also emphasize the importance of maintaining FAO technical capacity in fisheries and aquaculture (FAO, 2017h). Specific examples will be discussed in more detail in the following section.

9.1.2 Regional aquaculture and the Sustainable Development Goals

The 17 SDGs of the 2030 Agenda for Sustainable Development are a set of global priorities adopted by world leaders in September 2015 to end poverty and hunger, sustain the planet's natural resources and ensure prosperity for all. While food and agriculture cut across almost all the SDGs the most relevant to global aquaculture development are SDGs 1 (poverty), 2 (hunger), 5 (gender), 8 (growth, employment), 12 (production and consumption), 13 (climate change), 14 (marine resources & ecosystems) and 15 (biodiversity) (FAO, 2017j). Other SDGs with relevance to aquaculture include SDG 3 (good health and well-being), SDG 6 (clean water and sanitation), SDG 10 (reduced inequalities), SDG 16 (peace and justice, strong institutions) and SDG 17 (partnerships for the goals).

In NENA region, aquaculture systems in countries such as Egypt, Iraq, Saudi Arabia and Syrian Arab Republic already generate significant levels of employment and economic

activity along the value chain (input supply, farming, marketing) in rural areas that contribute towards ending poverty (SDG 1) and there is potential to increase aquaculture-related employment and economic activity in most countries of the region. This provides fish that is sold to local consumers and in Egypt is the main source of fish for the country, contributing to ending hunger (SDG 2). These value chains provide employment for women (SDG 5), particularly in retailing while there is potential to build further employment for women in sub-sectors such as processing and to some extent farming. Aquaculture provides significant economic activity and employment (SDG 8) in rural areas across NENA region for both large-scale and small-scale businesses as well as opportunities for informal businesses. Aquaculture production can contribute towards the sustainable supply of fish and other aquatic products in domestic and export markets ensuring sustainable consumption and production patterns (SDG 12). SDG 14 (Life below water) should be particularly pertinent to NENA aquaculture with its goal to "conserve and sustainably use the oceans, seas and marine resources". However, the SDG 14 targets (Table 13) are more focused on conservation of marine resources and ensuring the health of marine systems so to some extent, aquaculture is seen as threat rather than having potential to make a positive contribution. The same is true for SDG 15 where aquaculture development could be a threat to biodiversity. However, sustainable marine aquaculture is acknowledged as having potential to contribute towards SDG 14 targets by increasing fish and seafood supply to meet demand and stabilize fish prices as well as providing alternative business opportunities to fishers. One of the key aquaculture approaches put forward in a United Nations Conference on Trade and Development (UNCTAD) report is the use of BAP with minimal environmental impacts on coastal ecosystems as "the aquaculture development model which has prevailed until now in major aquaculture nations is not valid and needs a major revision" (UNCTAD, 2018; UNCTAD, 2019).

TABLE 13. SDG 14 – Life below water – targets

Number	Target
14.1	By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.
14.2	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.
14.3	Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.
14.4	By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.
14.5	By 2020, conserve at least 10 percent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.
14.6	By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation.
14.7	By 2030, increase the economic benefits to Small Island Developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.
14.A	Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries.
14.B	Provide access for small-scale artisanal fishers to marine resources and markets.
14.C	Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in United Nations Convention on the Law of the Sea (UNCLOS) which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want.

Within the SDG framework, FAO has specific responsibility for 21 indicators relating to 17 targets and six goals with the main emphasis on SDG 2: *End hunger, achieve food security and improved nutrition and promote sustainable agriculture*. FAO is also a key partner in relation to four other indicators.

In NENA region, FAO has been involved in several aquaculture-related projects and initiatives that address the SDGs (Table 14) mostly through building capacity and partnerships to develop sustainable aquaculture sectors across the region. This aligns with FAO SO 2 which is to "make agriculture, forestry and fisheries more productive and sustainable" and the Code of Conduct for Responsible Fisheries (CCRF), which also promotes responsible aquaculture (FAO, 2017c; GFCM, 2018).

Responsibility for SDGs is usually coordinated at a high level in government with targets and responsibility for particular goals distributed between different government ministries and departments. SDG 14 will usually fall under the ministry or department that deals with fisheries and aquaculture while responsibility for other SDGs will come under other ministries. While there are clear commitments to develop aquaculture in most NENA countries it could be difficult for achievements to be recognized under national SDG frameworks due to the omission of aquaculture-related targets from SDG 14 and the fact that aquaculture will make relatively small contributions to other SDGs when compared to other sectors. Even in countries where aquaculture is recognized as a national priority, it will be important to actively engage with the high-level SDG committees to make sure that aquaculture achievements are taken into account.

TABLE 14. Selected FAO projects in the Near East and North Africa region relevant to the SDGs

FAO Project	Reference	Relevant SDG
UTF/BAH/005/BAH: Supporting the sustainable development of the aquaculture sector in Bahrain	FAO, 2020k	2, 12, 14
UTF/UAE/009/UAE (Baby 2): Supporting Sustainable and Innovative Aquaculture in the United Arab Emirates	FAO, 2020k	2, 3, 12, 14, 17
Aquaculture capacity development in Morocco through the establishment of an Aquaculture Demonstration Center	FAO, 2020k	8
Sub-regional workshops on aquaculture in North African countries/	FAO, 2020l FAO, 2018f	2, 8, 17
Integrated agri-aquaculture in desert and arid lands: learning from case studies from Algeria, Egypt and Oman	FAO, 2020l	1, 2, 3, 6, 8, 12, 13, 15, 17
FAO Blue Hope project	FAO, 2020l	2, 8.12, 14, 17
Lebanon marine fisheries and aquaculture consumer behaviour survey and restaurant sector study	FAO, 2018f	12
Strategy for the sustainable development of Mediterranean and Black Sea aquaculture	FAO, 2018g	2, 12, 14, 17
Fish loss and waste in Egypt	FAO, 2018g	2, 12
Support to the development of a strategy for the development of aquaculture in Morocco	FAO, 2017l	8, 14, 17
Regional training on fisheries and aquaculture emergency response	FAO, 2017f	13, 17
Regional consultation for the establishment of the Red Sea and Gulf of Aden Aquaculture and Fisheries Organization	FAO, 2017f	14, 17
TCP/ALG/3103 : Support à l'aquaculture saharienne et la valorisation des étangs salés (2007-2008)	FAO, 2017f	2, 14
TCP/ALG/3402 : Programme d'assistance technique pour le développement de l'aquaculture en milieu désertique en Algérie (2013-2014)	FAO, 2017f	2, 13,15
TCP/ALG/3501 Appui technique à l'exécution du Programme de développement de l'aquaculture 2015-2020 et perspectives, filière aquaculture marine	FAO, 2017g	8, 12, 14

The recent GFCM Aquaculture Strategy (GFCM, 2018) is structured around three main targets addressing key Mediterranean transboundary vulnerabilities and cross-cutting issues, in line with SDG 14 and FAO SO 2 ("Make agriculture, forestry and fisheries more productive and sustainable"). They are Target 1 – Build an efficient regulatory and administrative framework to secure sustainable aquaculture growth; Target 2 – Enhance interactions between aquaculture and the environment while ensuring animal health and welfare; and Target 3 – Facilitate market-oriented aquaculture and enhance public perception.

9.1.3 Regional aquaculture and the Blue Growth Initiative

The FAO launched its Blue Growth Initiative in 2013, building on the FAO CCRF and focusing on fisheries, aquaculture, ecosystem services, trade and social protection. It seeks to reconcile economic growth with improved livelihoods and social equity through sustainable use of aquatic natural resources in capture fisheries and aquaculture, ecosystem services, trade, livelihoods and food systems (FAO, 2018b; Holmyard, 2019). The BGI was designed around three pillars of sustainable development, economic, social and environmental so that fisheries and aquaculture contribute to the 2030 Agenda SDGs. Initial priority actions were implemented across communities in the Caribbean, Asia/Pacific and Africa including three NENA countries (Algeria, Morocco and Tunisia) (FAO, 2017k) and emphasised Blue Production, Blue Trade and Blue Communities.

Key policy messages are as follows:

- Ocean and inland fisheries and aquaculture are among humanity's best opportunities to serve the world's growing population highly nutritious and safe food with a low ecological impact.
- Sustainable management of marine and aquatic ecosystem is a prerequisite for future food security and livelihoods, as well as regulating climate, moderating extreme weather events and supporting life cycles.
- The BGI is an inclusive and participatory approach to foster sustainable fisheries management. The aim is to safeguard food security and decent work benefits derived from wild fish stocks; as well as exploring alternative sources of food security and decent work, such as aquaculture.
- The BGI explores ways for economic diversification in fisheries and aquaculture, particularly through synergies with growing sectors such as tourism. Moreover, BGI increases system and energy efficiencies while adding value along the fisheries and aquaculture value chains.
- The BGI contributes to the 2030 Agenda SDGs by improving the use of aquatic resources and conserving biodiversity. One of the BGI's tools is the CCRF, which takes into account the economic, nutritional, social, environmental and cultural importance of fisheries and aquaculture.

One of the principles of BGI is the use of existing instruments such as the CCRF, the EAA and the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (Brugere *et al.*, 2019). Article 9.1.1 of the CCRF says that "States should establish, maintain and develop an appropriate legal and administrative framework which facilitates the development of responsible aquaculture". Moreover, Article 9.2 clearly addresses the protection of transboundary aquatic ecosystems by supporting responsible aquaculture practices and Article 11 puts forward the right of consumers to safe and quality products, encouraging states to set minimum standards in this regard and promoting certification (FAO, 2017d).

In NENA region, the FAO Blue Hope for the Mediterranean Project in Algeria and Tunisia is developing multi-sectoral investment plans to help local communities diversify their

livelihoods and economies. These include plans to integrate tilapia farming with agriculture in Tunisia and developing fish feed production capacity and sea cucumber hatcheries in Algeria (DeBey *et al*., 2020). Initiatives in Algeria, Morocco and Tunisia focused on Blue Communities, while Morocco is also developing Blue Production including support from FAO to its National Aquaculture Development Agency (ANDA) to develop and enhance policies, plans and best practices (FAO, 2017j; FAO, 2018b).

9.2 SALIENT ISSUES AND SUCCESS STORIES

While overall aquaculture development in NENA region fits well with FAO Strategic Objectives (SOs), the SDGs and the BGI, the degree to which development has actually been guided or influenced by these initiatives varies across the region.

For example, the growth of aquaculture in Egypt fits objectives for food security, nutrition, employment and economic development but it is more difficult to see that there has been clear progress on adoption of specific strategies such as the BGI or EAA. The development of aquaculture capacity in Egypt took place before these initiatives commenced, and in zones that were designated for aquaculture with little regard for holistic planning or ecosystem management. That is not to say that these approaches should not be applied, particularly as Egyptian aquaculture, agriculture and fisheries now face threats from climate change, increasing populations and over-use of limited water resources, and BGI and EAA are clearly more relevant than ever. Unfortunately, the current system leaves little room to be more inclusive and is somewhat resistant to change.

Aquaculture is a private-sector activity that requires investment well in excess of the primary investment by governments. Prospective aquaculture producers can be discouraged by lengthy participative processes with uncertain outcomes. A potential solution is to place the onus on the public sector to carry out consultations with local communities and designate aquaculture development zones. This approach has been applied in Saudi Arabia and is being encouraged by the GFCM through its programme of AZA (GFCM, 2018). These have similarities to the designation of land for aquaculture development in Egypt in the 1980s but are less prescriptive in terms of farm size and type. In Egypt, the system was designed to share land tenure among several thousand small farmers whereas current developments in Saudi Arabia and the Mediterranean tend to target mainly large-scale investments.

9.3 THE WAY FORWARD

Key message: ***FAO is a trusted partner for continued development of aquaculture in NENA region***

The important role that aquaculture can play in the achievement of FAO's SOs and BGI as well as the SDGs has been recognised and there are aquaculture-related interventions already underway in NENA region that will contribute towards these goals. These are built on the principles of cooperation between governments, stakeholders and other organizations. However, national aquaculture statistics reporting systems need to be strengthened in order to monitor and report on achievements.

Achievement of the SDGs requires multi-disciplinary and multi-sectoral thinking that will be easier to implement in some countries than others. A 2019 review of SDG achievements in the NENA region noted that "progress in realizing sustainable development in most parts of NENA is slow" and "that implementing the 2030 Agenda and achieving the SDGs in Arab countries cannot be realized in isolation from addressing the many violent conflicts in the region" (Göll, Uhl and Zwiers, 2019).

Responsibility for integration of SDGs into national planning is usually a "high-level" process and one of the main challenges is to ensure that aquaculture is included and recognised as being distinct from fisheries or agriculture. This is particularly important when targets for SDG 14 (Life below water) take little account of the main types of aquaculture practiced in NENA countries. This will require pro-active efforts to document the contribution that aquaculture is making towards all the relevant SDGs and follow-up to ensure that this is taken into account when national reports are written.

Nevertheless, the SOs, BGI and SDGs have established a direction of travel that is well-accepted. Aquaculture is able to make contributions towards these strategies and FAO should continue to support the programmes that are already underway in collaboration with governments, regional organizations, development organizations, NGOs and the private sector (Feidi, 2019). More technical, research and capacity building programmes should be initiated in the region in order to achieve these development goals.

10. References

Adamowski, J. 2018. *Algerian aquaculture: poised for growth. The Fish Site* [online]. [Cited 31 August 2020]. https://thefishsite.com/articles/algerian-aquaculture-poised-for-growth

Aguilar-Manjarrez, J., Soto, D. & Brummett, R. 2017. *Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture*. A handbook. Report ACS18071. Rome, FAO, and World Bank Group, Washington, DC. 62 pp. (also available at http://www.fao.org/3/a-i6834e.pdf).

Aga Khan Development Network (AKDN). 2020. *Aga Khan Award for Architecture: Muttrah Fish Market* [online]. [Cited 31 August 2020]. https://www.akdn.org/architecture/project/muttrah-fish-market

Ali, S.E., Jansen, M.D., Mohan, C.M., Delamare-Deboutteville, J. & Charo-Karisa, H. 2020. Key risk factors, farming practices and economic losses associated with tilapia mortality in Egypt. *Aquaculture*, 527(2020): 7354383. (also available at https://doi.org/10.1016/j.aquaculture.2020.735438).

National Agency of Investment Development (ANDI). 2020. *Fishing and aquaculture sector*. National Agency of Investment Development, Ministry of Industry and Mines, People's Democratic Republic of Algeria [online]. [Cited 31 August 2020]. http://www.andi.dz/index.php/en/secteur-de-la-peche

AQUAMED. 2013. The future of research on aquaculture in the Mediterranean region. Project number: 244999. European Union Seventh Framework Programme. (also available at https://archimer.ifremer.fr/doc/00167/27845/26063.pdf).

Arezki, R., Lederman, D., Abou Harb, A., El-Mallakh, N., Fan, R.Y., Islam, A., Nguyen, H. & Zouaidi, M. 2020. "*How transparency can help the Middle East and North Africa*." Middle East and North Africa Economic Update (April), Washington, DC: World Bank. Doi: 10.1596/978-1-4648-1561-4. (also available at https://openknowledge.worldbank.org/handle/10986/33475).

Barange, M., Bahri, T., Beveridge, M.C.M., Cochrane, K.L., Funge-Smith, S. & Poulain, F. (eds). 2018. *Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options*. FAO Fisheries and Aquaculture Technical Paper No. 627. Rome, FAO. 628 pp. (also available at http://www.fao.org/3/i9705en/I9705EN.pdf).

Barazi-Yeroulanos, L. 2010. *Synthesis of Mediterranean marine finfish aquaculture – a marketing and promotion strategy*. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 88. Rome, FAO. 198 pp. (also available at http://www.fao.org/3/i1696e/i1696e.pdf).

Béné, C., Arthur, R., Norbury, H., Allison, E.A., Beveridge, M.C.M., Bush, S., Campling, L., Leschen, W., Little, D.C., Squires, D., Thilsted, S.H., Troell, M. & Williams, M. 2016. Contribution of fisheries and aquaculture to food security and poverty reduction: assessing the current evidence. *World Development*, 77: 179–196. (also available at https://doi.org/10.1016/j.worlddev.2015.11.007).

BAP. 2016. *MoU with Saudi Arabia sets BAP as national standard* [online]. [Cited 31 August 2020]. https://bapcertification.org/blog/mou-with-saudi-arabia-sets-bap-as-national-standard/

Bevacqua, D., Melià, P., Gatto, M. & De Leo, G. 2015. A global viability assessment of the European eel. *Global Change Biology*, 21(9): 3323–35 (also available at DOI: 10.1111/gcb.12972).

Bogard J.R., Farook S., Marks G.C., Waid J., Belton B., Ali, M., Toufique, K., Mamun, A. & Thilsted, S.H. 2017. Higher fish but lower micronutrient intakes: Temporal changes in fish consumption from capture fisheries and aquaculture in Bangladesh. *PLoS ONE,* 12(4): e0175098. (also available at https://doi.org/10.1371/journal.pone.0175098).

Bondad-Reantaso, M.G., Sumption, K., Subasinghe, R., Lawrence, M. & Berthe, F. 2018. Progressive management pathway to improve aquaculture biosecurity (PMP/AB). *FAO Aquaculture Newsletter*, No. 58, (April). Rome, FAO. pp. 9–11. (also available at http://www.fao.org/3/i9200en/I9200EN.pdf).

Bosch-Belmar, M., Azzurro, E., Pulis, K., Milisenda, G., Fuentes, V., Kéfi-Daly Yahia, O., Micallef, A., Deidun, A. & Piraino, S. 2017. Jellyfish blooms perception in Mediterranean finfish aquaculture. *Marine Policy*, 76: 1–7. Elsevier. Amsterdam, the Netherlands. (also available at https://doi.org/10.1016/j.marpol.2016.11.005).

Bozkurt, D. & Sen, O.L. 2013. Climate change impacts in the Euphrates-Tigris Basin based on different model and scenario simulations. *Journal of Hydrology*, 480: 149–161. (also available at https://doi.org/10.1016/j.jhydrol.2012.12.021).

Brugere, C. & Williams, M. 2017. *Women in aquaculture profile* [online]. [cited 31 August 2020] https://www.genderaquafish.org/portfolio/women-in-aquaculture/

Brugere, C., Aguilar-Manjarrez, J., Beveridge, M.C.M. & Soto, D. 2019. The ecosystem approach to aquaculture 10 years on – a critical review and consideration of its future role in blue growth. *Reviews in Aquaculture*, 11: 493–514. (also available at Doi: 10.1111/raq.12242).

Cai, J. & Leung, P.S. 2017. *Short-term projection of global fish demand and supply gaps*. FAO Fisheries and Aquaculture Technical Paper No. 607. Rome, FAO. (also available at http://www.fao.org/3/i7623e/i7623e.pdf).

Cardia, F. & Lovatelli, A. 2016. Key project achievements in the Kingdom of Saudi Arabia: Latest FAO/KSA Aquaculture Unilateral Trust Fund Project recently terminated. *FAO Aquaculture Newsletter*, No. 55, (September). (also available at http://www.fao.org/3/c0382en/C0382EN.pdf).

Cardia, F., Ciattaglia, A. & Corner, R.A. 2017. Guidelines and criteria on technical and environmental aspects of cage aquaculture site selection in the Kingdom of Saudi Arabia. Strengthening and supporting further development of aquaculture in the Kingdom of Saudi Arabia Project UTF/SAU/048/SAU. (also available at www.fao.org/3/a-i6719e.pdf).

Cataudella S., Crosetti D., & Massa F. (eds). 2015. *Mediterranean coastal lagoons: sustainable management and interactions among aquaculture, capture fisheries and the environment*. General Fisheries Commission for the Mediterranean. Studies and Reviews No 95. Rome, FAO. 2015. 278 pp. (also available at http://www.fao.org/3/a-i4668e.pdf).

Central Intelligence Agency (CIA). 2020. *The World Factbook* [online]. [Cited 31 August 2020]. https://www.cia.gov/library/publications/the-world-factbook/

CFS. 2014. *Sustainable Fisheries and Aquaculture for Food Security and Nutrition – Policy recommendations*. (also available at http://www.fao.org/3/a-av032e.pdf).

Community Research and Development Information Service (CORDIS). 2020. *Final report summary – AQUAMED: the future of research on aquaculture in the Mediterranean Region* [online]. [Cited 31 August 2020]. https://cordis.europa.eu/project/id/244999/reporting

Corner R.A., Aguilar-Manjarrez, J., Massa, F. & Fezzardi, D. 2020. Multi-stakeholder perspectives on spatial planning processes for mariculture in the Mediterranean and Black Sea. *Reviews in Aquaculture*, 12:347–364. (also available at https://doi.org/10.1111/raq.12321).

Corner, R., Fersoy, H. & Crespi, V. (eds). 2020. *Integrated agri-aquaculture in desert and arid Lands: Learning from case studies from Algeria, Egypt and Oman*. Fisheries and Aquaculture Circular No. 1195. Cairo, FAO. (also available at https://doi.org/10.4060/ca8610en).

Craze, M. 2020. *Most of the aquaculture industry as it currently stands is uninsurable, AXA says* [online]. [Cited 31 August 2020]. https://www.undercurrentnews.com/2020/01/09/most-of-the-aquaculture-industry-as-it-currently-stands-is-uninsurable-axa-says/

Dabbadie, L. 2020. *How the fish reached your plate during the coronavirus lockdown. The National UAE* [online]. [Cited 15 July 2020] https://www.thenational.ae/opinion/comment/how-the-fish-reached-your-plate-during-the-lockdown-1.1049116

Dabbadie, L., Beveridge, M.C.M. & Ababouch, L. 2017. Support to the National Agency for Aquaculture Development (ANDA) in Morocco. *FAO Aquaculture Newsletter* No 57 (September), pp. 24. (also available at www.fao.org/3/a-i7851e.pdf).

DeBey, H., Mahjoub, S., Mokrane, Z. & Vurdem, D. 2020. Strengthening blue communities in the Mediterranean. *FAO Aquaculture Newsletter* No. 61, (April). pp. 33–34. (also available at http://www.fao.org/3/ca8302en/CA8302EN.pdf).

Diana, J.S. 2009. Aquaculture Production and Biodiversity Conservation. *BioScience*, 59(1): 27–38. (also available at https://doi.org/10.1525/bio.2009.59.1.7).

Dickson, M., Nasr-Allah, A., Kenawy, D. & Kruissen, F. 2016. Increasing fish farm profitability through best management practice training in Egypt. *Aquaculture*, 465: 172–178. (also available at http://dx.doi.org/10.1016/j.aquaculture.2016.09.0150).

Diwakar. D. 2020 Vision 2040: *Oman's ambitious strategy towards a post-oil economy* [online]. [Cited 28 September 2020]. https://english.alaraby.co.uk/english/indepth/2019/4/16/vision-2040-omans-ambitious-strategy-towards-a-post-oil-economy

Drakeford, B., Failler, P. & Asche, F. 2014. Work package 7: trades and markets. In: *Final Technical Report- Aquaculture for Food Security, Poverty Alleviation and Nutrition*. pp. 31–33. (also available at https://cordis.europa.eu/docs/results/289/289760/final1-afspan-final-technical-report.pdf).

EAD. 2019. *Aquaculture Policy for Abu Dhabi to accelerate development of the sector* [online]. [Cited 18 August 2020]. https://www.ead.gov.ae/en/may-2019/aquaculture-policy-for-abu-dhabi-to-accelerate-development-of-the-sector

Eltholth, M., Fornace, K., Grace, D., Rushton, J. & Häsler, B. 2015. Characterisation of production, marketing and consumption patterns of farmed tilapia in the Nile Delta of Egypt. *Food Policy*, 51: 131–143. Science Direct. (also available at https://doi.org/10.1016/j.foodpol.2015.01.002).

Emam, A. 2018. *Egyptian province shows fish farming better lure than migration. The Arab Weekly* [online]. [Cited 02 November 2020]. https://thearabweekly.com/egyptian-province-shows-fish-farming-better-lure-migration

European Union. 2019. Country Analysis 2018. EUMOFA-European Market Observatory for Fisheries and Aquaculture Products. Luxemburg. (also available at https://www.eumofa.eu/documents/20178/136822/Country+analyses.pdf).

El-Ezaby, K.H., El-Sonbati, M.A. & El-Sayed, A.B. 2010. Impact of fish cages on the Nile water quality at Damietta Branch. *Journal of Environmental Sciences*, 39: 329–344. (also available at https://www.researchgate.net/publication/283498374_Impact_of_fish_cages_on_the_Nile_water_quality_at_Damietta_Branch).

FAO. 2010. *Aquaculture development. 4. Ecosystem approach to aquaculture*. FAO Technical Guidelines for Responsible Fisheries No. 5, Suppl. 4. Rome, FAO. 2010. 53 pp. (also available at http://www.fao.org/3/i1750e/i1750e.zip).

FAO. 2011. *Aquaculture development. 6. Use of wild fishery resources for capture-based aquaculture*. FAO Technical Guidelines for Responsible Fisheries No. 5, Suppl. 6. Rome, FAO. 2011. 81 pp. (also available at http://www.fao.org/3/ba0059e/ba0059e.pdf).

FAO. 2014. *Report of the Expert Meeting on the Review of Fisheries and Aquaculture Activities in the Tigris Euphrates Basin, Erbil, Iraq, 11–12 November 2012*. FAO Fisheries and Aquaculture Report No. 1079. Rome, FAO. 125 pp. (also available at http://www.fao.org/3/a-i4217e.pdf).

FAO. 2015. Regional Overview of Food Insecurity – Near East and North Africa: Strengthening Regional Collaboration to Build Resilience for Food Security and Nutrition. Cairo, Egypt, FAO. (also available at http://www.fao.org/3/a-i4644e.pdf).

FAO. 2016. Atlas of potential areas for cage aquaculture Red Sea – Kingdom of Saudi Arabia. FAO Fisheries and Aquaculture Department. Rome. 104 pp. (also available at http://www.fao.org/3/a-c0046b.pdf).

FAO. 2017a. *Regional review on status and trends in aquaculture development in the Near East and North Africa – 2015*, by Abdel-Fattah M. El-Sayed. FAO Fisheries and Aquaculture Circular No. 1135/6. Rome, FAO. 32 pp. (also available at http://www.fao.org/3/a-i6876e.pdf).

FAO. 2017b. *World aquaculture 2015: a brief overview*, by Rohana Subasinghe. FAO Fisheries and Aquaculture Circular No. 1140. Rome. FAO. 34 pp. (also available at: http://www.fao.org/3/a-i7546e.pdf).

FAO. 2017c. *Regional Conference "Blue Growth in the Mediterranean and the Black Sea: developing sustainable aquaculture for food security", 9–11 December 2014, Bari, Italy*, edited by F. Massa, R. Rigillo, D. Bourdenet, D. Fezzardi, A. Nastasi, H. Rizzotti, W. Emam and C. Carmignac. FAO Fisheries and Aquaculture Proceedings. No. 46. Rome. FAO. 179 pp. (also available at: http://www.fao.org/3/a-i6902e.pdf).

FAO. 2017d. *General Fisheries Commission for the Mediterranean. Report of the tenth session of the Scientific Advisory Committee on Aquaculture. Izmir, Turkey, 27–29 March 2017*. FAO Fisheries and Aquaculture Report No. 1206(Bi). Rome, FAO. 64 pp. (also available at: http://www.fao.org/3/b-i7607b.pdf).

FAO. 2017e. *Regional review on status and trends in aquaculture development in Asia-Pacific – 2015*, by Rohana Subasinghe. FAO Fisheries and Aquaculture Circular No. 1135/5. Rome, FAO. 32 pp. (also available at http://www.fao.org/3/a-i6875e.pdf).

FAO. 2017f. *FAO Aquaculture Newsletter*. No. 56, (April). Rome, FAO. 62 pp. (also available at http://www.fao.org/3/a-i7171e.pdf).

FAO. 2017g. Evaluation of FAO's contribution to the reduction of rural poverty through Strategic Programme 3 – Annex 4: assessment of progress on decent rural employment. Office of Evaluation – Thematic Evaluation Series. Rome, FAO. 42 pp. (also available at http://www.fao.org/3/a-bd601e.pdf).

FAO. 2017h. *Near East and North Africa Regional Overview of Food Insecurity 2016*. Cairo, pp. 35. (also available at http://www.fao.org/3/a-i6860e.pdf).

FAO. 2017i. Reviewed Strategic Framework. Report of the Conference of FAO. Fortieth Session. Rome, 3–8 July 2017. Rome. (also available at http://www.fao.org/3/a-mu208e.pdf).

FAO. 2017j. *The 2030 Agenda and the Sustainable Development Goals: The challenge for aquaculture development and management*, by John Hambrey. FAO Fisheries and Aquaculture Circular No. 1141, Rome, Italy.

FAO. 2017k. Blue Growth Initiative – Partnering with countries to achieve the Sustainable Development Goals. (also available at http://www.fao.org/3/a-i7862e.pdf).

FAO. 2017l. *FAO Aquaculture Newsletter.* No. 57 (September). Rome. (also available at http://www.fao.org/3/a-i7851e.pdf)

FAO. 2018a. Le développement de l'aquaculture en Algérie en collaboration avec la FAO – Bilan 2008–2016. FAO, *Circulaire sur les pêches et l'aquaculture*, n. 1176. Rome. 112 pp. Licence: CC BY-NC-SA 3.0 IGO. (also available at http://www.fao.org/3/ca2769fr/CA2769FR.pdf).

FAO. 2018b. Achieving Blue Growth. Building vibrant fisheries and aquaculture communities. Policy Support and Governance – FAO Fisheries and Aquaculture Department. Rome, Italy. 28 pp. (also available at http://www.fao.org/3/CA0268EN/ca0268en.pdf).

FAO. 2018c. *The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals*. Rome. (also available at http://www.fao.org/3/I9540EN/i9540en.pdf)

FAO. 2018d. *Report of the Eighth Meeting of the RECOFI Working Group on Aquaculture, Kuwait City, State of Kuwait, 17–19 April 2018*. FAO Fisheries and Aquaculture Report No. 1242. Rome. License: CC BY-NC-SA 3.0 IGO. (also available at http://www.fao.org/3/ca1351en/CA1351EN.pdf).

FAO. 2018e. The Impact of Disasters and Crises on Agriculture and Food Security 2017. Food and Agriculture Organization of the United Nations, Rome. (also available at http://www.fao.org/3/I8656EN/i8656en.pdf).

FAO. 2018f. *FAO Aquaculture Newsletter. No. 59 (October).* Rome. (also available at http://www.fao.org/3/ca2325en/ca2325en.pdf).

FAO. 2018g. *FAO Aquaculture Newsletter. No. 58 (April).* Rome. (also available at http://www.fao.org/3/i9200en/I9200EN.pdf)

FAO. 2019a. The new investment wave into aquaculture in Middle East countries: Opportunities and challenges by Chalil G. In: *GLOBEFISH – Information and Analysis on World Fish Trade* [online]. Rome. [Cited 31 August 2020]. http://www.fao.org/in-action/globefish/fishery-information/resource-detail/en/c/338614/

FAO. 2019b. Rural transformation – key for sustainable development in the Near East and North Africa. Overview of Food Security and Nutrition 2018. Cairo. 80 pp. Licence: CC BY-NC-SA 3.0 IGO. (also available at http://www.fao.org/3/ca3817en/CA3817EN.pdf).

FAO. 2019c. *Report of the Special Session on Advancing Integrated Agriculture Aquaculture through Agroecology, Montpellier, France, 25 August 2018*. FAO Fisheries and Aquaculture Report No. 1286. Rome. (also available at http://www.fao.org/3/ca7209en/CA7209EN.pdf).

FAO. 2019d. *Report of the FAO/MSU/WB First Multi-Stakeholder Consultation on a Progressive Management Pathway to Improve Aquaculture Biosecurity (PMP/AB), Washington, D.C., United States of America, 10–12 April 2018*. FAO Fisheries and Aquaculture Report No. 1254. Rome. 76 pp. Licence: CC BY-NC-SA 3.0 IGO. (also available at http://www.fao.org/3/ca4891en/ca4891en.pdf).

FAO. 2019e. Toolkit on allocated zones for aquaculture. Benefits, implementation and management. Rome, Italy. 20 pp. (also available at: http://www.fao.org/3/ca5736en/CA5736EN.pdf).

FAO. 2019f. Our priorities – The Strategic Objectives of FAO. Rome. 28 pp. Licence: CC BY-NC-SA 3.0 IGO. (also available at http://www.fao.org/3/I8580EN/i8580en.pdf).

FAO. 2020a. *FAO Regional Office for Near East and North Africa – Regional Perspectives* [online]. Cairo. [Cited 31 August 2020]. http://www.fao.org/neareast/perspectives/en/

FAO. 2020b. *FAOSTAT* [online]. [Cited 31 August 2020]. Rome. http://www.fao.org/faostat/en/#home

FAO. 2020c. Fishery and Aquaculture Statistics. Global production by production source 1950–2018 (FishstatJ). In: *FAO Fisheries and Aquaculture Division* [online]. Rome. Updated 2020. www.fao.org/fishery/statistics/software/fishstatj/en

FAO. 2020d. Aquastat databases. In: *AQUASTAT – FAO Global Information System on Water and Agriculture* [online]. [Cited 31 August 2020]. http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en

FAO. 2020e. *The State of World Fisheries and Aquaculture 2020. Sustainability in action.* Rome. (also available at https://doi.org/10.4060/ca9229en).

FAO. 2020f. FAO yearbook. Fishery and Aquaculture Statistics 2018/FAO annuaire. Statistiques des pêches et de l'aquaculture 2018/FAO anuario. Estadísticas de pesca y acuicultura 2018. Rome/Roma. (also available at http://www.fao.org//fishery/publications/yearbooks/en).

FAO. 2020g. *FAO framework on ending child labour in agriculture*. Rome. (also available at https://doi.org/10.4060/ca9502en).

FAO. 2020h. Fishery and Aquaculture Statistics. Global Fisheries commodities production and trade 1976–2018 (FishstatJ). In: *FAO Fisheries and Aquaculture Division* [online]. Rome. Updated 2020. www.fao.org/fishery/statistics/software/fishstatj/en

FAO. 2020i. Fishery and Aquaculture Statistics. Food balance sheets of fish and fishery products 1961–2017 (FishstatJ). In: *FAO Fisheries and Aquaculture Division* [online]. Rome. Updated 2020. www.fao.org/fishery/statistics/software/fishstatj/en

FAO. 2020j. *How is COVID-19 affecting the fisheries and aquaculture food systems.* Rome. (also available at https://doi.org/10.4060/ca8637en).

FAO. 2020k. *FAO Aquaculture Newsletter*. No. 62, (October). Rome, FAO. 64 pp. (also available at http://www.fao.org/3/cb1550en/cb1550en.pdf).

FAO. 2020l. *FAO Aquaculture Newsletter*. No. 61, (April). Rome, FAO. 60 pp. (also available at http://www.fao.org/3/ca8302en/CA8302EN.pdf).

FAO. 2003–2020. National Aquaculture Sector Overview. Egypt. National Aquaculture Sector Overview Fact Sheets. Text by Salem, A.M.; Saleh, M.A. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 16 November 2010. [Cited 25 June 2020].

FAO. 2005–2020a. National Aquaculture Sector Overview. United Arab Emirates. National Aquaculture Sector Overview Fact Sheets. Text by Al-Shaer, M. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 27 May 2016. [Cited 25 June 2020].

FAO. 2005–2020b. National Aquaculture Sector Overview. Vue générale du secteur aquacole national – Tunisie. National Aquaculture Sector Overview Fact Sheets. Texte par Hamza, H. Dans: *Département des pêches et de l'aquaculture de la FAO* [en ligne]. Rome. Mis à jour 19 October 2015. [Cité le 25 June 2020].

FAO. 2005–2020c. National Aquaculture Sector Overview. Lebanon. National Aquaculture Sector Overview Fact Sheets. Text by El Mokdad, D. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 20 February 2015. [Cited 25 June 2020].

FAO. 2005–2020d. National Aquaculture Sector Overview. Vue générale du secteur aquacole national – Maroc (le). National Aquaculture Sector Overview Fact Sheets. Texte par Abdellatif, O.; El-Ahdal, M. Dans: *Département des pêches et de l'aquaculture de la FAO* [en ligne]. Rome. Mis à jour 18 December 2015. [Cité le 25 June 2020].

FAO. 2006–2020a. National Aquaculture Sector Overview. Oman. National Aquaculture Sector Overview Fact Sheets. Text by Al-Yahyai, D.S. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 8 May 2017. [Cited 25 June 2020].

FAO. 2006–2020b. National Aquaculture Sector Overview. Syrian Arab Republic. National Aquaculture Sector Overview Fact Sheets. Text by Krouma, I. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 28 January 2006. [Cited 25 June 2020].

FAO. 2006–2020c. National Aquaculture Sector Overview. Vue générale du secteur aquacole national – Algérie. National Aquaculture Sector Overview Fact Sheets. Texte par Oussaid, M. Dans: *Département des pêches et de l'aquaculture de la FAO* [en ligne]. Rome. Mis à jour 25 August 2014. [Cité le 25 June 2020].

FAO. 2009–2020a. National Aquaculture Sector Overview. Qatar (2009). National Aquaculture Sector Overview Fact Sheets. Text by Falamarzi, M. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 13 March 2015. [Cited 25 June 2020].

FAO. 2009–2020b. National Aquaculture Sector Overview. Iraq. National Aquaculture Sector Overview Fact Sheets. Text by Jassem, T. & Sarkess, V. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 1 January 2009. [Cited 25 June 2020].

FAO. 2010–2020. National Aquaculture Sector Overview. Kingdom of Saudi Arabia. National Aquaculture Sector Overview Fact Sheets. Text by Odaiby, M. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 6 November 2015. [Cited 25 June 2020].

FAO/General Fisheries Commission for the Mediterranean. 2015. *Report of the ninth session of the Committee on Aquaculture. Marrakech, Morocco, 24–26 February*. FAO Fisheries and Aquaculture Report No. 1111. Rome, FAO. 45 pp. (also available at http://www.fao.org/documents/card/en/c/773f3a4d-6cbc-465e-8cde-4567c08ec949/).

FAO/Regional Commission for Fisheries. 2011. *Report of the Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture. Doha, the State of Qatar, 24–28 October 2010*. FAO Fisheries and Aquaculture Report No. 961. Rome. FAO. 118 pp. (also available at http://www.fao.org/3/i3362e/i3362e.pdf).

FAO & ILO. 2013. Guidance on addressing child labour in fisheries and aquaculture. (also available at http://www.fao.org/3/i3318e/i3318e.pdf).

FAO & International Technical Panel on Soils (ITPS). 2015. Status of the World's Soil Resources. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy. (also available at http://www.fao.org/documents/card/en/c/c6814873-efc3-41db-b7d3-2081a10ede50/).

FAO, IFAD, UNICEF, WFP and WHO. 2019. The State of Food Security and Nutrition in the World 2019. Safeguarding against economic slowdowns and downturns. Rome, FAO. Licence: CC BY-NC-SA 3.0 IGO. (also available at http://www.fao.org/3/ca5162en/ca5162en.pdf).

Fathi, M., Dickson, C.A., Dickson, M.W., Leschen, W., Baily, J.A., Muir, F., Ulrich, K. & Weidman, M. 2017. Identification of Tilapia Lake Virus in Egypt in Nile tilapia affected by 'summer mortality' syndrome. *Aquaculture*, 473: 430-432. (also available at http://dx.doi.org/10.1016/j.aquaculture.2017.03.014).

Feidi, I. 2018. Will the New Large-Scale Aquaculture Projects Make Egypt Self Sufficient In Fish Supplies? *MedFAR*., 1(1): 31–41. (also available at https://pdfs.semanticscholar.org/f639/55bb0327850bb3268733db40f3ffa17a0fae.pdf).

Feidi, I. 2019. *The changing face of seafood marketing in the Arab Gulf States. Globefish FAO* [online]. Rome. [Cited 31 August 2020]. http://www.fao.org/in-action/globefish/market-reports/resource-detail/en/c/1241685/

Fezzardi, D., Massa, F., Àvila-Zaragoza, P., Rad, F., Yücel-Gier, G., Deniz, H., Hadj Ali Salem, M., Hamza, H.A. & Ben Salem, S. 2013. *Indicators for sustainable aquaculture in Mediterranean and Black Sea countries*. Guide for the use of indicators to monitor sustainable development of aquaculture. Studies and Reviews. General Fisheries Commission for the Mediterranean No 93. Rome, FAO. 60 pp. (also available at http://www.fao.org/3/i3194e/i3194e.pdf).

Fouly, M. & Danni, W. 2019. Chinese companies turn unwanted Nile River crayfish into money-making delicacy [online]. [Cited 31 August 2020] http://www.xinhuanet.com/english/2019-08/07/c_138290867.htm

Fourdain, L., Hamza, H., Bourdenet, D. & Massa, F. 2019. Capacity-building on allocated zones for aquaculture in the Mediterranean and the Black Sea. *FAO Aquaculture Newsletter* No. 60, (August), pp. 24–25. Rome. (also available at http://www.fao.org/3/ca5223en/ca5223en.pdf).

Fundación Observatorio Español de Acuicultura (FOESA). 2011. Sustainability indicators for aquaculture sea cages in the Mediterranean. FOESA, Madrid, Spain. 116 pp. (also available at https://www.academia.edu/24661991/Sustainability_Indicators_for_Aquaculture_Sea_Cages_in_the_Mediterranean).

Food Security. 2020. UAE Aquaculture Pulse 2020. Abu Dhabi, United Arab Emirates. (also available at http://www.foodsecurity.gov.ae/).

Freyhof, J., Els, J., Feulner, G.R., Hamidan, N.A. & Krup, F. 2020. Freshwater fishes of the Arabian Peninsula. Motivate Media group, Dubai, UAE: 272 pp.

GAFRD. 2020. Fish Statistics Year Book 2018. Cairo, Egypt, General Authority for Fish Resources Development. 116 pp.

García, N., Harrison, I., Cox, N. & Tognelli, M.F. 2015. The Status and Distribution of Freshwater Biodiversity in the Arabian Peninsula. Gland, Switzerland, Cambridge, UK and Arlington, USA. IUCN. (also available at https://www.researchgate.net/publication/280610639_The_Status_and_Distribution_of_Freshwater_Biodiversity_in_the_Arabian_Peninsula).

Gennari, L. 2019. FAO Technical Support Mission for the project TCP/TUN/3602 – Renforcement de la gouvernance et développement de la pêche en Tunisie.

GFCM. 2013. Conclusions of the ad hoc meeting to launch the GFCM Aquaculture Multi-stakeholder Platform (AMShP). Izmir, Turkey, 12–13 December 2013. Rome, Italy. 5 pp. (also available at http://www.fao.org/3/a-ax834e.pdf).

GFCM. 2018. Strategy for the sustainable development of Mediterranean and Black Sea aquaculture. Food and Agriculture Organization of the United Nations, Rome. (also available at http://www.fao.org/3/I9766EN/i9766en.pdf).

GFCM. 2020. Fisheries and aquaculture in the Mediterranean and Black Sea: An updated analysis of the impacts of the COVID-19 crisis. Rome. FAO. (also available at https://doi.org/10.4060/ca9902en).

Goulding, I. & Kamel, M. 2013. *Institutional, Policy and Regulatory Framework for Development of the Egyptian Aquaculture Sector*. WorldFish Project Report, 2013–39. 32 pp. (also available at http://pubs.iclarm.net/resource_centre/WF-2013-39.pdf).

Göll, E., Uhl, A. & Zwiers, J. 2019. Sustainable development in the MENA region. Middle East and North Africa regional Architecture: mapping geopolitical shifts, regional order and domestic transformations. Future Notes, No. 20, March, 2019. 8 pp. (also available at https://www.cidob.org/en/publications/publication_series/menara_papers/future_notes/sustainable_development_in_the_mena_region/(language)/eng-US).

Hall, S. 2015. Can aquaculture contribute to food and nutrition security in the Middle East? [online]. [Cited 31 August 2020]. http://blog.worldfishcenter.org/2015/09/can-aquaculture-contribute-to-food-and-nutrition-security-in-the-middle-east/

Haubrock, P.J., Inghilesi, A.F., Mazza, G. Bendoni, M., Solari, L. & Tricarico, E. 2019. Burrowing activity of *Procambarus clarkii* on levees: analysing behaviour and burrow structure. *Wetlands Ecol Manage* 27: 497–511. (also available at https://doi.org/10.1007/s11273-019-09674-3).

Hebisha, H. & Fathi, M. 2014. *Small and medium-scale aquaculture value chain development in Egypt: Situation analysis and trends*. WorldFish/ILRI Project Report. Nairobi, Kenya: ILRI. (also available at https://core.ac.uk/download/pdf/132653842.pdf).

Henriksson, P., Dickson, M., Nasr Allah, A.M., Al-Kenawy, D. & Phillips, M. 2016. Benchmarking the environmental performance of best management practice and genetic improvements in Egyptian aquaculture using life cycle assessments. *Aquaculture*, 468: 53–59. (also available at http://dx.doi.org/10.1016/j.aquaculture.2016.09.051).

Henriksson, P.J.G., Mohan, C.V. & Phillips, M.J. 2017. Evaluation of different aquaculture feed ingredients in Indonesia using life cycle assessment. *IJoLCAS* 1: 13–21. (also available at https://fish.cgiar.org/sites/default/files/publications/4177_2017_Henriksson_Evaluation.pdf).

Hishamunda, N., Ridler, N. & Martone, E. 2014. *Policy and governance in aquaculture: lessons learned and way forward.* FAO Fisheries and Aquaculture Technical Paper No. 577. Rome, FAO. 59 pp. (also available at http://www.fao.org/3/a-i3156e.pdf).

Holmyard, N. 2019. How aquaculture furthers the Blue Growth Initiative. Global Aquaculture Advocate [online]. [Cited 31 August 2020]. https://www.aquaculturealliance.org/advocate/how-aquaculture-furthers-the-blue-growth-initiative/

Ibrahim, N.A., Nasr-Allah, A.M. & Charo-Karisa, H. 2019. Assessment of the impact of dissemination of genetically improved Abbassa Nile tilapia strain (GIANT-G9) versus commercial strains in some Egyptian governorates. *Aquaculture Research*, 50(10): 2951–1959. (also available at https://doi.org/10.1111/are.14249).

Joffre, O., Klerkx, L., Dickson, M. & Verdegem, M. 2017. How is innovation in aquaculture conceptualized and managed? A systematic literature review and reflection framework to inform analysis and action. *Aquaculture*, 470: 129–148. (also available at http://dx.doi.org/10.1016/j.aquaculture.2016.12.020).

Kantor, P. & Kruijssen, F. 2014. *Informal fish retailing in rural Egypt: opportunities to enhance income and work conditions for women and men*. WorldFish Project Report, 2014–5. Penang, Malaysia. (also available at http://pubs.iclarm.net/resource_centre/2014-51.pdf).

Kara, M.H., Lacroix, D., Rey-Valette, H., Mathé, S. & Blancheton, J.P. 2018. Dynamics of Research in Aquaculture in North Africa and Support for Sustainable Development and Innovation. *Reviews in Fisheries Science & Aquaculture*, 26(3): 309–318. (also available at DOI: 10.1080/23308249.2017.1410521).

Katsanevakis, S., Coll, M., Piroddi, C., Steenbeek, J., Ben Rais Lasram, F., Zenetos, A. & Cardoso, A.C. 2014. Invading the Mediterranean Sea: biodiversity patterns shaped by human activities. *Front. Mar. Sci.*, 1: 32. (also available at doi: 10.3389/fmars.2014.00032).

Keeley, N.B., Cromey, C.J., Goodwin, E.O., Gibbs, M.T. & Macleod, C.M. 2013. Predictive depositional modelling (DEPOMOD) of the interactive effect of current flow and resuspension on ecological impacts beneath salmon farms. *Aquaculture Environment Interactions*, 3: 275–291. (also available at Doi: 10.3354/aei00068. https://www.int-res.com/articles/aei2013/3/q003p275.pdf).

Kruijssen, F., McDougall, C.L. & Asseldonk, I.J.M. 2018. Gender and aquaculture value chains: A review of key issues and implications for research. *Aquaculture*, 493: 328–337. (also available at https://doi.org/10.1016/j.aquaculture.2017.12.038).

Little, D.C., Belton, B., Beveridge, M.C., Bush, S.R., Dabaddie, L., Demaine, H., Edwards, P., Haque, M.M., Kibria, G., Morales, E., Murray, F.J., Leschen, W.A. & Nandeesha, M.C. 2012. Alleviating poverty through aquaculture: progress, opportunities and improvements. *In* R.P. Subasinghe, J.R. Arthur, D.M. Bartley, S.S. De Silva, M. Halwart, N. Hishamunda, C.V. Mohan, & P. Sorgeloos (eds.), *Proceedings of the Global Conference of Aquaculture 2010: Farming the Waters for People and Food, 22–25 September 2010* (pp. 719–783). FAO/NACA. (also available at http://www.fao.org/docrep/015/i2734e/i2734e.pdf#page=731).

Lund, P.C. 2019. Fisheries and Aquaculture in Oman. Innovation Norway Middle East. Dubai. (also available at https://aquatechcluster.no/wp-content/uploads/2019/03/aquaculture-in-oman-feb-2019.pdf).

Macfadyen, G., Nasr-Alla, A.M., Kenawy, D.A., Fathi, M., Hebicha, H., Diab, A.M., Hussein, S.M., Abouzied, R.M. & El Naggar, G.O. 2012. Value-chain analysis – An assessment methodology to estimate Egyptian aquaculture sector performance. *Aquaculture*, 362–363: 18–27. (also available at https://www.academia.edu/23167796/Value_chain_analysis_An_assessment_methodology_to_estimate_Egyptian_aquaculture_sector_performance).

Macias, J.C., Avila Zaragozá, P., Karakassis, I., Sanchez-Jerez, P., Massa, F., Fezzardi, D., Yücel Gier, G., Franičević, V., Borg, J.A., Chapela Pérez, R.M., Tomassetti, P., Angel, D.L., Marino, G., Nhhala, H., Hamza, H., Carmignac, C. & Fourdain, L. 2019. *Allocated zones for aquaculture: a guide for the establishment of coastal zones dedicated to aquaculture in the Mediterranean and the Black Sea*. General Fisheries Commission for the Mediterranean. Studies and Reviews No 97. Rome, FAO. 90 pp. (also available at http://www.fao.org/gfcm/publications/studies-reviews/azaguide/en/).

Ministry of Agriculture and Fisheries Wealth (MAFW). 2011. Investment guidelines for aquaculture development in the Sultanate of Oman. Ministry of Agriculture and Fisheries Wealth, Sultanate of Oman. 46 pp. (also available at http://www.raisaquaculture.net/uploads/media/Investment%20Guidlines.pdf).

El Mahrad, B., Abalansa, S., Newton, A., Icely, J.D., Snoussi, M. & Kacimi, I. 2020. Frontiers in Environmental Science, 23 April 2020. (also available at https://www.frontiersin.org/article/10.3389/fenvs.2020.00037).

Massa, F., Onofri, L. & Fezzardi, D. 2017. Aquaculture in the Mediterranean and the Black Sea: A Blue Growth perspective. *In* Nunes, P.A.L.D., Svensson, L.E. & Anil Markandya, A. (eds). *Handbook on the Economics and Management of Sustainable Oceans*, 624 pp. Edward Elgar Publishing. (also available at https://www.researchgate.net/publication/313359435_Aquaculture_in_the_Mediterranean_and_the_Black_Sea_a_Blue_Growth_perspective).

Massa, F., Demian, S. & Bourdenet, D. 2018. A Strategy for the Sustainable Development of Mediterranean and Black Sea Aquaculture. *FAO Aquaculture Newsletter* No. 58 (April), pp. 20–22. (also available at http://www.fao.org/3/i9200en/I9200EN.pdf).

Meaden, G.J., Aguilar-Manjarrez, J., Corner, R.A., O'Hagan, A.M. & Cardia, F. 2016. *Marine spatial planning for enhanced fisheries and aquaculture sustainability – its application in the Near East*. FAO Fisheries and Aquaculture Technical Paper No. 604. Rome, FAO. (also available at http://www.fao.org/3/a-i6043e.pdf).

Metian, M., Pouil, S., Boustany, A.M. & Troell, M. 2014. Farming of Bluefin tuna – Reconsidering global estimates and sustainability concerns. *Reviews in Fisheries Science & Aquaculture*, 22(3): 184–192. (also available at https://www.academia.edu/12445227/Farming_of_Bluefin_Tuna_Reconsidering_Global_Estimates_and_Sustainability_Concerns)

MEWA. 2020a. Aquaculture: A promising sector promoting the national economy and attracting local and foreign investors. Ministry of Environment, Water and Agriculture, Kingdom of Saudi Arabia. (also available at https://www.mewa.gov.sa/en/Ministry/Deputy%20Ministries/AgencyofAgriculture/Topics/ Pages/Topic-28-1-2019.aspx).

MEWA. 2020b. Invest Saudi: Aquaculture. Ministry of Environment, Water and Agriculture, Kingdom of Saudi Arabia. (also available at https://investsaudi.sa/media/1248/aquaculturer3.pdf).

El-Mezayen, M.M., Rueda-Roa, D.T., Essa, M.A., Muller-Karger, F.E. & Elghobashy, A.E. 2018. Water quality observations in the marine aquaculture complex of the Deeba Triangle, Lake Manzala, Egyptian Mediterranean coast. *Environ Monit Assess*, 190: 436 (2018). (also available at https://doi.org/10.1007/s10661-018-6800-6).

Moawad, R.K., Mohamed, G.F, Hanna, El-Banna. A., Bareh G.F. & Mahmoud, K.F. 2017. Assessment of hurdle technology to preserve Nile tilapia fillets during refrigeration with the application of marjoram oil/polyphosphates dipping. *Asian Journal of Scientific Research,* 10: 116–127. (also available at DOI: 10.3923/ajsr.2017.116.127).

MOFW. 2010. Atlas of suitable sites for aquaculture projects in the Sultanate of Oman. Ministry of Fisheries Wealth, Sultanate of Oman. Registration No. 123/2010. (also available at: https://www.maf.gov.om/BakEnd/Publications/636515855545080076.pdf).

Ministere de la Pêche et des Resources Halieutiques (MPRH). 2014. Plan Aquapeche 2020. Secteur de la peche et de l'aquaculture. Ministere de la Pêche et des Resources Halieutiques, Republique Algerienne Democratique et Populaire. 60 pp. (also available at http://www.fao.org/fi/static-media/MeetingDocuments/BlueHope/secondmeeting/Investment/bilan%20aquapeche.pdf).

Murphy, S., Charo-Karisa, H., Rajaratnam, S., Cole, S.M., McDougall, C., Nasr-Allah, A.M., Kenawy, D., Abou Zead, M.Y., van Brakel, M.L., Banks, L.K. & Ibrahim, N. 2020a. Selective breeding trait preferences for farmed tilapia among low-income women and men consumers in Egypt: Implications for pro-poor and gender-responsive fish breeding programmes. *Aquaculture*, 525, 735042. (also available at https://doi.org/10.1016/j.aquaculture.2020.735042).

Murphy, S., Arora, D., Kruijssen, F., McDougall, C. & Kantor, P. 2020b. Gender-based market constraints to informal fish retailing: Evidence from analysis of variance and linear regression. PLOS ONE, 15(3):e0229286. (also available at https://doi.org/10.1371/journal.pone.0229286).

Nasr-Allah, A.M. & Dickson, M.W. 2017. Price setting in markets for Egyptian farmed fish. *Environment and Ecology Research*, 5(3): 184–194. (also available at https://digitalarchive.worldfishcenter.org/handle/20.500.12348/543?show=full).

Nasr-Allah, A.M., Dickson, M.W., Kenawy, D.A., Ahmed, M.F.M & El-Naggar, G.O. 2014a. Technical characteristics and economic performance of commercial tilapia hatcheries applying different management systems in Egypt. *Aquaculture*, 426–427: 220–230. (also available at https://www.academia.edu/31097323/Technical_characteristics_and_economic_performance_of_commercial_tilapia_hatcheries_applying_different_management_systems_in_Egypt).

Nasr-Allah, A.M., Dickson, M., Kenawy, D.A.R., El Naggar, G., Ahmed, M.F.M., Azazy, G., Garana, Y. & Diab, A.M. 2014b. Value Chain Analysis of Egyptian Fish Seed Production. 4th Scientific Conference in Aquaculture, organized by (CLAR) 11–12 March 2014. *Egyptian Journal for Aquaculture* and *Abbassa International Journal*, (2014), 351–372. (also available at https://www.researchgate.net/publication/267827089_value_chain_analysis_of_egyptian_fish_seed_production).

Nasr-Allah, A.M., Al-Kenawy, D. & Karisa, H. 2019. In-pond raceway production system application for tilapia production in Egypt. *J. Mar. Biol. Oceanography*, 2018. 7. DOI: 10.4172/2324-8661-C1-011. (also available at https://www.scitechnol.com/conference-abstracts-files/2324-8661-C1-011-009.pdf).

Nasr-Allah, A., Gasparatos, A., Karanja, A., Brako, E.D., Murphy, S., El-Kenawy, D., Rossignoli, C., Phillips, M. & Charo-Karisa, H. 2019. *Employment generation in the Egyptian aquaculture value chain*. WorldFish Program Report, 2019–04. Penang, Malaysia. (also available at https://digitalarchive.worldfishcenter.org/handle/20.500.12348/3343).

Naziri, D. 2011. Financial services for SME aquaculture producers: Egypt case study. Project report funded by the German Agency for Technical Cooperation (GTZ) for the benefit of developing countries, 30 pp. (also available at http://www.africanfisheriesinvestment.org/files/casestudies/casestudy-egypt.pdf).

NordOest. 2016. *Aquaculture in Saudi Arabia. Innovasjon Norge* [online]. [Cited 31 August 2020]. http://akvarena.no/uploads/Ekstern%20informasjon/Saudi%20Arabia%20Aquaculture.pdf

Nutreco. 2015. *Nutreco continues its commitment to growth in Egypt* [online]. [Cited 31 August 2020] https://www.nutreco.com/en/Recycle-Bin/nutreco-continues-its-commitment-to-growth-in-egypt/1226320

OECD. 2020a. *COVID-19 crisis response in MENA countries* [online]. [Cited 31 August 2020]. http://www.oecd.org/coronavirus/policy-responses/covid-19-crisis-response-in-mena-countries-4b366396/

OECD. 2020b. *Fisheries, aquaculture and COVID-19: Issues and Policy Responses* [online]. [Cited 18/8/2020]. http://www.oecd.org/coronavirus/policy-responses/fisheries-aquaculture-and-covid-19-issues-and-policy-responses-a2aa15de/

Palm, H.W., Knaus, U., Appelbaum, S., Goddeck, S., Strauch, S.M., Vermeulen, T, Jijakli, M.H. & Kotzen, B. 2018. Towards commercial aquaponics: a review of systems, designs, scales and nomenclature. *Aquacult International*, 26: 813–842. (also available at https://doi.org/10.1007/s10499-018-0249-z).

Pinello, D. & Majdalani, S. 2018. Assessment of the Commercial Seafood Chain in Lebanon. FAO TCP/LEB/3601 C2. Beirut, Lebanon (FAO/Ministry of Agriculture, Lebanon). 188 pp. (also available at http://www.agriculture.gov.lb/getattachment/3446e66a-1147-457b-a75f-08a5ca6b97a3/Assessment-of-the-Commercial-Seafood-Chain-in-Lebanon).

Potts, J., Wilkings, A., Lynch, M. & McFatridge, S. 2016. State of Sustainability Initiatives Review: Standards and the Blue Economy. International Institute for Sustainable Development (IISD). Winnipeg, Canada. (also available at https://www.iisd.org/sites/default/files/publications/ssi-blue-economy-2016.pdf).

Prins, T. 2015. Aquaculture development in the Sultanate of Oman- Towards a blue revolution in a hydrocarbon society? Utrecht University, the Netherlands. (also available at https://dspace.library.uu.nl/bitstream/handle/1874/316219/Thesis%20Final%201%20-%20reduced.pdf?sequence=2&isAllowed=y).

Rad, F., Massa, F., Afanasjeva, A., De Rossi, F. & Fezzardi, D. 2014. A preliminary survey on aquaculture farmers' organizations in the Mediterranean and Black Sea. *Journal of Academic Documents for Fisheries and Aquaculture*, 2: 55–62. (also available at https://dergipark.org.tr/en/pub/jadfa/issue/9803/121501).

Rafih, H. & Pons, S. 2019. *Aquaculture offers lifeline to floundering Moroccan fishermen. Phys. org. Douglas, Isle of Man, United Kingdom* [online]. [Cited 31 August 2020]. https://phys.org/news/2019-10-aquaculture-lifeline-floundering-moroccan-fishermen.html

Regunathan, C. 2012. Industry perspective of aquaculture in the Middle East – Status and issues. Chapter 8, pp.103-154. In: *Aquaculture in the Middle East and North Africa*. Editors: Azad Ismail Saheb and Salam Al-Ablani. Published by Nova Science Publishers, Inc. New York. 335 pp. (also available at http://www.novapublishers.org/catalog/product_info.php?products_id=22355).

Rimmer, M.A. & Glamuzina, B. 2017. A review of grouper (Family Serranidae: Subfamily Epinephelinae) aquaculture from a sustainability science perspective. *Reviews in Aquaculture*, 11(1): 58-87. (also available at https://doi.org/10.1111/raq.12226).

Robb, D.H.F., MacLeod, M., Hasan, M.R. & Soto, D. 2017. *Greenhouse gas emissions from aquaculture: a life cycle assessment of three Asian systems.* FAO Fisheries and Aquaculture Technical Paper No. 609. Rome, FAO. 110 pp. (also available at http://www.fao.org/3/a-i7558e.pdf).

Sadek, S. 2019. Marine shrimp culture in Egypt: Case study. General Fisheries Commission for the Mediterranean (GFCM), FAO workshop on shrimp farming: opportunities and challenges, Monastir, Tunisia (11 April, 2019). (also available at http://www.fao.org/gfcm/technical-meetings/detail/en/c/1234290/).

Saleh, M. 2008. Capture-based aquaculture of mullets in Egypt. *In* A. Lovatelli and P.F. Holthus (eds). *Capture-based aquaculture*. Global overview. FAO Fisheries Technical Paper No. 508. Rome, FAO. pp. 109–126 (also available at http://www.fao.org/3/i0254e/i0254e00.htm).

Saliola, F. 2019. *World Bank Blogs. A new era of work in the Middle East and North Africa: What is to be done?* [online]. [Cited 31 August 2020]. https://blogs.worldbank.org/jobs/new-era-work-middle-east-and-north-africa-what-be-done

Samaras, A.G., Karambas, T.V. & Archetti, R. 2015. Simulation of tsunami generation, propagation and coastal inundation in the Eastern Mediterranean. *Ocean Science*, 11(4): 643-655 (also available at DOI: 10.5194/os-11-643-2015).

Sanchez-Jerez, P., Karakassis, I., Massa, F., Fezzardi, D., Aguilar-Manjarrez, J., Soto, D., Chapela, R., Avila, P., Macias, J.C., Tomassetti, P., Marino, G., Borg, J.A., Franičević, V., Yucel-Gier, G., Fleming, I., Biao, X., Nhhala, H., Hamza, H., Forcada, A. & Dempster, T. 2016. Aquaculture's struggle for space: the need for coastal spatial planning and the potential benefit of Allocated Zones for Aquaculture (AZA) avoid conflict and promote sustainability. *Aquacult Environ Interact*, 8: 41–54. (also available at https://core.ac.uk/download/pdf/83022059.pdf).

SAS. 2016. *Aquaculture and job opportunities for women in Kingdom of Saudi Arabia* [online]. [Cited 12 November 2020] http://www.sas.org.sa/en/news/details/131/2016-02-16

SAS. 2018. *The Saudi Aquaculture Society attracts a number of Saudi girls with higher degrees to work in the genetic resources program in the Kingdom's experience in the aquaculture sector* [online]. [Cited 12 November 2020]. http://www.sas.org.sa/en/news/details/197/2018-04-01

El-Sayed, A.F.M., Dickson, M.W. & El-Naggar, G.O. 2015. Value chain analysis of the aquaculture feed sector in Egypt. *Aquaculture*, 437: 92–101. (also available at https://doi.org/10.1016/j.aquaculture.2014.11.033).

Scott, A.G., Penman, D.J., Beardmore, J.A. & Skibinski, D.O.F. 1989. The 'YY' supermale in *Oreochromis niloticus* (L.) and its potential in aquaculture. *Aquaculture*, 78: 237–251. (also available at https://doi.org/10.1016/0044-8486(89)90102-6).

Soliman, N.F. 2017. Aquaculture in Egypt under changing climate: challenges and opportunities. 2017. ARCA Working Paper No. 4. Alexandria, Egypt, Alexandria Research Center for Adaptation to Climate Change. 39 pp. (also available at http://arca-eg.org/wp-content/uploads/2017/06/Working-Paper-4-Jan.2017.pdf).

Soto, D., White, P., Dempster, T., De Silva, S., Flores, A., Karakassis, Y., Knapp, G., Martinez, J., Miao, W., Sadovy, Y., Thorstad, E. & Wiefels, R. 2012. Addressing aquaculture-fisheries interactions through the implementation of the ecosystem approach to aquaculture (EAA). *In* R.P. Subasinghe, J.R. Arthur, D.M. Bartley, S.S. De Silva, M. Halwart, N. Hishamunda, C.V. Mohan & P. Sorgeloos (eds). *Farming the Waters for People and Food. Proceedings of the Global Conference on Aquaculture 2010, Phuket, Thailand. 22–25 September 2010.* pp. 385–436. FAO, Rome and NACA, Bangkok. (also available at http://www.fao.org/3/i2734e/i2734e03h.pdf).

Stutzman, E., Molnar, J., Atukunda, G. & Walakira, J. 2017. Understanding the Role of Fish Farmer Associations as Intermediaries for the Commercialization of Aquaculture in Uganda. *Fish Aqua J*, 8: 214. (also available at doi:10.4172/2150-3508.1000214).

Al-Sulami, M. 2018. *Saudi shrimp prove to be a hit across the globe* [online]. [Cited 12 November 2020]. https://www.arabnews.com/node/1289041/saudi-arabia

Takouleo, J.B. 2020. *Egypt: Metito and Hassan Allam to reuse agricultural wastewater in Ismailia* [online]. [Cited 31 August 2020]. https://www.afrik21.africa/en/egypt-metito-and-hassan-allam-to-reuse-agricultural-wastewater-in-ismailia/

Al-Tameemi, R.A. 2015. Evaluation of five commercial diets used for fish feeding in Basra governorate, southern Iraq. *Iraqi J Aquacult*, 12(1): 71–82. (also available at http://www.ijaquaculture.org/admin/documents/107154.pdf).

Thompson, T., Anton, P., Curtis, L. & Mannini, P. 2016. FAO launches the Blue Growth Initiative for champion countries in Near East and North Africa. *FAO Aquaculture Newsletter*, 54 (March), pp. 36–37. (also available at http://www.fao.org/3/bc866en/BC866EN.pdf).

Towers, L. 2015. *Saudi Arabia aquaculture company receives GlobalG.A.P. certification* [online]. [Cited 31 August 2020]. https://thefishsite.com/articles/saudi-arabia-aquaculture-first-certified-in-middle-east

UNCTAD. 2016. Trade and Environment Review 2016. Fish Trade. UNCTAD/DITC/TED/2016/3. Geneva, Switzerland. (also available at https://unctad.org/en/PublicationsLibrary/ditcted2016d3_en.pdf).

UNCTAD. 2018. Achieving the targets of Sustainable Development Goal 14: Sustainable fish and seafood value chains and trade. Background Note for the Second Oceans Forum 16–17 July 2018. (also available at https://unctad.org/meetings/en/SessionalDocuments/Background-Note-Second-Oceans-Forum-July2018-v4.pdf).

UNCTAD. 2019. Advancing Sustainable Development Goal 14: Sustainable fish, seafood value chains, trade and climate. UNCTAD/DITC/TED/2019/3. Geneva, Switzerland. 40 pp. (also available at https://unctad.org/en/PublicationsLibrary/ditcted2019d3_en.pdf).

Undercurrent News. 2020a. *Norway, Netherlands invest in Moroccan aquaculture training project* [online]. [Cited 31 August 2020]. https://www.undercurrentnews.com/2020/05/04/norway-netherlands-invest-in-moroccan-aquaculture-training-project/

Undercurrent News. 2020b. *Saudi Arabia sees e-commerce surge during COVID-19 outbreak* [online]. [Cited 31 August 2020]. https://www.undercurrentnews.com/2020/04/06/saudi-arabia-sees-e-commerce-surge-during-covid-19-outbreak/

Van der Heijden, P.G.M., Van Dien, F. & El-Beshbishi, D.A. 2015. Investigating the suitability of constructed wetlands for the treatment of water for fish farms. Centre for Development Innovation, Wageningen. 26 pp. (also available at https://www.wur.nl/en/project/Investigating-the-suitability-of-constructed-wetlands-for-the-treatment-of-water-for-fish-farms-1.htm).

Van der Meer, M. 2018. Aquaculture business opportunities in Morocco for Dutch entrepreneurs. Netherlands Enterprise Agency. 36 pp. (also available at https://www.rvo.nl/sites/default/files/2018/06/Aquaculture-Business-Opportunities-Morocco.pdf).

Wabnitz, C.C.C., Lam, V.W.Y., Reygondeau, G., The, L.C.L., Al-Abdulrazzak, D., Khalfallah, M., Pauly, D., Palomares, M.L.D., Zeller, D. & Cheung, W.W.L. 2018. Climate change impacts on marine biodiversity, fisheries and society in the Arabian Gulf. *PLoS ONE,* 13(5): e0194537. (also available at https://doi.org/10.1371/journal.pone.0194537).

Waycott, B. 2020. *A salmon farm in Dubai, because of course. Global Aquaculture Advocate* [online]. [Cited 31 August 2020]. https://www.aquaculturealliance.org/advocate/a-salmon-farm-in-dubai-because-of-course/

Win, T.H. 2018. *From camels to catfish, Algeria boosts fish farming in the Sahara Desert. Reuters. United States* [online]. [Cited 31 August 2020]. https://www.reuters.com/article/us-algeria-agriculture-fish-idUSKCN1IL0PL

World Bank. 2013. Fish to 2030: *Prospects for Fisheries and Aquaculture. Agriculture and Environmental Services Discussion Paper 03*. World Bank Report No. 83177-GLB. Washington DC. 102 pp. (also available at http://www.fao.org/3/i3640e/i3640e.pdf).

World Bank. 2020a. *World Bank Data Bank* [online]. Washington. [Cited 31 August 2020]. https://databank.worldbank.org/home.aspx

World Bank. 2020b. *Middle East and North Africa Overview* [online]. Washington. [Cited 31 August 2020]. https://www.worldbank.org/en/region/mena/overview#1

WorldFish. 2017. WorldFish in Egypt. Penang, Malaysia. Factsheet: 2017-20. (also available at http://pubs.iclarm.net/resource_centre/2017-20.pdf).

WorldFish. 2018. *Milestone achievement: first Egyptian fish farmers awarded quality certifications* [online]. [31 August 2020]. https://fish.cgiar.org/impact/stories-of-change/'milestone-achievement'-first-egyptian-fish-farmers-awarded-quality

WorldFish. 2019. Empowering Women Fish Retailers in Egypt (EWFIRE) Project. Penang, Malaysia. Factsheet: 2019–09. (also available at https://hdl.handle.net/20.500.12348/2898).

WorldFish. 2020. *Africa Aquaculture Research and Training Center, Abbassa, Egypt* [online]. Egypt. [Cited 31 August 2020]. https://www.worldfishcenter.org/africa-aquaculture-research-and-training-center-aartc-abbassa-egypt

Zingstra, H.L. 2013. Lake Burullus: local food security and biodiversity under Pressure. Centre for Development Innovation, Wageningen UR. 68 pp. (also available at https://edepot.wur.nl/297256).

Annex 1. FAO statistical data

Data used in this regional aquaculture review, derive mainly from the different FAO fisheries and aquaculture statistics (FishStat), accessible through different tools, including the FAO Yearbook Fishery and Aquaculture Statistics, online query panels and FishStatJ (FAO, 2020a; FAO, 2020b; FAO, 2020c). These tools provide free access to fisheries and aquaculture data, including production, trade, consumption and employment for over 245 countries and territories from 1950 to the most recent year available. FAO represents the only global source of fisheries and aquaculture statistics, which are mainly compiled from data submitted by member countries. Statistics received are validated by FAO through adequate quality controls and, in the absence of official reporting, FAO estimates the missing data based on information obtained from alternative sources or standard estimation methods. Estimates also involve disaggregating some of the data received by FAO in aggregated form by species and, in the case of production, also by culture environment.

FAO highlights that data received from countries show different levels of quality in terms of coverage of species, environment and overall national reporting. Inconsistencies may occur in data reported or data are not reported at all. For example, in the case of aquaculture production, FAO has noted that not all the countries have adequate and effective data collection systems set in place. Many countries still do not have a systematically established framework aligned with internationally and regionally accepted standards for data collection from fish farms. In addition, in several countries, the staff responsible for reporting aquaculture production lack the relevant knowledge, support or relevant mechanisms such as specifically designed databases to develop accurate production estimates and improve monitoring and control of the industry. Production data are often estimated through extrapolation by multiplying the area under fish culture by an estimate of average productivity, with adjustments according to advice from key contacts in the industry. Improvements to this problem could, for example, be found by resolving issues related to the fish farm licensing process and devising a system for direct reporting of production, coupled with validation through sample survey by trained enumerators.

Problems occur as well for other typologies of aquaculture statistics. Only a very limited number of countries have a breakdown for farmed vs wild species in their trade statistics and, in addition, many farmed species are often reported in an aggregated form under miscellaneous entries as other fish. The lack of accurate trade data on farmed fish and fish products implies the impossibility to calculate separate consumption statistics on farmed species, with no clear assessment of the nutritional role of farmed species in the countries. In addition, not all the countries have a good collection of employment data in the primary and secondary aquaculture sectors, including insufficient detail on the role of women in the sector, which is captured mainly by ensuring employment data is sex-disaggregated and that all types (part time, full time, occasional time use) are all collected and reported . These data are essential to better assess dependency on the sector and other relevant indicators.

Due to the key role that accurate and timely data play in the management and policy formulation for sustainable aquaculture development, FAO remarks the urgent need for national capacity development in aquaculture statistics systems at several levels, including:

- the legal status, institutionalization and resource allocation;
- development of national statistical standards in line with international standards;
- adequate and stable staffing plus an effective mechanism for data collection, compilation, storage, dissemination and reporting; (FAO, 2020d);
- improvement in the coverage of farmed species in trade statistics, with the clear separation of farmed vs wild species; and,
- improvement in the coverage and accuracy of employment data, disaggregated by sex, occupational status and age.

In continuing the global efforts to achieve aquaculture sustainability through dissemination of up-to-date information on the status and trends of the sector, FAO publishes Aquaculture Regional Reviews and a Global Synthesis about every 5 years, starting in 1997. This review paper summarizes the status and trends of aquaculture development in the Near East and North Africa. Relevant aspects of the social and economic background of each region are followed by a description of current and evolving aquaculture practices and the needs of the industry in terms of resources, services and technologies. Impacts of aquaculture practices on the environment are discussed, followed by a consideration of the response by the industry to market demands and opportunities, and its contribution to social and economic development at regional, national and international levels. External pressures on the sector are described, including climate change and economic events, along with associated changes in governance. The review concludes with an analysis of the contributions of aquaculture to the Sustainable Development Goals, the FAO Strategic Objectives, and the FAO Blue Growth Initiative. Throughout the review, outstanding issues and success stories are identified, and a way forward is suggested for each main topic.

ISBN 978-92-5-135381-3 ISSN 2070-6065

9 789251 353813

CB7818EN/1/01.22