



Climate change risks and opportunities in Iraqi agrifood value chains

Strengthening the Agriculture and Agrifood Value Chain and Improving Trade Policy in Iraq (SAAVI)





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The study presents the findings of the Climate and Environment Risk Assessment (CERA) conducted to support the project's environmental mainstreaming assessment and approach, Strengthening the Agriculture and Agrifood Value Chain and Improving Trade Policy in Iraq (SAAVI), funded by the European Union. The project is implemented under the leadership of the Government of Iraq through the Ministry of Planning (MoP), Ministry of Agriculture (MoA) and Ministry of Trade (MoT). It forms part of a series of assessments conducted in agrifood supply chains across the globe to ensure that principles of climate resilience and environmental sustainability are incorporated in the ITC project design.

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ACRONYMS AND ABBREVIATIONS

CERA	Climate and Environment Risk Assessment
DRC	Danish Refugee Council
EVI	Enhanced Vegetation Index
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GHG	Greenhouse gases
IDMC	Internal Displacement Monitoring Centre
IFAD	International Fund for Agricultural Development
IOM	International Organization for Migration
IR	Islamic Relief
KRI	Kurdistan Region of Iraq
MSME	Micro, small and medium-sized enterprises
NRC	Norwegian Refugee Council
RO	Reverse Osmosis
SAAVI	Strengthening the Agriculture and Agrifood Value Chain and Improving Trade Policy in Iraq
SI	Social Inquiry
SREO	SREO Consulting Ltd
USAID	United States Agency for International Development

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Executive summary

Located in the eastern part of Western Asia, the Republic of Iraq falls in a region encompassing the Mesopotamian alluvial plain of the Tigris and Euphrates Rivers, the north-western side of the Zagros Mountains and the eastern end of the Syrian Desert. While most of Iraq has a hot, arid, subtropical climate, the country hosts five agro-ecological zones with varied climatic conditions, making it suitable for the production of several crops, predominantly cereals, palm dates and vegetables. Home to some of the world's most fertile land and where modern agriculture originated and developed, Iraq faces the severe threat of climate change, presenting challenges for agricultural production, economic resilience and competitiveness.

[Strengthening the Agriculture and Agrifood Value Chain and Improving Trade Policy in Iraq \(SAAVI\) is a €22.5 million project funded by the European Union \(EU\) and implemented by the International Trade Centre \(ITC\).](#) SAAVI contributes to inclusive economic growth and job creation, particularly for the youth, by improving Iraq's agriculture competitiveness and supporting trade development in the country. Started in November 2020, the project forms part of the overall EU special measure for supporting employment creation and improving economic governance in Iraq.

[SAAVI aims to improve livelihoods by strengthening value chains in domestic and regional markets, creating jobs and upskilling young entrepreneurs, and enhancing competitiveness of micro, small and medium-sized enterprises \(MSMEs\) and farmers participating in agrifood supply chains.](#) MSMEs, in particular, have the potential of becoming a key driver for employment creation and contributing to greater resilience of the Iraqi economy in the face of current daunting challenges. Through the SAAVI project, ITC is working with the Government of Iraq to implement practical solutions that allow to "build back better" after the COVID-19 pandemic, ensuring a green recovery in which the agribusiness sector is called to play a crucial role.

[In this context, a Climate and Environment Risk Assessment \(CERA\) was conducted during the inception phase with the objective of mapping key climate and environmental risks affecting the tomato and](#)

[animal products \(eggs, chicken meat and dairy\) value chains,](#) and quantifying their impacts over time on sector competitiveness. The assessment identifies market opportunities arising in environmental markets, as well as obstacles to and practices in resilience-building by local farmers and MSMEs. The report presents key insights and knowledge generated by the assessment, based on a mixed approach combining original analysis, data-driven country benchmarking and literature reviews. It consolidates key findings into an easy-to-read format and makes them available to decision-makers, in order to inform policy-making, future field research and capacity building.

Facilitating engagement of Iraqi MSMEs in building green, climate-resilient value chains from 'farm to fork' is a difficult undertaking. Entry points need to be identified that offer clear actionable measures not only at the farm level, but also at the processing and marketing stages. [This report highlights solutions developed locally by entrepreneurs to take action on climate change with a specific focus on vegetables and animal products, and by geographic region](#) (Northern rain-fed areas and Central/Southern irrigated production areas).

Structured as a country profile, [Section 1](#) provides an overview of the local climate, identifying slow-onset events and weather extremes affecting the country, as well as trends and projections in temperature and precipitation. [Section 2](#) describes the agriculture sector's vulnerabilities relating to climate hazards and benchmarks the country against other countries in the region in terms of climatic changes and environmental performance. [Section 3](#) focuses on the country's two agro-ecological regions (north, centre and south). After profiling key production systems in each region, it maps out climate and environmental risks and green market opportunities at each stage of the tomato (vegetables) and animal products (eggs, chicken meat and dairy) value chains. It identifies obstacles to adopting practices in climate change adaptation by local farmers and MSMEs, highlighting key implications for and constraints to competitiveness. [Section 4](#) provides a summary of findings and recommendations for action.

Climate change country profile¹

Iraq



AGRO-ECOLOGICAL PROFILE AND CLIMATE OVERVIEW

Figure 1: Iraq's agro-ecological zones based on moisture regime and types of seasons



Source: Alwan et al. (2019).

Iraq is a country in Western Asia, encompassing the Mesopotamian alluvial plain of the Tigris and Euphrates Rivers (centre), the north-western side of the Zagros Mountains (north) and the eastern end of the Syrian Desert (west). It is located at latitude 33.223191 and longitude 43.679291 and has a surface area of approximately 437,072km². While most of Iraq has a hot, arid, subtropical climate, five agro-ecological zones can be identified by interpolating satellite-based temperature and precipitation data (Figure 1). The south-eastern

and western parts of the country have an arid climate, with extremely hot summers and cool to mild winters (ACZ 1 and 2). The north-east is home to a variety of climates, ranging from very humid to semi-arid through Mediterranean depending on topography. Winters are mild to cold, while summers are generally hot (ACZ 2–5). Varied climatic conditions make the country suitable for the production of a several crops, predominantly cereals and vegetables.

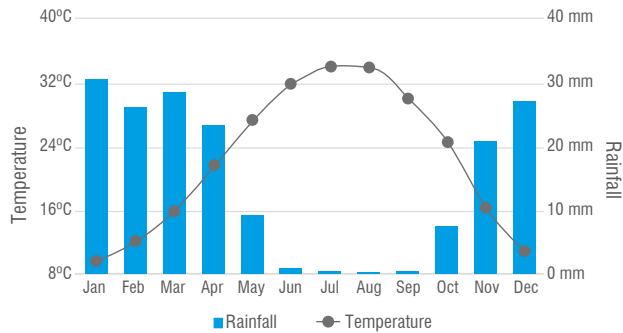
Köppen climate subtype Hot desert (BWh) – 64% Hot-summer, Mediterranean (Csa) – 22% Hot, semi-arid (BSh) – 13%	Timing of rainy season North: Long, November to April. Centre and south: Short, December to February	Mean temperature 21.6°C North (Al-Mosul): 13°C–28°C South (Al-Basrah): 19°C–33°C	Mean precipitation 193.6 mm North-east: 1,000 mm West and south: 100 mm <i>per year</i>
Slow-onset events Increasing temperatures, decreasing precipitation, desertification, salinization of water and soils	Extreme weather events Droughts, high temperatures, heatwaves, strong winds (sand and dust storms), erratic heavy rains, floods	Mean sea level 5 m Over tide gauge zero (Al-Basrah, Shatt al-Arab delta)	Disaster risk Medium Exposure: Low Vulnerability: High

¹ Detailed information on data and indicators used in the assessment, as well as underlying sources, is provided in annex.

HISTORICAL CLIMATE

Temperature and rainfall

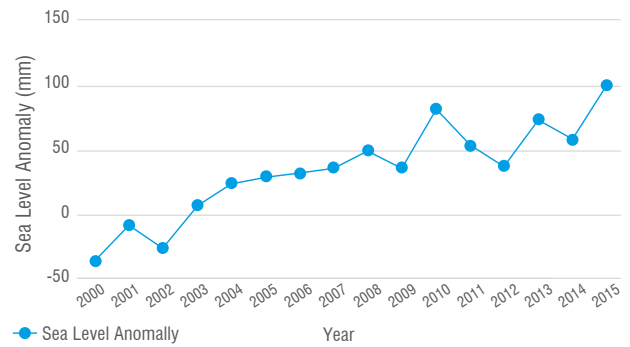
Figure 2: Average monthly temperature and rainfall (1991–2016)



Source: World Bank Climate Change Knowledge Portal (2020).

Sea-level anomaly

Figure 3: Average annual sea level anomaly (2000–15)



Source: World Bank Climate Change Knowledge Portal (2020).

Key trends

Slow-onset events

- Since the 1950s, mean annual **temperatures** have increased at a rate of 0.7°C per century (United States Agency for International Development (USAID), 2017).
- In 1951–2000, **rainfall** decreased in the west and in the south-east (respectively –5.9mm and –0.9mm / month per century), while it has increased in the north-east (+2.4mm/month per century) (WBCKP, 2020).
- Starting from 2003, the mean **sea level** observed on the Iraqi coast has been 5mm – 100mm above historical average, with the anomaly intensifying in recent years (author on data, WBCKP).

Weather extremes

- **Droughts** have been recurrent in 1970–2013, with the most severe events occurring in 1998–99 and 2008–09. In those periods, droughts covered approximately 87% and 82% of Iraq in those periods respectively (Hameed et al., 2018).
- The southern and central parts of Iraq have witnessed more frequent, but shorter droughts, while the most severe and longer events have been recorded in the north-east (Jasim and Awchi, 2020; Hameed et al., 2018).
- **Floods** caused by **heavy rains** have become more frequent in recent years, with hotspots located along the southern stretch of the Tigris–Euphrates river



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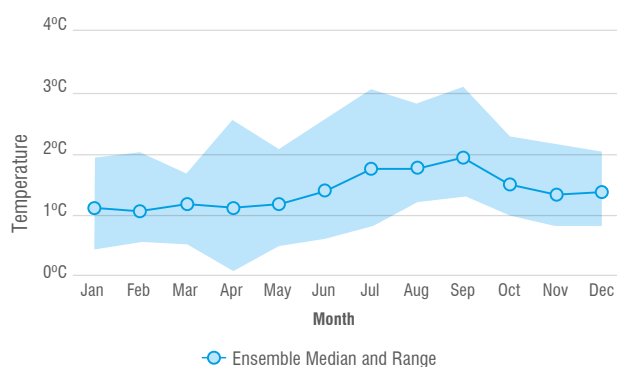
system (REACH and the United Nations Institute for Training and Research, 2020).

- **Sand and dust storms**, which are likely to hit the Tigris and Euphrates river valleys in summer, have been as frequent as 120 a year (Sissakian et al., 2013; United Nations Iraq, 2013).

CLIMATE OUTLOOK

Temperature

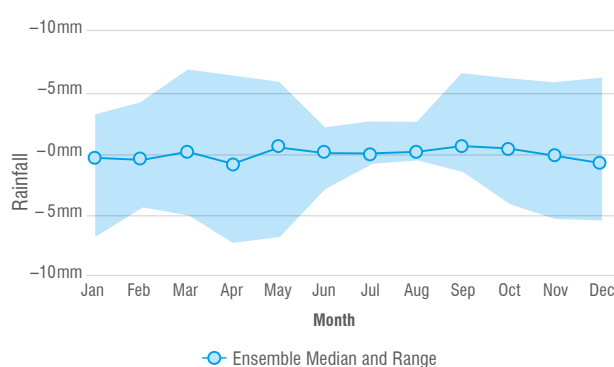
Figure 4: Projected change in monthly temperature (2020–39, RCP 8.5)



Source: World Bank Climate Change Knowledge Portal (2020).

Rainfall

Figure 5: Projected change in monthly rainfall (2020–39, RCP 8.5)



Source: World Bank Climate Change Knowledge Portal (2020).

Key prospects

Slow-onset events

- Model projections indicate an increase in mean annual **temperature** of 2°C by 2050, while mean annual **rainfall** is expected to decrease by 9% in the same period (WBCKP, 2020).
- While mean annual precipitation is expected to decrease by mid-century, with drops as high as 17% during the rainy season, **rainfall events** will become more **intense** (WBCKP, 2020).
- By 2050, the southernmost districts of Iraq, including the second-largest city, Al-Basrah, could be partially submerged as a result of **rising sea waters** (Kulp and Strauss, 2019).

Weather extremes

- Model estimates point to an increase in the occurrence of **extreme temperatures** above 50°C by 2100. In southern Iraq, such extremes will last up to 21 consecutive days (Levi and Mann, 2020).
- The frequency of **sand and dust storms** can increase in the future and reach up to 300 events per year, as opposed to 120 that are currently recorded (Sissakian et al., 2013; United Nations Iraq, 2013).
- In line with the ongoing drying trend, **drought** and **heat** are likely to intensify and **rainfall** to become more variable in the Fertile Crescent, further exacerbating water stress (Barlow et al., 2016).

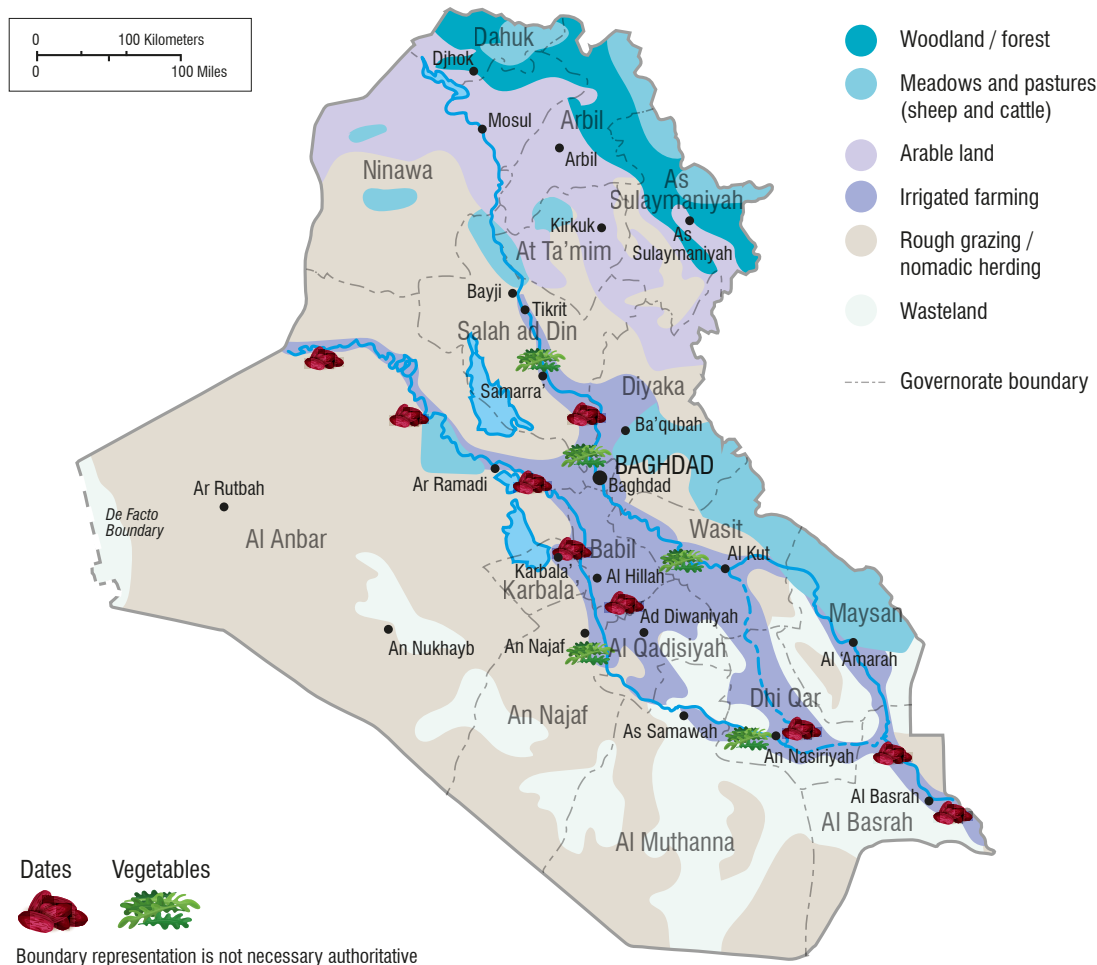


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Climate change vulnerabilities and environmental performance of agriculture

SECTOR OVERVIEW

Figure 6: Land use map including main cultivated crops

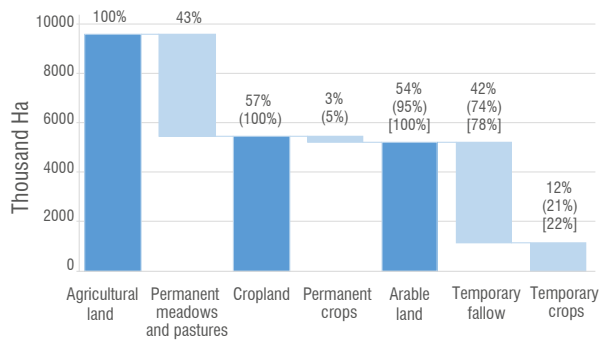


Source: Adapted from Central Intelligence Agency (CIA) (2003).

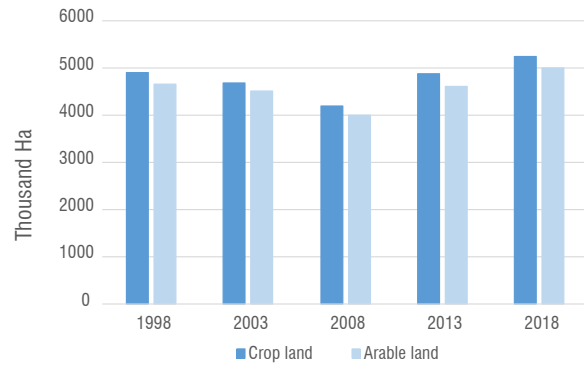
The agriculture sector contributes to a substantial share of Iraq's economy, as it accounts for 5% of gross domestic product (GDP) and 20% of employment (World Bank, 2019). The total cultivated area is estimated to be 6 million ha, corresponding to roughly 25% of all land (Alwan et al., 2019). Of this, almost 50% is **rain fed** and located in **northern Iraq**, where the climate is milder and more suitable for cropping. While there is evidence of surface irrigation being increasingly adopted in this area, **irrigated land** is traditionally located along the southern stretch of the Tigris–Euphrates river system. In this region, which extends along **central** and

south-western Iraq, the soil is made fertile by natural river flows. Land is irrigated by flow from rivers and canals through small channels, by water-lifting with wheels or pumps and, to a lesser extent, by direct inundation (Owen et al., 2016). Main cultivated crops include grains such as wheat and barley, which are predominant in rain-fed areas. In irrigated regions, mixed farming systems of dates and horticultural crops are more common. These include fruit, tomatoes and potatoes (World Bank and FAO, 2012). Livestock rearing, including backyard poultry farming, is common and enhances food security of many rural households.

Land use change

Figure 7: Composition of agricultural land (2018)

Source: Author analysis on data FAOSTAT (2021).

Figure 8: Change in surface of cropland and arable land (1998–2018)

Source: Author analysis on data FAOSTAT (2021).

KEY HAZARDS AND VULNERABILITIES

- Drought** events have been recurrent in recent years and intensifying in the first decade of the 2000s. Jointly with the long-term trends of declining rainfall and increasing temperatures, drought poses a serious threat to the **availability of water** for the sector and particularly for **irrigation**. Consequences on land productivity and crop yields are potentially disruptive. The risk is further exacerbated by the **obsolescence** of the **irrigation network**, which has been degraded by years of insufficient maintenance and limited investment in infrastructure.
- The **availability of water** in production areas of central and southern Iraq, which heavily depend on the Tigris–Euphrates river system, is at risk due to the **lack of international regulations for water pricing and use**. In these regions, water availability is largely determined by **precipitations** in upstream countries, such as **the Republic of Turkey** and **the Islamic Republic of Iran**, which have established their own river-fed irrigation systems. **No international water use agreement** has been signed by the three countries and Iraq could face increased shortages of water as a consequence. From the 2000s, irrigation acreage has been increasing (World Bank and FAO, 2012).
- Waters of the Tigris and Euphrates Rivers** contain large amounts of **salts**. **Flooding** and **poor irrigation practices** contribute to spreading it on the land. Intrinsic location characteristics, such as a high water table and poor surface and subsurface drainage, tend to concentrate the salts near the surface of the soil. This results in **salinity intrusion**, which reduces soil quality and leads, in some cases, to



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plant mortality. In general, the salt content of soil increases from Baghdad to the Persian Gulf and threatens crop production in the southern regions where it may be exacerbated by **rising sea levels**.

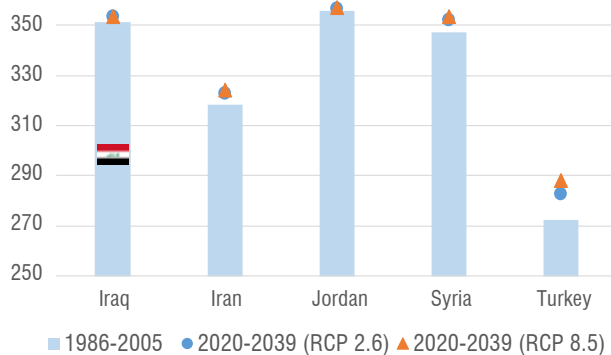
- In recent years, the **intensity and frequency of dust storms** have increased due to **low soil moisture** caused by the interplay of drought, urbanization and agricultural activities. Dust storms cause direct crop damage and reduce visibility, disrupting key value chain operations such as air and road transport and causing an overall loss of human productivity (WBCKP, 2020).

COUNTRY BENCHMARKING: IRAQ VIS-À-VIS REGIONAL PEERS

Climate change

Crop season

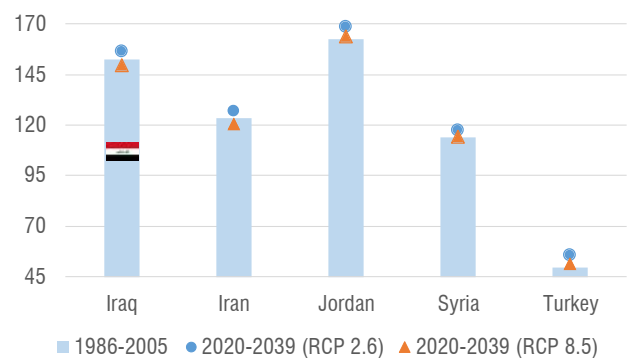
Figure 9: Growing season length (days)
(1986–2005 and projected, 2020–39)



Source: Author analysis on data WBCKP (2021).

Drought

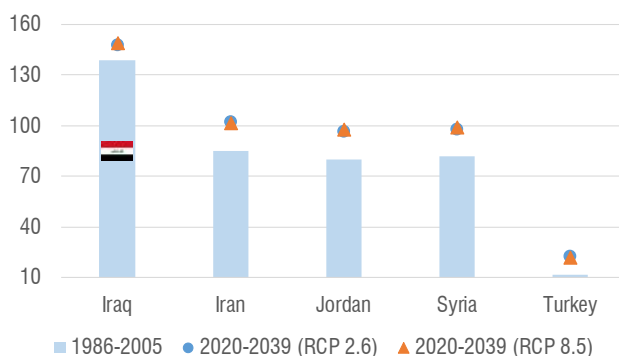
Figure 10: Maximum number of consecutive dry days
(1986–2005 and projected, 2020–39)



Source: Author analysis on data WBCKP (2021).

Heat

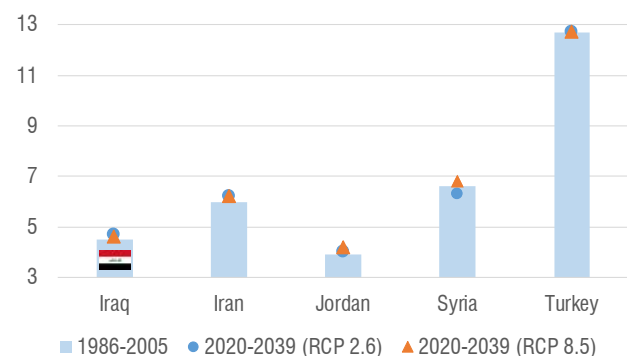
Figure 11: Number of very hot days (Tmax > 35°C)
(1986–2005 and projected, 2020–39)



Source: Author analysis on data WBCKP (2021).

Flooding

Figure 12: Maximum number of consecutive wet days
(1986–2005 and projected, 2020–39)

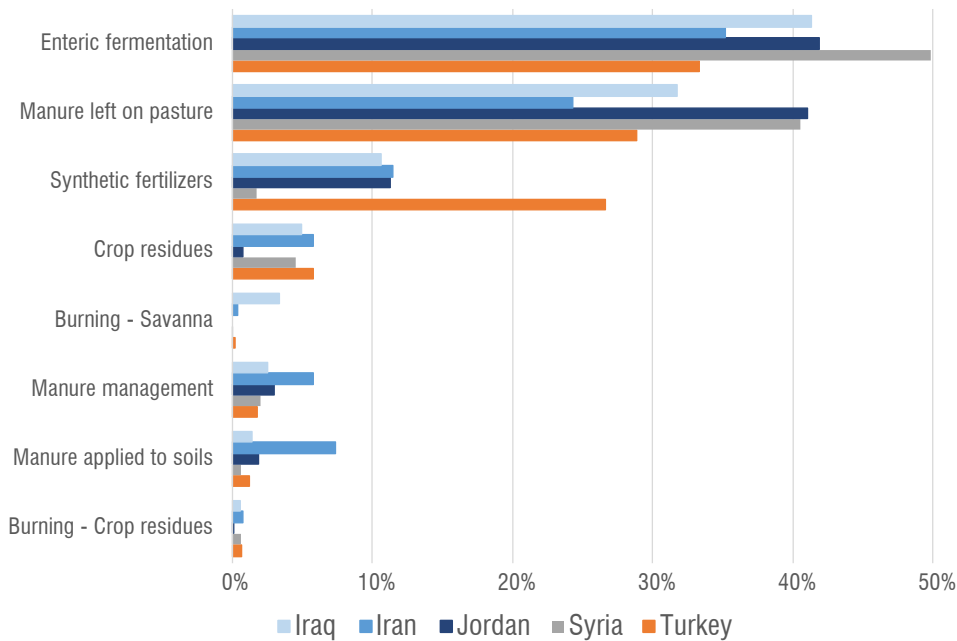


Source: Author analysis on data WBCKP (2021).

Environmental performance

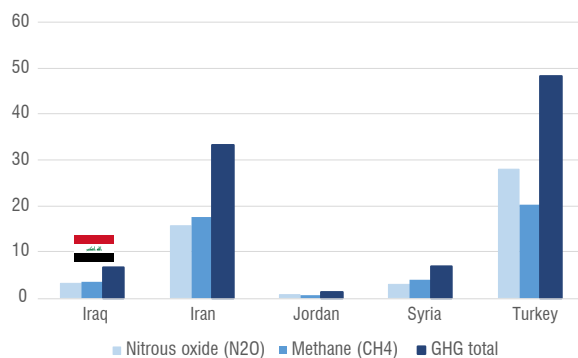
Greenhouse gas (GHG) emissions

Figure 13: Contributing activity as a share of agriculture emission total (per cent, 2016)



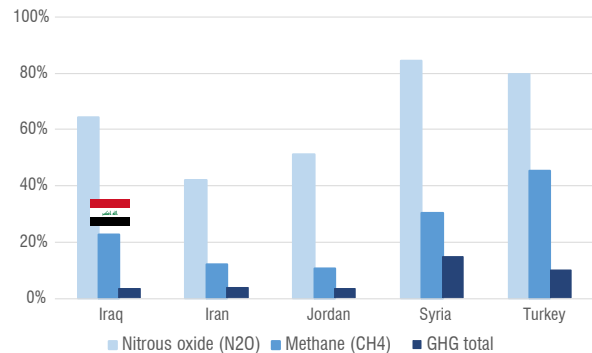
Source: Author analysis on data Ritchie and Roser (2017).

Figure 14: Type of emissions from agriculture as CO₂ equivalent (million t, 2016)



Source: Author analysis on data World Resources Institute, CAIT Climate Data Explorer (2021).

Figure 15: Type of emissions from agriculture as share of country total (per cent, 2016)



Source: Author analysis on data World Resources Institute, CAIT Climate Data Explorer (2021).

Other top contributors

Nitrous oxide (N2O) emissions	Waste, other fuel combustion, industry (all except the Syrian Arab Republic)
Methane (CH4) emissions	Waste, fugitive emissions, other fuel combustion
GHG emissions total	Electricity and heat, transport, buildings (Iran and Turkey), waste (the Hashemite Kingdom of Jordan, and Syria), fugitive emissions (Iraq)

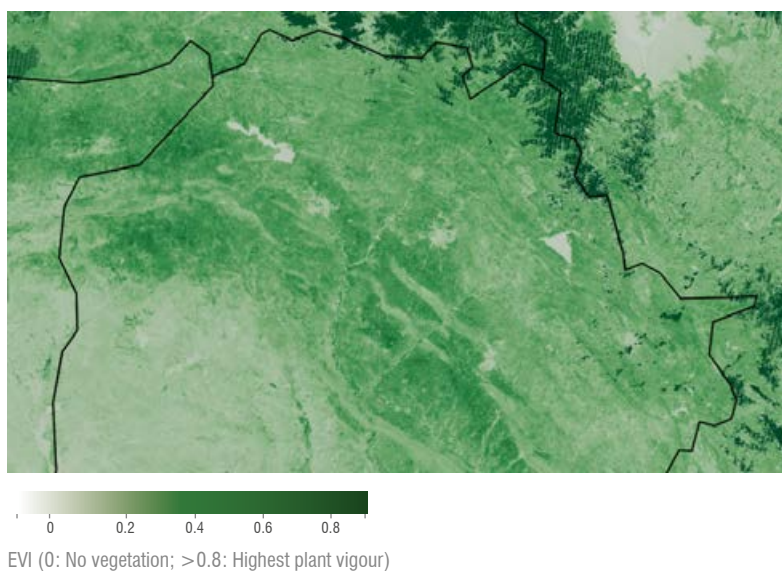
Vegetables and animal products: Climate change risks, opportunities and options for adaptation

NORTHERN IRAQ: RAIN-FED AGRICULTURE

Sector overview

Figure 16: Remote sensing land cover map of northern Iraq

Enhanced Vegetation Index (EVI), maximum (2019)



Standard satellite view



Note: Dark green clustered areas with uniform pixel texture denote active crop land ($0.3 < \text{EVI} < 0.8$). Further assessment at the district level is needed to detect small-sized cultivated areas and control capture of non-agricultural land cover (e.g. grassland, forests).

Source: Author analysis.

The region, which encompasses Ninewa, Kirkuk, as well as the Kurdistan Region of Iraq (KRI) (Duhok, Erbil, Al-Sulaymaniyah Governorates), is home to a variety of climates, ranging from very humid to semi-arid through Mediterranean depending on altitude. Warm to cold winters, generally hot summers and the relatively abundant precipitations (200mm–900mm per year) render the climate suitable for **rain-fed cropping** (Alwan et al., 2019). Remote sensing data reveals that the largest production areas are clustered in Ninewa, Kirkuk and Erbil Governorates in proximity of the Tigris and Great Zab Rivers (Figure 16). More dispersed cropland, alternated with pastures and forests, is located in Duhok and Al-Sulaymaniyah. Production is organized in **mixed cereal–legumes cropping systems**, with predominance of winter crops planted in the fall and harvested in the spring. The main crops are **grains**, primarily **wheat and barley**, with a minority of irrigated **horticultural crops (tomatoes and potatoes, etc.)** and **fruit** (World Bank and FAO, 2012).

Farming units

- Farming units are **small**, with an average household size of seven individuals, the majority of whom are male and of working age. They employ on average 10 daily labourers. The median size of cultivated land is small and ranges from 3.5ha to 5ha. In Duhok and Erbil, most farmers did not receive any form of education, while they received compulsory primary education in Ninewa (Food and Agricultural Organization (FAO) and Islamic Relief (IR), 2014).

Crops and irrigation

- Government-subsidized cereal crops, particularly wheat and barley, are predominant, while **fruit** and **vegetables** occupy only 0%–5% of cultivated land. Rain-fed agriculture is predominant and yields vary year by year. The quasi totality of surveyed land in Duhok is **rain fed** (99%), and approximately 80% is in Erbil (FAO and IR, 2014). In Ninewa, it ranges from 75% to 99% (FAO and IR, 2014; FAO, 2020a; FAO, 2020b).
- Most **irrigated land** depends on **groundwater** extracted from wells or channelled from canals and is located in proximity to vast irrigation projects such as the Al Jazeera. In areas where irrigation water is available year-round, **double harvests** are practiced (World Bank and FAO, 2012).

Land tenure

- **Land** tenure arrangements vary by governorate. The majority of land is **shared** or **rented** in Duhok, while it is **owned** or shared in Erbil (FAO and IR, 2014). Prior

to conflict, Ninewa had the highest area of owned land in the region, although recent research points to renting as a common practice (FAO and IR, 2014; FAO, 2020b). The division of land through **inheritance** causes a risk of **excessive fragmentation**, further reducing scale and profitability of farming (FAO and IR, 2014).

Insight into key production systems

Tomatoes (vegetables)

Duhok, Erbil, Salah Al-Din

- Tomatoes are grown on plots of different **sizes**, of 1–4 ha in Erbil to 2–4 ha in Salah Al-Din. In Erbil, all surveyed farmers produce tomatoes in the **open field**, while in Salah Al-Din they mostly rely on **greenhouses**. Overall, farmers acknowledge the profitability of greenhouse farming, which is becoming a more common approach.
- All tomato **harvesting** is done by hand, irrespective of the cropping method. Yet, greenhouse farming is associated with better **packing practices**; i.e. cartons as opposed to baskets, which are common in open-field farming. No surveyed farmers perform value-adding post-harvest activities (washing and sorting), and only a few acknowledge their benefits to product quality and value.
- **Growing** international **demand** for premium varieties and processed tomato products, such as **sundried tomatoes**, may entail opportunities for **on-farm value addition**, particularly for **women**, who account for roughly 25% of the Iraqi agricultural work force (FAO, 2021). Yet, there is **no** evidence of women being involved in **off-farm activities** (e.g. marketing), which require leaving the home and could conflict with **traditional gender norms**.

Ninewa

- In vegetable farming units, the **average household** exclusively relies on agriculture and counts 7.5 individuals, mostly male and 50 years old. Producers grow both **summer crops** (e.g. tomatoes, cucumber and eggplant) and **winter crops** (e.g. onion, cauliflower and turnip) planted during the autumn (October to December) and the spring (February to April). Of the surveyed producers, 66% are **internally displaced people** returning to homeland after displacement.
- In Al-Mosul, there is **low participation** of **women** in the agricultural labour force (farming, trading and marketing) due to **conservative gender norms** and

the **physical nature of labour**. Yet, **vegetables** such as **tomatoes** are believed to be **suitable** for women, as farming activities are less physically demanding and opportunities exist in **on-farm value addition** (e.g. pickles). Cultural norms also make it difficult for women to pursue **entrepreneurial opportunities** outside of the home, such as in **food retail** (SREO Consulting Ltd and Cordaid, 2020).

- Vegetable crops are mainly produced where **water sources** are available. In some cases, this enables **multiple harvests** per year. However, they are only scarcely integrated with the predominant mixed wheat–barley systems. While **production** is modest and accounts for 1%–2% of the total, increased vegetable production has been observed around urban centres, where access to markets is easier and water availability is higher. Tomato production is mainly large scale.
- Most farmers are aware of **modern cropping techniques**. Some of them have already adopted state-of-the-art solutions. While 32% of farmers rely on least-efficient surface irrigation, the majority of them have adopted advanced technologies such as **drip and sprinkler irrigation** (68%).
- Despite many farmers having seen **infrastructure** and equipment **damaged or destroyed** during conflict and facing huge financial constraints, greenhouse farming is becoming increasingly common (FAO, 2016). **Improved, yet outdated seeds**, such as hybrid tomato varieties and chemical fertilizers and pesticides, are also widely used, although access to quality material remains poor (FAO, 2020a and FAO, 2020b).

Dairy

Ninewa and Duhok

- Sheep productivity (milk, meat) is negatively affected by the **limited availability of feed**, particularly during winters, as feeding is largely linked to local cereals cropping and alternatives sell at a high price. Similarly, supplies of **drinking water** – an important determinant to milking potential – could become unreliable in the summer months.
- On average, marketable milk available to each household is 70–120 litres daily. Most households are producing milk for home consumption and **marketing as raw milk** (40%) or traditional **dairy products** (20%). Dairy products, which are usually processed by **women**, include butter, ghee, laban, kaymak, guishwa and white cheeses. Such activities, sometimes coupled with growing crops, are encouraged by the **lack of a milk collection system** and contribute to cash needs and food security of households.

- There is a big domestic market for milk and dairy products, which are consumed by locals on a daily basis. Products are sold via **direct retail** to villages, also by **women**, or to shops and factories in large cities. Raw milk is also sold to small local processing units or dairy processing plants in urban areas through village **milk collectors**. Yet, access to markets is limited by **the lack of cooling facilities**, which forces producers to only operate in proximity (FAO, 2020a; GOAL and Big Heart, 2016).
- At present, the local supply of milk and dairy products fails to meet local demand. This triggers increases in **imports of powder milk** for processing and **dairy products** from neighbouring countries (Iran, the Arab Republic of Egypt, and Turkey).

Poultry

Al-Anbar, Ninewa, Duhok and Salah Al-Din

- In select municipalities of Telafar District (Ninewa) and Zakho District (Duhok), poultry farming is a **low-input, women-led business** undertaken in **households** of average size of nine members owning an **average of 10–20 birds**. Chickens are raised mainly for **subsistence** as a source of protein and more rarely as small-scale businesses that sell surplus eggs locally. The sale of meat products is less common, as it has higher barriers to entry.
- **Households** mainly own **low-producing indigenous breeds**, which produce on average 50 eggs per year and can be up to seven times less productive than **imported breeds**. The latter are imported in bulk and used in **commercial establishments**, usually counting hundreds to thousands of birds. Eggs from **household production** are **sold directly to consumers** in informal networks, while **commercial farmers** rely on more structured **marketing channels** (e.g. **retailers**) (GOAL and Big Heart, 2016).
- **Feed** is the most expensive input, accounting for approximately 60% of production costs. While commercial farmers can afford purchasing feed – a mix of **wheat, barley and soybean** – at household level, birds are often fed **scraps** with no predetermined diet, which greatly affects productivity.
- Prior to conflict, Al-Anbar, Ninewa and Salah Al-Din were collectively one of the main sources of poultry products (e.g. chicken meat and eggs), selling their surplus nationwide. Value chains have been largely disrupted by **conflict**, as **access to feed and key inputs** became **difficult** and farmers have **lost** or **sold flocks**. This has not only impacted household **incomes**, but also increased **malnutrition** (FAO, 2018).

Mapping of climate and environmental risks

Key hazards

- Frequent drought and water stress
- Scarce precipitations, especially in the summer months
- High temperatures, heatwaves
- Flooding
- Water and soil salinity
- Water pollution (siltation of dams, upstream human activity)

Top value chain risks and impact

Input supplies

- While the market for inputs (seeds, pesticides, fertilizers) is relatively underdeveloped and **vegetable** farmers face limited availability and high prices, there is a widespread adoption of **chemical fertilizers** that are **preferred over organic material** due to **poor quality** options. This increases emissions from production and poses a risk of pollution and eutrophication of waters in proximity of fields (FAO, 2020b).

Vegetable seedlings, which are mainly grown in ground nurseries using **traditional methods**, show weak growth after planting and **decreased survivability to weather extremes** (drought, high temperature or strong winds) as opposed to those grown with modern methods, which are a minority. Similarly, high-producing **seed varieties** such as GS-12 tomatoes, which are popular among farmers, are **outdated** and could **respond poorly to new climate stressors** (e.g. drought or water stress) (FAO, 2020b).

- In Diyala and Ninewa, the **availability** of **animal feed** is reduced as a result of seasonal **droughts**, insufficient rainfall and eroded soils in the rangelands. This limits the availability of agricultural by-products and negatively affects **milk production**, thus reducing the quality and quantity of milk available for **dairy** processing (Danish Refugee Council (DRC) and SREO, 2020; FAO, 2020a).
- The **uptake** of **modern farming equipment** (e.g. **drip irrigation and greenhouses**) is constrained by **limited financial means** and **scarce access to credit**. Investment is either unfeasible or done with limited resources, resulting in inadequate returns in terms of quantity and quality. In addition, the **quality of spare parts, water pumps** and other equipment, mainly imported from the People's Republic of China, and

Iran, is **poor** and lowers investment returns (FAO, 2021; FAO, 2020b).

- Similarly, the majority of livestock and poultry keepers are unable to obtain **formal financing services** (e.g. **bank loans**), including **credit from suppliers** for purchasing working capital. Among other things, this affects their ability to build resilience to changing weather, such as by **restocking assets** or **improving feed** (GOAL and Big Heart, 2016; IR, 2020a; IR, 2020b).

Agricultural production

- **Water scarcity** takes a toll on the sector in summer months, when **rains** are **scarce** and farmers face shortages of potable water (SREO and Cordaid, 2020). The scarcity and **poor quality** of water resources, also subject to **salinity**, hampers **crop production (tomato)** either through direct damage to crops or by decreasing the **efficiency of irrigation systems**. The latter are also constrained by frequent **drought** and **flooding** (FAO, 2021).
- While having been less intense than in the central and south-western parts of Iraq, **prolonged droughts** have become more frequent and notoriously affect **production of rain-fed crops**. In 2008–09, droughts damaged approximately 50% of agricultural land (Price, 2018).
- While **water-efficient irrigation** (e.g. drip or sprinkler) is increasingly common – particularly among **tomato** producers – one out of four farmers still rely on traditional **surface irrigation**. This practice, which causes a large **waste in irrigation water** and has a negative impact on **vegetable productivity**, is still predominant in areas near rivers, such as those of Al-Mosul and Al-Hamdaniya Districts, (FAO, 2021; FAO, 2020b).
- While **mixed crop–livestock systems** exist and may enhance **diversification** and resilience to climatic shocks, **vegetable land** is **poorly integrated** with the **wheat–barley cropping system**. Only a minority of tomato farmers practice **crop rotations** (11%) and none do **intercropping**. This makes systems more prone to catastrophic losses from weather extremes (FAO, 2021; FAO, 2020a).
- Similarly, the **mixed wheat–barley system** on which livestock feeding is highly dependent does not incorporate **fodder crops** (e.g. **corn and soy**) that are essential for animal nutrition and are **imported** (FAO, 2020a). Therefore, the availability of quality feed could be reduced further in the event of climate extremes (drought or flooding) as a result of crop damage or supply route disruptions.
- Although **indigenous breeds** that are prevalent in household **poultry** farming are more resilient than



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imported breeds, **temperatures** in Iraqi summers and winters can prove too **extreme** for the birds, whose optimal living conditions are between 18°C and 20°C. This, coupled with the lack of temperature control and ventilation in enclosures, results in **lowered egg production** and, in the worst case scenario, **bird mortality** (GOAL and Big Heart, 2016).

- **Native sheep breeds**, which represent the majority of the population, are hardy and generally adapted to the local climate. However, while the climate is relatively mild in the north, **rainfall** can be **limited** and **irregular** and breeds be exposed to **water stress**. The main climate risk for sheep is **drought**, which has resulted in significant **livestock loss** for farmers in the most acute events of 1999 and 2008–09 (GOAL and Big Heart, 2016).

Post-production: Storage, processing, transport and retail

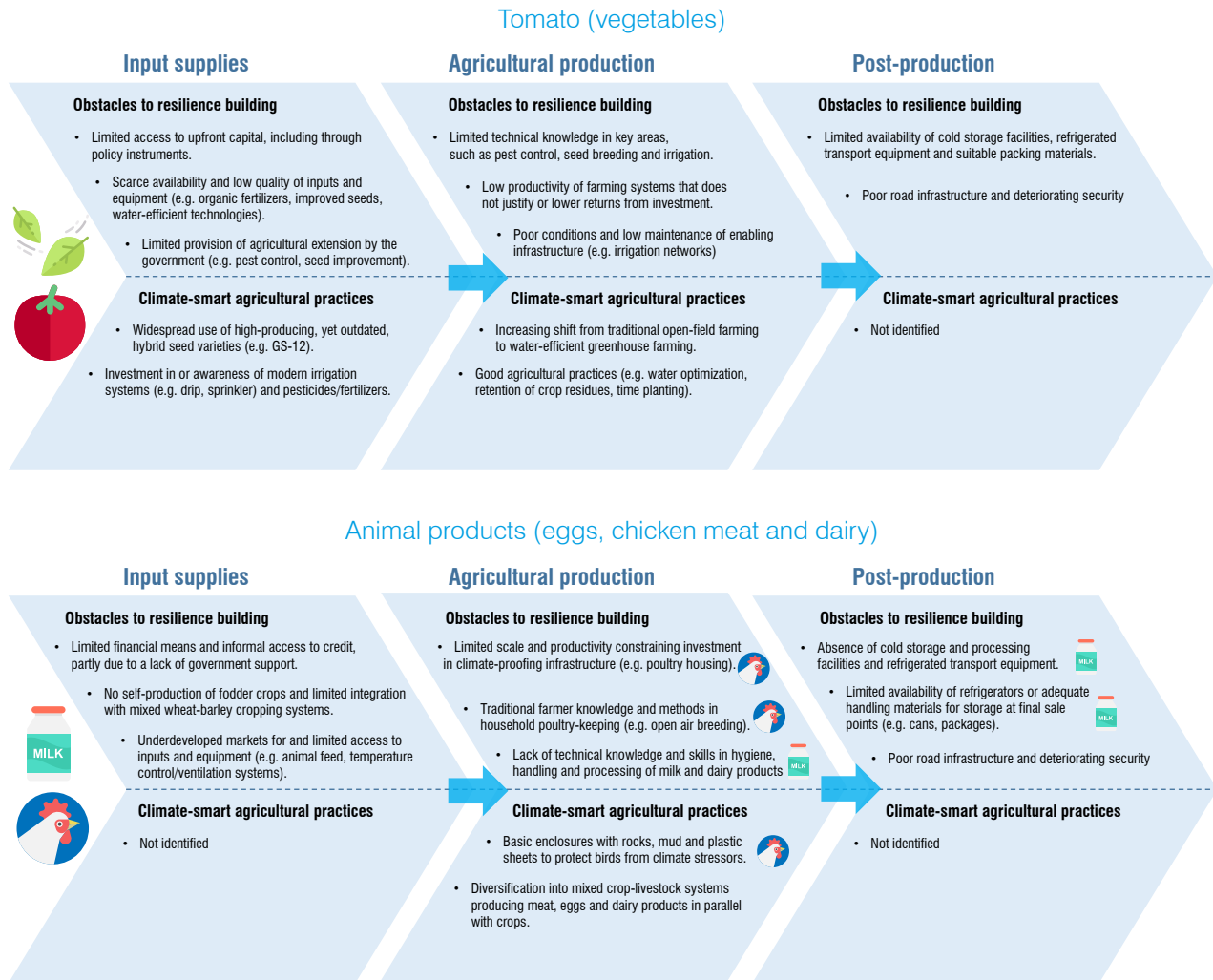
- Due to the **absence of cold storage** and **refrigerated transportation means**, raw produce is long exposed to high temperatures while awaiting processing (milk) or in transit to market (tomatoes). Together with poor post-harvest management due to the **lack of technical skills** in **milk hygiene**, **handling** and **processing** (milk) or **inappropriate packing** (tomatoes), the result is **post-harvest losses** and **waste**, particularly in the summer months. The issue is worsened by the poor conditions of road infrastructure and delays at checkpoints (FAO, 2021; FAO, 2020a; DRC and SREO, 2020).
- At the lower end of the value chain, dairy **retailers** do not always have **refrigerators** or **adequate handling materials** to **store products** (cans and **packages**) and **contamination** issues arise following prolonged exposure of products to high temperatures, particularly in the summer months (SREO and Cordaid, 2020).

Green market opportunities

- Opportunities for the youth in urban areas are scarce and agriculture represents an area where entrepreneurial young graduates can engage. While **young graduates** in Al-Mosul demonstrate interest in and ideas for **climate-proofing innovation**, such as advanced methods in poultry breeding, dairy production and cold storage, they **lack** the **financial capacity** and access to **capital** (microcredit and grants) to start up projects and pursue their ideas independently (SREO and Cordaid, 2020).
- While product quality and yields are affected by poor post-harvest handling (storage and cold chains, etc.), there is **preference of domestic consumers for Iraqi-grown tomatoes** relating to specific attributes (e.g. taste) and growing international **demand** for **organic tomato products**. In this context, there are also opportunities to shift to **environmentally friendly packaging solutions** using bio-recyclable materials (FAO, 2021; FAO, 2020b; SREO and Cordaid, 2020).
- Similarly, **strong demand** for **specialty dairy products**, which are considered of higher quality than foreign ones, involves opportunities for milk and cheese producers and provides scope for **import substitution**. **Consumers** are also willing to **pay a premium** for **locally produced eggs**, which are considered **healthier** and **fresher** than foreign ones. Yet, supply does not match demand and **eggs** are largely **imported** from Turkey and Iran (FAO, 2020a; GOAL and Big Heart, 2016).

Knowledge and practices of farmers and SMEs² in climate change adaptation

Figure 17: Overview of obstacles to climate resilience and main adaptation practices



Source: Author

Obstacle to resilience building

- Scarce availability of and access to **climate finance products** for smallholders, particularly those required to back up invest in water-efficient technologies (irrigation and rainwater harvesting, etc.) and climate-resilient production infrastructure (greenhouses). The situation deteriorated after conflict when the State Agricultural Bank stopped providing interest-free or subsidized loans. Access to credit now entirely relies on informal systems such as family and friends networks (GOAL and Big Heart, 2016).
- Limited **crop productivity** and scarce **access to markets** (low prices and highly competitive imports),

which reduces scale and profitability of farming and depresses investment in risk-reducing measures (production infrastructure, equipment, and water irrigation technologies).

- Scarce availability and low **quality of agricultural inputs** (organic fertilizers, improved seed varieties, and water equipment, etc.), **animal feed** and **drinking water**, which is needed to effectively counter climatic shocks (pest and disease outbreaks, and drought, etc.), shift to environmentally friendly farming methods and maintain productivity at a level that justifies investment in green production technologies (greenhouse and irrigation, etc.)

² Small and medium-sized enterprises (SMEs).



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- Widespread predominance of **traditional farmer knowledge** (planting and growing of vegetables, and poultry-keeping), as well as limited skills in milk hygiene, handling and processing, which could be inappropriate to cope with changing weather patterns (higher temperatures and erratic rainfall, etc.) and depress innovation. This is the case, for instance, for vegetable seedlings, which are predominantly grown with traditional methods and proved to be non-resilient to drought.
- Absence or weak provision of **climate-smart extension services** in key areas, such as pest and disease control and seed improvement. This is due, inter alia, to the fact that the government does not consider vegetables and poultry as priority crops and diverts most resources and efforts to subsidizing cereals, which are instead considered strategic and subject to government purchase schemes.
- Poor conditions, slow reconstruction of or limited investment in **key enabling infrastructure**, from **seed-certifying bodies** to **cold storage and processing facilities** through to **irrigation networks/projects**, due to significant damage suffered during the conflict. Investment is further depressed by unclear government vision and the limited availability of investment capital.

Climate-smart agricultural practices

- Investment in or awareness of **climate-resilient production infrastructure** is on the rise. Particularly in **tomato** and **fresh vegetable** cropping, **greenhouse farming** is becoming a common approach and an increasing number of farmers are shifting from open-field to greenhouse farming. Yet, barriers related to access to upfront capital, labour and management capabilities remain relevant (FAO, 2021; FAO, 2020b).

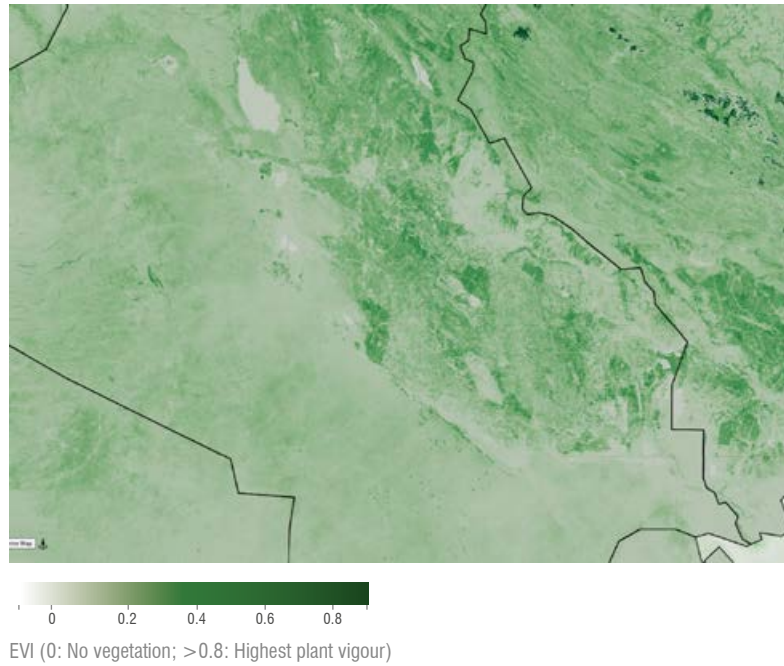
As greenhouse tomato production requires more efficient irrigation schemes and involves better post-harvest handling (e.g. packing), a switch from open field to greenhouse could not only improve resilience to climate shocks (e.g. heavy rains), but also increase water efficiency and product quality.

- Investment in or awareness of **water-efficient technologies** such as wells, and **drip** and **sprinkler irrigation systems**, is becoming more popular. Depending on governorates and product, the former has been already adopted by 45%–60% of **vegetable** farmers. These techniques not only enable better water use, but also enhance crop productivity (FAO, 2021; FAO, 2020b).
- There is evidence of **good agricultural practices (GAP)** that, in addition to enhancing crop productivity, could strengthen resilience to climatic shocks in value chains. The most popular GAP among **tomato** farmers in Erbil, Duhok and Salah Al-Din are water optimization, retention of crop residue and time planting. Despite raising awareness, knowledge constraints remain in selected domains, such as efficient pest control (pesticide application) and breeding of new seed varieties (FAO, 2021).
- While **backyard poultry farmers** lack access to advanced equipment enabling **temperature control and ventilation** inside enclosures – only available to commercial enterprises – some household are moving away from open-air roaming to making **basic enclosures with rocks, mud and plastic sheets** with a view to protecting birds from climate stressors such as high temperatures (GOAL and Big Heart, 2016).
- While vegetable production is scarcely integrated with the broad wheat–barely cropping systems, at farm level, **diversification** is enhanced by **mixed crop–livestock systems**, as farmers commonly produce **meat, eggs and dairy products in parallel with crops**, providing access to alternative incomes that make them more resilient to damage from weather shocks (FAO, 2016; FAO, 2020a).

CENTRAL AND SOUTHERN IRAQ: IRRIGATED AGRICULTURE

Sector overview

Figure 18: Remote sensing land cover map of central and southern Iraq
Enhanced Vegetation Index (EVI), maximum (2019)



Standard satellite view



Note: Dark green clustered areas with uniform pixel texture denote approximate active crop land ($0.3 > \text{EVI} > 0.8$). Further assessment at the district level is needed to detect small-sized cultivated areas and control capture of non-agricultural land cover (e.g. grassland, forests).

Source: Author analysis.

The central and southern agro-ecological region, which spans the southern stretch of the [Tigris–Euphrates river system](#), is characterized by an arid climate, with extremely hot summers and cool winters. Insufficient rainfall makes crop production largely dependent on irrigation, with main production areas clustered along rivers (Figure 18). The region is home to most of Iraq's [irrigated land](#) and irrigation absorbs some 80% of water resources (Republic of Iraq, 2016). Land is traditionally irrigated by flow from rivers and canals through small channels, by water-lifting with wheels or pumps and, to a lesser extent, by direct inundation (Owen et al., 2016). However, [soil salinity](#) and [water logging](#) and [pollution](#), which have worsened in recent years due to ageing [irrigation and drainage infrastructure](#), affect crop production. Irrigated farming systems, which are also threatened by [unreliable supplies](#) and [inefficient water use](#) (e.g. surface irrigation), see a predominance of [summer crops](#), with [fruit trees](#) inter-planted in [date palm orchards](#) (World Bank and FAO, 2012). [Vegetables](#), both winter and summer types, are important cash and food crops. While cereals are relatively less common than in the north and productivity is low compared to global rates, [irrigated wheat and barley](#) can be four to six times as productive (Republic of Iraq, 2016).

Farming units

- The [average rural household](#) is [small](#) with a size of 6.9 [persons](#). In southern and central Iraq, female-headed households make up 9.5% of the total, part of whom are divorcees and widows. In Al-Muthanna, Al-Qadissiya, Maysan and Thi Qar, more than 90% of farming households are smallholders. In terms of [land](#), [small-scale](#) establishments (2.5ha–7.5ha) account for 35% of the total (for irrigated lands, less than 4ha), while medium-sized farms (7.6ha–12.5ha) make up 34%.
- The level of [poverty](#) in these governorates is [41%–51%](#) and is among the highest in the country. Smallholder farmers are frequently the most [marginalized households](#). There is also a high presence of [internally displaced people](#) who have fled violence from military occupation in the northern regions, which potentially exacerbates socioeconomic issues (International Fund for Agricultural Development (IFAD), 2017).

Crops and irrigation

- [Summer crops](#), including [rice](#), [corn](#), [cotton](#), and [vegetables \(tomatoes and potatoes\)](#), are predominant. Yet, [winter crops](#) such as [barley and wheat](#) –grown via surface irrigation or in proximity of irrigation projects– occupy relevant shares of cropland in some

areas (40%). Due to high water requirements, [rice](#) is mainly cultivated in Al-Qadissiya and Al-Najaf Governorates, where conditions are suitable.

- [Palm trees](#), which are more common in the southern governorates, are grown in the summer and orchards are frequently interplanted with [fruit trees](#). However, the relative importance of [dates](#) in terms of cultivated area and productivity has been declining in the past decades due to water scarcity and disruptions from conflict. Al-Basrah is an illustrative case in point (Republic of Iraq, 2016; Internal Displacement Monitoring Centre (IDMC), Social Inquiry (SI) and Norwegian Refugee Council (NRC), 2020).
- In the southern governorates (Al-Basrah, Maysan and Thi Qar), farmland is only located in proximity of rivers and irrigation canals. Indeed, due to [low precipitations](#) year-round, [farming systems](#) are entirely [dependent on river water](#) (IDMC, SI and NRC, 2020). In this context, [water availability](#) and [soil salinity](#) are great determinants of whether households engage in farming activities or [abandon farming](#) in favour of [daily wage labour](#) – an increasingly common trend.
- [Backyard poultry](#) is common among farmers. Usually practiced back to back with livestock rearing (e.g. goat and sheep), it is a major source of food security (IFAD, 2017).

Land tenure

- Similarly to other parts of Iraq, there is a mix of tenure arrangements, as [land](#) is [owned](#) and [operated](#), [leased](#) or [shared](#) by farmers. Various [land reforms](#) undertaken in the past decades, including tenure reform associated with irrigation development, have further [fragmented ownership](#). While no law explicitly prevent them from doing so, very [few women own land](#) due to [custom](#) and [Islamic norms](#) (IFAD, 2017).
- In Al-Basrah, most [farmers do not own the land they farm](#), which belongs to the [government or private individuals](#). In the former case, land is allocated to farmers free of charge by local [Muqtars](#), while in the latter farmers pay owners a minimum amount of money or in kind, depending on their relationship with the owner. In some areas, such as select districts of Al-Basrah, [agricultural land](#) is informally being diverted [to residential](#) use due to increasing demand, although farmers do not report access to land being an issue (NRC, 2018).
- In addition to reducing scale and profitability of agricultural production, increased land fragmentation impedes farmers from applying [traditional methods for combating soil salinity](#), such as alternate year fallows, allowing rainfall to leach out salts (World Bank and FAO, 2012).

Insight into key production systems

Tomatoes (vegetables)

Al-Basrah

- As per the whole central and southern agro-ecological zone, Al-Basrah receives insufficient amounts of rainfall and **crop production**, composed of date palm trees, wheat, barley and **vegetables**, is **irrigation based**. Farming is mainly conducted along the **Tigris River** and areas around the **marshlands**, which supply the water. Vegetables are planted in August, grown from September to November and harvested from December to May. There is no evidence of double harvests.
- **Vegetable production** is concentrated in the **south of Al-Basrah** and includes **tomatoes, cucumbers, okra, onions and eggplant**, while in the north vegetables are grown in mixed cropping systems, with barley and wheat requiring higher amounts of water. **Open-field production is predominant**, while a minority of farmers (10%) rely on **protected agriculture** (winter land covering and greenhouse farming).
- Vegetables are mostly sold in the local markets and in Al-Basrah city. In the southern districts such as Abu Al-Khaseeb, farmers report **vendors buying vegetables directly from farms** without the intermediation of traders. This allows them to save on overhead costs, including transport, and retains more value at farms. There is **no evidence of women** being involved in **marketing** activities.
- Due to **water shortages** (drought and limited supply from riparian countries) and increasing **salinity** issues, farmers in the north of Al-Basrah are **shifting away from wheat and barley to vegetable** production, which has **lower water requirements**, and market-driven demand that is less dependent on declining government purchases (NRC, 2018). This is an effort to adapt to a changing climate also entailing market opportunities.

Thi Qar, Diyala

- The sector is nested in the **mixed cropping system** of the **marshlands**, where smallholder farmers grow **tomatoes and other vegetables**, such as okra, in conjunction with **wheat and barley**. Vegetables are grown on **small plots** of land **owned by farmers**, which tend to employ family members or people in personal networks via word of mouth. **Productivity is low**, as vegetables are grown using **subsistence methods** with no mechanization, although **greenhouse farming** is practiced.

- Agricultural production, especially greenhouse farming, is the main source of employment in Thi Qar, although it also pays the lowest salaries. There is **potential for business development and entrepreneurship in value-added activities** (e.g. groceries and food processing) – a business that is currently led by **women**. While private entrepreneurship is constrained by the lack of access to finance, there is evidence of **women-owned businesses** in the **food processing** sector.
- Farmers from Thi Qar report selling their produce at low prices due to late government purchase. While **inputs and equipment** are **available** and purchased locally, they sell at **high** and increasing **prices** (International Organization for Migration (IOM), 2020; IFAD, 2017).
- Despite facing barriers to entering the labour force due to **traditional gender norms**, in Diyala, **women** play an important role in tomato farming by undertaking **plant maintenance** and **harvesting**. Opportunities for greater women participation in the value chain are also identified in **on-farm value-added activities** such as producing tomato paste and sauces (DRC and SREO, 2020).

Poultry

Al-Basrah, Maysan, Thi Qadissiya, Al-Muthanna, Babil

- Poultry farming is mainly practiced by **women** on **land they do not own**, but for which they have **use rights**. It enables rural households to substantially lower expenses on meat and eggs while enhancing food security (proteins). Depending on scale, **eggs** and **chicken meat** can be **consumed at farms, sold to third parties, or both** – although the **size of farms** is generally **small**.
- Producers organize in **farmer associations**, such as the Poultry Association of Thi Qar, which counts up to 300 members. A minority of them are engaged in **semi-industrial projects** (6,000–25,000 birds) (IFAD, 2017). Poultry farming is done **jointly** with **other types of rearing** (e.g. sheep and goats) and is more or less **common** depending on governorate. In Al-Basrah, it is a least preferred option compared to cattle, buffalo and sheep, and only represents roughly 20% of the population's livelihood (NRC, 2018).
- **Demand** for poultry products, particularly **meat, outstrips supply**, and **production** has been **declining** in recent years, with broilers declining from 1,884 to 1,634 nationwide in 2011–16. In Babil, **competition from imported products, high costs of feed, poor extension services** and inappropriate environmental conditions are the main constraints to value chain development (Kshash and Oda, 2019).



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Dairy

Al-Basrah, Maysan, Thi Qar, Diyala

- In southernmost governorates, communities relying on livestock, mainly **water buffalos, sheep and goats**, produce **dairy products** from their milk, including **cheese, ghee and yoghurt**. In this context, farmers owning cattle are considered to be better off than those who do not. **Women** and youth participation in livestock **breeding** and **milk processing** is **high** (IDMC, SI and NRC, 2020; IFAD, 2017; IOM, 2020).
- In Diyala, **milk production** is highly fragmented, as it is run by **a large number of uncoordinated small actors**, which does not create incentive for large dairy processing units to purchase milk locally (unpredictability of supply chains and high bargaining costs, etc.). Cooperatives and associations ran in the past, but are now non-existent.
- Coupled with strong **price competition, production fragmentation** exacerbates **import dependence**. It is estimated that, at present, only 10% of Iraq's dairy demand is met from domestic production. Imports include milk (fresh and powdered), cheese and yoghurt, and come primarily from Iran (46% in 2016), Turkey, the Kingdom of Saudi Arabia, and Europe.
- Local **dairy products** (e.g. cheese) are considered by consumers as a **local specialty** for which they might be willing to **pay a premium**. In this context, dairy producers in Diyala, including **women**, managed to secure markets by betting on **quality** and **fair pricing**. Demand from urban centres is also on the rise. Dairy **marketing** traditionally involves **women** and **youth**, particularly in the **marshlands** of Thi Qar and Maysan, where women sell **dairy products** jointly with **fish** (DRC and SREO, 2020; IFAD, 2017).

Mapping of climate and environmental risks

Key hazards

- Water scarcity (drought/low precipitation and unreliable, declining supplies from riparian countries)
- Salt water contamination of rivers (sea level rise and excess pumping)
- Water pollution (upstream human activity, and run-off of pesticides and other contaminants)
- Soil salinity
- High temperatures and heatwaves
- Insufficient rainfall, particularly in the summer months
- Erratic heavy rains and flooding
- Persistent drought

Top value chain risks and impact

Input supplies

- Despite growing interest of farmers in climate-resilient farming methods, **limited access to key inputs (seeds, fertilisers and pesticides)** and **equipment (greenhouses, field covers, irrigation and machinery)**, as well as **finance** and **agronomic skills**, have hindered their adaptation efforts and ability to produce high yields of vegetables. Yet, demand for inputs has reduced following water salinity issues and abandonment of farm land (NRC, 2018).
- The **lack of financial resources** constrains adaptation action in that it limits the ability of farmers to **purchase climate-proofing inputs and equipment** (e.g. greenhouses, field covers and irrigation systems), impedes **shift to water-efficient crops** and prevents farmers from **engaging in non-agricultural livelihoods** in districts that are worse hit by the water crisis (e.g. small business). (NRC, 2018; IOM, 2020; IDMC, SI and NRC, 2020; DRC and SREO, 2020).
- Farmers suffered from ecosystem degradation, particularly in the **marshlands**, where **draining of water bodies** have impeded animal feeding. The **lack of animal feed** (e.g. wheat residues) and **drinking water** has caused livestock deaths, affecting 67% of livestock owners surveyed in Maysan, 65% in Thi Qar and 27% in Al-Basrah. Among others, this may have impacted productivity and reduced the quantity and quality of **milk** available for dairy production.
- While a few farmers have been able to **purchase extra fodder** and **purified water** selling at **high prices** in the **local market**, many had to sell part of their livestock in order to ensure access to water and feed, or

left land after having seen their incomes significantly lowered (IDMC, SI and NRC, 2020; NRC, 2018).

Agricultural production

- In Al-Basrah, **diminished flows of fresh water** allow greater **seawater intrusion** to the extent that saltwater reaches irrigation canals (IDMC, SI and NRC, 2020). This has resulted in accumulation of **salts** and dissolved solutes in the **soils**, causing **declines in crop yields** and **plant mortality**. In the southern districts, where rainfall is low and alternate sources of irrigation water are not available, most agricultural activities have ceased and farmland has been abandoned (NRC, 2018; World Bank and FAO, 2012).
- Similarly, field experiments conducted in Al-Basrah reveal that increased levels in total dissolved solutes and **salinity** of **water** result decreased body weight, haematological traits, and increases in feed/water intake and feed conversion ratios of birds – all indicators of **declining health and productivity of chicken** (Mohammed, 2011).
- While the water quality is relatively better in the northern districts of Al-Basrah, especially in Al-Qurna, these areas are witnessing **increasing salinity** and **reduced water levels** in rivers, mostly attributable to **upstream river damming in neighbouring countries** (Turkey and Iran). Due to the inability of rainfall to compensate for water deficits, **crop production** has **declined** (NRC, 2018).
- The amount of **arable land** is **declining** due to the interplay of **water shortages/salinity** and **desertification, abandonment of non-fertile land and informal rezoning of agricultural land into residential**. While the latter is partly due to increasing demand for housing resulting from rural–urban migration, the former two drivers can be attributed to climate and environmental hazards.
- Despite access to alternative water sources from shallow wells in a few southern areas of Al-Basrah, such as Al-Zubair, which should make farming possible in the absence of reliable river water supplies, **agricultural land** has **dramatically reduced** in recent years, from 7,000 acres to approximately 2,000 acres, and **agricultural production has declined** (NRC, 2018).
- In some cases, **water scarcity** and **salinity** have triggered **displacements** of **entire communities** and forced livelihoods to **abandon** their **land** in search of **better opportunities**. Yet, the move has not made many farmers better off, especially **women**, who find it hard to secure alternative livelihood options, as they are not allowed to work in the market due to **social norms**. **Migrations** were mainly **local**, to

other villages of sub-district capitals and driven by informal networks (IDMC, SI and NRC, 2020; NRC, 2018).

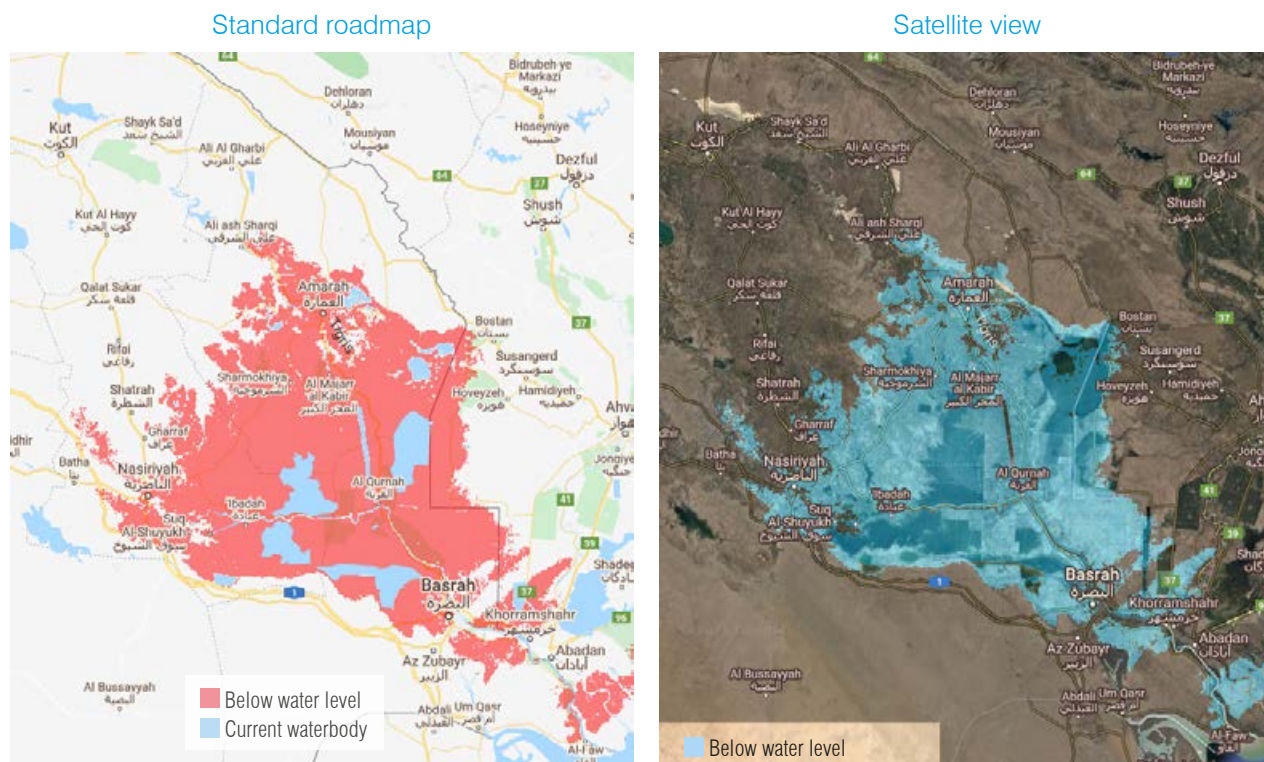
- Traditional **farming** in the **marshlands** of Thi Qar, where poverty rates are the highest in the country, has been **disrupted** by **draining**, which also caused biodiversity losses and damage to the ecosystem (IFAD, 2017). In Al-Basrah, **diminished water levels in the marshes** due to prolonged **drought** and a steady **decline in annual rainfall** have been further exacerbated by the **draining of wetlands by the government** – a strategy used to fight insurgents during conflict in the 1990s (NRC, 2018).
- **River water** in Al-Basrah, Thi Qar and Maysan is **polluted** by **pesticide run-off** from intensive farming practices and **untreated wastewater** coming **from upstream regions**. Sporadic peaks in pollution levels happen with no warning, leaving farmers with few possibilities to mitigate risk and resulting in **plant mortality** (IDMC, SI and NRC, 2020).
- While providing temporary relief from water shortages to farmers, **extraordinary heavy rains** have also caused **extensive flooding** in Al-Basrah and Maysan. Torrential rain and floods **damage or destroy** homes, causing displacement of entire communities in affected districts (IDMC, SI and NRC, 2020).
- In Al-Basrah, **heatwaves** have caused **harvest losses**, forcing farmers to stop growing summer crops and rely on reduced, less diversified incomes (IDMC, SI and NRC, 2020). Similarly, in Babil, **extreme temperatures**, ranging from below 0°C in the winter to up to 50°C in the summer, **high humidity** and **dust storms** usually hitting land from March to October resulted in high economic losses from **increased bird mortality** and **reduced yields** (Kshash and Oda, 2019; Morshed et al., 2018).

Post-production: Storage, processing, transport and retail

- Due to the **lack of cold storage facilities**, farmers sell products right after harvests so as not to incur losses from **exposure to high temperatures**. This frequently causes **excess one-time supply**, exerting **downward pressure on prices** and competitiveness of local produce against foreign imported items, while also threatening **product safety** and **quality** (DRC and SREO, 2020).
- **Chicken meat** sold in local markets and restaurants in multiple districts of Al-Basrah shows **above-threshold values of microbial and heavy metals contamination** (zinc, lead, cadmium and copper), posing a serious risk to consumer health (Makka, 2019).

Top issue focus: Sea level rise and salt water intrusion

Figure 19: Land projected to be below tideline by 2100 in Al-Basrah, Maysan and Thi Qar



Note: The analysis is based on median projected rises in sea level on a 2°C temperature increase by 2100. “Tideline” is used to denote the recent historical average of the highest daily local tide level or, technically, the mean higher high water (MHHW) line.

Source: Author.

In Al-Basrah, Maysan and Thi Qar Governorates, [water scarcity](#), [pollution](#) and [soil salinity](#) have been growing concerns in the recent past and now top the adaptation agenda. They result from the interplay of [environmental](#) and [institutional factors](#), ranging from the adverse effects of a [drying climate](#) in the region (drought, low precipitation and heatwaves) to the [lack of regulation for water use](#) with [neighbouring countries](#). These issues and their socioeconomic effects can be further exacerbated by the [rise in sea levels](#) projected globally, which is expected to severely hit the northern coasts of the Persian Gulf. As Figure 19 shows and recent research found, by 2050, the southernmost districts of Iraq could be partially submerged as a result of rising sea waters (Kulp and Strauss, 2019). The resulting [intrusion of saltwater in groundwater aquifers](#) could further [disrupt irrigation](#) and [farming activities](#), exert additional [pressure](#) on [arable land](#) and cause displacement of entire communities.

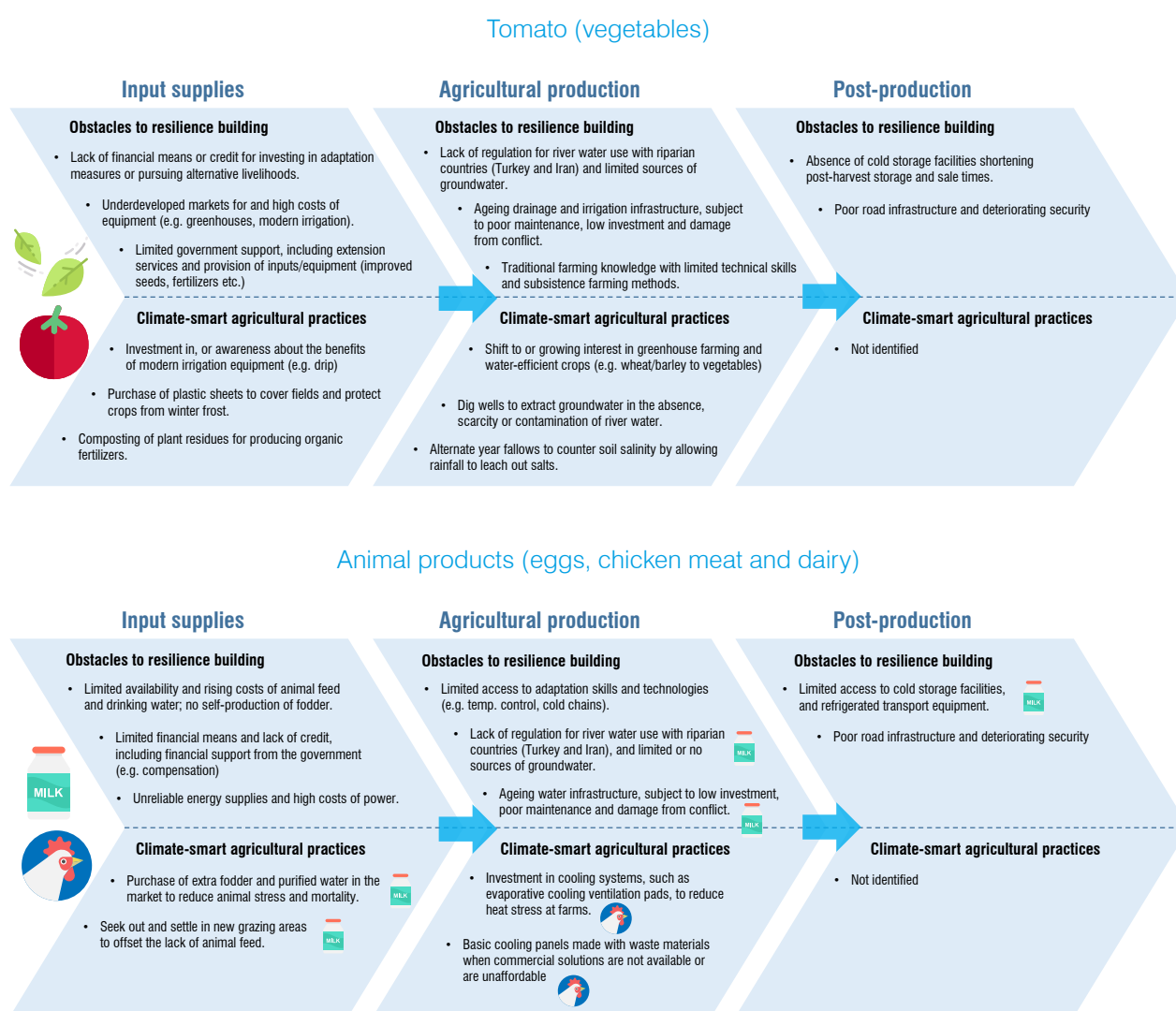
Green market opportunities

- Demand of fertilizers is strong, particularly those providing urea and potassium to soil. Synthetic fertilizers, which used to be supplied by the Ministry of Agriculture prior to the crisis, are reportedly hard to procure. In order to deal with supply failures, some farmers are [composting plant residues](#) and [use remains](#) to [fertilize](#) their [land](#) (DRC and SREO, 2020). This practice could make them self-sufficient and, at the same time, help [reduce emissions](#) from [chemical fertilizer use](#).
- [Market opportunities](#) involving [new business models](#) exist in value-added activities related to [sustainable agriculture](#) and [water management](#). These include [market-led greenhouse farming](#) to supply the local market, opening grocery stores and providing of [water purification services](#) such as reverse osmosis (RO) – already in high demand in the livestock sector (NRC, 2018).

- Traders from local markets report **local animal (eggs and cheese) and horticultural products** being of **higher quality** compared to imported food items (e.g. from Iran). Yet, imported vegetables accounts for 80% of supply, as local produce faces strong price competition from foreign products, which are on average 10%–15% cheaper. The issue is amplified by **water salinity issues** that, by **reducing output**, have **pushed up prices** of local products by an additional **20%** (DRC and SREO, 2020; NRC, 2018).

Knowledge and practices of farmers and SMEs in climate change adaptation

Figure 20: Overview of obstacles to climate resilience and main adaptation practices



Source: ITC

Obstacle to resilience building

- Lack of regulation for water use by and supply from riparian countries** (Turkey and Iran), which retain high amounts of water to feed their own irrigation networks, is considered one of the top drivers of water scarcity and salinity. Among broader **disruptions** to cropping activities, **water scarcity** and **contamination** has **limited** the **availability** of key inputs to milk production, such as **drinking water** and **animal feed** (IDMC, SI and NRC, 2020; NRC, 2018).
- As part of a nationwide trend, **government support**, including the provision of **financial** and **extension services**, as well as access to **inputs and equipment**

(greenhouses and improved seeds, etc.) is poor. While the situation is governorate-specific, inputs supplies are irregular and entirely up to a small number of private entities, resulting in low competition and high prices.

- The farming knowledge base is overall traditional, with limited technical skills and a prevalence of subsistence farming methods. In addition, skills mismatches prevail among farmers, who, due to reduced water levels in the north, are shifting from wheat and barley to vegetable production – an adaptation measure in itself that requires crop-specific knowledge and skills (NRC, 2018).
- The limited availability of and access to financial products targeted at rural households is not only a bottleneck to adaptation in farming, but it also hinders farmers' ability to diversify and pursue opportunities in non-agricultural livelihoods. These include small businesses, such as food processing, where opportunities exist for women and youth.
- Ageing drainage and irrigation infrastructure, subject to poor maintenance, low investment and damage from conflict, exacerbates water quality and salinity issues. By the same token, in Al-Basrah, Maysan and Thi Qar, most farmers and livestock owners operate on a very small scale, which imposes a financial limit on them and constrains private investment in climate-proofing physical assets such as cold storage facilities and refrigerated transport equipment.
- Even producers who managed to invest in temperature-controlled environments face challenges relating to unreliable energy supplies. In particular, frequent power shortages force them to rely on alternative power generation systems (e.g. generators). Adding to supply chain disruptions, a generator's fuel and maintenance pushes up operating expenditures and emissions. This is the case of poultry houses in Babil and refrigerated storage for dairy products in Diyala (DRC and SREO, 2020; Kshash and Oda, 2019).
- During winters, covering fields with plastic sheets to protect them from frost and maintain optimum temperature for cropping is relatively popular among farmers in Al-Basrah. This sort of equipment is provided by private suppliers at market prices (NRC, 2018).
- In selected areas of Diyala such as Muqtadiyah, some farmers are compensating for the limited availability of fertilizers – particularly those providing urea and potassium to soil – by composting plant residues and using remains to fertilize their land (DRC and SREO, 2020).
- In the absence or scarcity of river and canal water, farmers in Maysan and Thi Qar have dug wells to extract groundwater. However, its quality is far from optimal and there is a risk of over-extraction that may trigger saltwater intrusion (IDMC, SI and NRC, 2020). In districts where salinity is an issue, some farmers try to counter soil salinity by applying alternate year fallows, allowing rainfall to leach out salts (World Bank and FAO, 2012).
- Due to increasing water shortages and advancing salinity towards the northern districts of Al-Basrah, farmers are shifting towards irrigated vegetable farming and away from water-intensive barley and wheat (NRC, 2018). However, shifts require crop-specific agro-economic knowledge and equipment (e.g. greenhouses) that might not be available locally. Skill mismatches constrain crop diversification and impede farmers from pursuing non-agricultural livelihoods (e.g. small business) (NRC, 2018).
- While facing extra costs, livestock owners who could afford it have purchased extra fodder and purified water for their animals with the objective of reducing animal stress and mortality resulting from water scarcity and contamination. In Al-Basrah, some owners have also sought new grazing areas, but this has resulted in competing use with and damage to local crop production (IDMC, SI and NRC, 2020).
- Some poultry farmers are investing in cooling systems, such as evaporative cooling ventilation pads, to reduce heat stress at poultry houses. Yet, in the hotter months (June to September), these might not be enough to create minimum acceptable conditions. In some cases, smallholders facing limited technical knowledge and financial means are replacing commercial pads with basic panels made of waste materials, reducing costs and providing relatively good performance (Morshed et al., 2018).

Climate-smart agricultural practices

- There is evidence of a growing interest for climate-resilient production infrastructure (e.g. greenhouses) and modern irrigation systems (e.g. drip). For instance, greenhouse farming is practiced by small-scale vegetables producers in Al-Zubair (Al-Basrah), where water salinity is relatively low and farmers have access to alternative water sources (shallow wells). Yet, uptake in Al-Basrah, Maysan and Thi Qar remains limited due to, inter alia, constrained access to and high costs of equipment (IDMC, SI and NRC, 2020; IOM, 2020; NRC, 2018).

CONCLUSIONS

Analysis of literature and expert insight reveals that the highest level of risks are concentrated in agricultural production (cropping, etc.). In this area, there are some modest increases in adoption of sustainable farming practices that counter the adverse impact of climate and environmental hazards. Underdeveloped markets for inputs and equipment (e.g. climate-adapted seeds and water-efficient technologies), limited availability of financial products targeted at rural smallholders, and the lack of climate-proofing post-harvest infrastructure (e.g. cold chains) constrain productivity upstream and threaten product safety and quality from storage to retail. This results in a reduction of competitiveness for MSMEs. The assessment's key findings are detailed below.

The scarcity and poor quality of water is the main risk to agribusiness. This results from a combination of climate, environmental and institutional drivers. The lack of international regulation on water use limits water supplies to Iraq, as most water is retained by riparian countries feeding their own irrigation networks (e.g. Iran and Turkey). As a result, river water flow, on which most agricultural production depends, has declined and is polluted by upstream human activity (fertilizer run-off and sewage, etc.). Poor water management practices (e.g. surface irrigation and excessive pumping) and ageing irrigation infrastructure suffering damage from conflict, poor maintenance and limited investment further contribute to the problem. Furthermore, it exacerbates the negative effects of a drying climate in the region, which are hitting Iraq in the form of slow-onset events and weather extremes. These include increasing temperatures, declining precipitation, and prolonged droughts and heatwaves – all of which have direct impacts on agribusiness activities. Erratic heavy rains could also result in abundant flooding and directly damage production infrastructure (e.g. fields and farms).

Climate and environmental hazards have significant impacts on competitiveness across the tomato (vegetables) and animal products value chains, from farming to post-production activities:

- Farmers are suffering from degraded soil in the form of reduced moisture content and intrusion of salts from irrigation water. While arable land has

not declined in surface area in the past 20 years, changes in the suitability of cropping areas have triggered local changes in the geography of production, causing, in the worse cases, displacements of entire communities. Crop failures, including reduced yields and plant mortality, are recurrent in vegetable farming and are mainly linked to scarce or contaminated water. Animal stress from high temperatures, as well as the lack of fodder and drinking water, lower the milking potential of cattle and the productivity of chicken. Jointly with low levels of crop diversification, these factors hamper the ability of MSMEs to serve end markets successfully.

- Downstream, the absence of cold chains in storage, transport and processing exposes tomatoes, milk and dairy products to high temperatures for long periods, especially in the summer months. This is a major threat to product safety and quality, and frequently results in post-harvest losses and waste. Poor road infrastructure and precarious safety conditions also delay times to market and reduce profit margins.

There are notable long-term impacts on competitiveness in specific value chains and agro-ecological regions. Poor water quality and scarcity affects northern and southern governorates differently. In northern Iraq, water scarcity hampers vegetable production, particularly in the summer months when rainfall is low. This scarcity is exacerbated by the wide use of traditional surface irrigation that results in high water losses. The efficiency of irrigation systems also decreases due to soil salinity, prolonged droughts, and flooding. In southern regions, the issue is contributing to a humanitarian crisis. The level of dissolved solutes in soil is higher due to the combination of reduced water flows from the north and salt water intrusion from the south. River water is also polluted by pesticide run-off from intensive farming practices and untreated wastewater flowing from upstream regions. Water scarcity and pollution hampers crop production, not only resulting in direct crop failures, but also limiting the availability of drinking water and feed for livestock. Farmers report facing high levels of livestock losses and high market prices of key inputs (e.g. purified drinking water). In some cases, agribusiness activities had to close, leaving farmers to pursue alternative, non-agricultural livelihoods.

Despite awareness about the impacts of climate change and the need to invest in adaptation measures, farmers and agribusinesses in the vegetables and animal products value chains face obstacles to building resilience capacity. There are a number of key constraints to climate change adaptation at each value chain point. Overall, there is a limited availability of and access to financial products for smallholders, particularly to enable investment in water-efficient technologies (e.g. modern irrigation and rainwater harvesting) and climate-proofing infrastructure (greenhouses). Access to credit relies mostly on informal systems such as family and friends networks. Markets for key inputs and equipment such as organic fertilizers, improved seeds and irrigation technologies are usually underdeveloped and governed by a small number of private actors, resulting in low competition and high prices. Equipment is largely imported from China and neighbouring countries such as Iran, and farmers report it being of low quality.

The provision of financial support, inputs and extension services to vegetables and livestock farmers remain weak. Areas where extension support is most in demand include pest and disease control, seed improvement and access to/self-production of fodder. Adaptation action is further constrained by the widespread predominance of traditional farming methods applied in key processes, such as irrigation, growing of vegetable seedlings and poultry keeping. Specialist knowledge is also in short supply. For instance, limited skills in milk hygiene, handling and processing makes it challenging to cope with changing weather patterns such as temperature extremes, and depresses innovation in dairy production. Other obstacles include weak policy frameworks and law enforcement, such as in water management and use, unreliable energy supplies hampering functionality of cold chains and poultry houses, and ageing irrigation and transport infrastructure.

Irrespective of these bottlenecks, there is evidence of farmers and agribusinesses investing in adaptation measures, including climate-smart agricultural practices. In a few cases, when actors have access to adequate financial means and enabling skills and technologies, there is evidence of investment in adaptation measures. More frequently, in the absence of scale, resources and assets needed for investment, farmers and agribusinesses adopt basic, yet effective subsistence solutions. In the former case, investment in greenhouses and modern irrigation systems (e.g. drip and sprinkler) is on the rise, particularly among fresh vegetable farmers in northern governorates. In the south, many farmers purchase plastic sheets in the local market to cover fields and protect them from

winter frost. Basic low-tech solutions are more popular among poultry keepers. In southern governorates where temperatures are higher, those who cannot afford investment in advanced cooling systems for poultry houses (e.g. evaporative cooling ventilation pads) are replacing them with basic panels made of waste materials that provide relatively good performance. Similarly, some smallholders in the north are moving away from open-air roaming to making basic enclosures with rocks, mud and plastic sheets, with a view to protecting birds from temperature extremes and winds.

Climate-smart agricultural practices are also growing in uptake as farmers seek to optimize water use on farms, enhance crop diversification and improve soil management practices. For example, some farmers apply alternate year fallows, allowing rainfall to leach out salts. Others are compensating for the limited availability of fertilizers – particularly those providing urea and potassium to soil – by composting plant residues and using remains to fertilize land. In areas where salinity and water shortages are increasing, such as the northern districts of Al-Basrah, farmers are shifting away from barley and wheat towards water-efficient vegetable farming, requiring less water and providing better market opportunities.

The climate crisis is creating demand for goods and services that relate to climate adaptation and improving environmental outcomes. In Iraq, there is the potential for new business opportunities around value-added activities in climate-smart agriculture and water management. These include piloting organic greenhouse farming to providing water purification services such as reverse osmosis (RO) – already in high demand in the livestock sector. Although they lack the financial capacity to start projects independently, young graduates in urban areas demonstrate interest in and ideas for climate-proofing innovation in relevant areas, such as advanced methods in poultry breeding, dairy production and cold storage. In addition, growing international demand for organic products and related attributes could encourage a shift to environmentally friendly packaging solutions based on bio-recyclable materials, whose uptake in the value chain is limited.

Scaling adaptation practices and capitalizing on green market opportunities, through the coordinated support of government institutions, international providers of trade-related technical assistance and large market players, can make Iraq's vegetables and animal products value chains not only wealth-enhancing, but also more climate-resilient and environmentally sustainable.

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METHODOLOGY

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ANNEX

DESCRIPTION AND SOURCES OF INDICATORS

CLIMATE CHANGE COUNTRY PROFILE

Agro-ecological profile and climate overview

Indicator/graph	Description	Source
Agro-ecological map and description	Agro-ecological zones based on winter type, summer type and moisture regime derived from satellite temperature and precipitation data.	Alwan et al. (2019) and multiple sources.
Köppen climate subtype	Top 3 climate subtype(s) of the Köppen Climate Classification, per cent of district count.	Author elaboration on data at Climate-data.org.
Timing of rainy season	Time span of the rainy season, by macro agro-ecological zone.	World Bank Climate Change Knowledge Portal
Slow-onset events	Key slow-onset events as highlighted in referenced literature.	Multiple sources
Extreme weather events	Key weather extremes as highlighted in referenced literature.	Multiple sources
Mean temperature	Mean annual temperature in °C measured over the period 1901–2016.	World Bank Climate Change Knowledge Portal Original source: Observational datasets from the Climate Research Unit of the University of East Anglia: http://www.cru.uea.ac.uk/about-cru . Regional breakdown: Saleem et al. (2017)
Mean precipitation	Mean annual precipitation measured over the period 1901–2016. <i>Regional data is for the period 1970–2013.</i>	World Bank Climate Change Knowledge Portal Original source: Observational datasets from the Climate Research Unit of the University of East Anglia: http://www.cru.uea.ac.uk/about-cru Regional breakdown: Jasim and Awchi (2020).
Mean sea level	Mean sea level above tide gauge zero. <i>Tide gauge zero is the level for which the gauge would record zero sea level.</i>	Abbas et al. (2020)
Disaster risk	World Risk Index 2020 (world rank: 96 th). <i>The index measures the risk of disaster arising directly from natural events, including climate extremes based on country exposure and vulnerability.</i>	Bündnis Entwicklung Hilft (BEH) and Ruhr University Bochum (RUB) (2020).

Historical climate

Indicator/graph	Description	Source
Temperature and rainfall	Average monthly temperature and rainfall measured over the period 1991–2016.	World Bank Climate Change Knowledge Portal Original source: Observational datasets from the Climate Research Unit of the University of East Anglia: http://www.cru.uea.ac.uk/about-cru .
Sea level anomaly	Average annual sea level anomaly measured over the period 2000–15. <i>Sea level anomaly is the difference between the actual sea surface height and a mean sea surface height.</i>	World Bank Climate Change Knowledge Portal Original source: Satellite data from the European Space Agency's Sea Level Climate Change Initiative: https://climate.esa.int/en/projects/sea-level/
Key trends	Historical trends for key weather events (slow onset and extremes) as highlighted in referenced literature.	Hameed et al. (2018), Jasim and Awchi (2020), REACH and United Nations Institute for Training and Research (UNITAR) (2020), Sissakian et al. (2013), UN Iraq (2014), USAID (2017), World Bank Climate Change Knowledge Portal (2020), author analysis

Climate outlook

Indicator/graph	Description	Source
Temperature Rainfall	Projected change in monthly temperature and rainfall for the period 2020–39 compared to the reference period 1986–2005 (historical mean). <i>Projections under a RCP 8.5 scenario based on a multi-model ensemble of 16 models used by the Intergovernmental Panel on Climate Change.</i>	World Bank Climate Change Knowledge Portal Original source: General circulation model data from the Coupled Model Intercomparison Project (v.5-CMIP5) (Taylor et al., 2012).
Key prospects	Prospects for key weather events (slow onset and extremes) as highlighted in referenced literature. <i>If not elsewhere specified, projections are under a RCP 8.5 (high emission) scenario.</i>	Barlow et al. (2016), Kulp and Strauss (2019), Levi and Mann (2020), Sissakian et al. (2013), UN Iraq (2014), World Bank Climate Change Knowledge Portal (2020).

CLIMATE CHANGE VULNERABILITIES AND ENVIRONMENTAL PERFORMANCE OF AGRICULTURE

Sector overview

Indicator/graph	Description	Source
Land use map and description	Land use map and discussion, including main cultivated crops, and mapping of main agricultural clusters (locations and irrigation, etc.).	Alwan et al. (2019), Central Intelligence Agency (CIA) (2003), World Bank and FAO (2012), Owen et al. (2016), World Bank (2019).
Land use change	Waterfall chart showing the composition of agricultural land (thousand ha and per cent of total/sub-totals, 2018) and bar chart displaying bi-decadal change in surface of arable land and cropland (thousand ha, 1998–2018).	FAOSTAT (2021). Data includes official data reported by countries to the FAO, data published on country official publications or websites, and FAO estimates. For definitions and concepts (e.g. arable land), see FAOSTAT metadata ("Item"): http://www.fao.org/faostat/en/#definitions .

Key hazards and vulnerabilities

Indicator/graph	Description	Source
	Overview of key climate stressors, impact on and vulnerabilities of the agriculture sector, as highlighted in literature.	World Bank and FAO (2012), WBCKCP (2020), expert knowledge and project evidence

Country benchmarking (Iraq, Iran, Jordan, Syria, Turkey)

Indicator/graph	Description	Source
Climate change		
Crop season	Growing season length: Number of days between the first and last period of six or more consecutive days with a daily mean temperature above 5°C (median).	World Bank Climate Change Knowledge Portal Original source: Climate statistics indicators from the joint CCI/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI): http://etc-cdi.pacificclimate.org/list_27_indices.shtml .
Drought	Maximum number of consecutive dry days: Number of days in the longest period without significant rainfall of at least 1mm (median).	Projections based on a multi-model ensemble of up to 35 models used by the Intergovernmental Panel on Climate Change.
Heat	Number of very hot days (Tmax > 35°C): Number of days with maximum temperature above 35°C (median).	
Flooding	Maximum number of consecutive wet days: Number of days in the longest period with continuous significant rainfall of 1mm or more (median).	

Indicator/graph	Description	Source
Environmental performance		
Greenhouse gas (GHG) emissions of agriculture, by contributing activity	GHG emissions by agricultural subsector or activity, expressed as a per cent of sector total (2016).	Author analysis on data Ritchie and Roser (2017). Underlying data: World Resources Institute, CAIT Climate Data Explorer (2021).
Greenhouse gas (GHG) emissions of agriculture, by type	Nitrous oxide (N2O) emissions, methane (CH4) emissions and GHG emissions total (gross of land use change), expressed in million tons (t) of carbon dioxide equivalent (CO2e) and per cent of country total (2016).	Author analysis on data World Resources Institute, CAIT Climate Data Explorer. Underlying data: FAO, FAOSTAT Emissions database (2021).
Other top contributors	Top contributors to GHG emissions other than agriculture, in each peer country.	Author analysis on data World Resources Institute, CAIT Climate Data Explorer. Underlying data: FAO, FAOSTAT Emissions database (2021).

VEGETABLES AND ANIMAL PRODUCTS: CLIMATE CHANGE RISKS, OPPORTUNITIES AND OPTIONS FOR ADAPTATION

Sector overview

Indicator	Description	Source	
		Northern Iraq	Central and southern Iraq
Remote sensing land cover map – Enhanced Vegetation Index (EVI)	EVI is an enhanced version of the Normalized Difference Vegetation Index (NDVI), which uses surface reflectance to quantify the density of plant growth on the Earth. Similarly to the NDVI, it is calculated from the visible and near-infrared light reflected by vegetation. The figure is based on maximum values recorded in 2019. For calculation and interpretation of the indices, please see: NASA Earth Observatory.	Author analysis on data from the United States Geological Survey (USGS) and National Aeronautics and Space Administration (NASA) LandSat 4/5/7/8 Surface Reflectance (Jan. to Dec. 2019).	Author analysis on data from United States Geological Survey (USGS) and National Aeronautics and Space Administration (NASA) LandSat 4/5/7/8 Surface Reflectance (Jan. to Dec. 2019). Maps generated with Climate Engine web app.
Introduction	Overview of geography, climate and agricultural production system(s), including geo-mapping of crop land, main crops and farming practices.	Author analysis, Alwan et al. (2019), World Bank and FAO (2012)	Author analysis, Republic of Iraq (2016), Owen et al. (2016), World Bank and FAO (2012)
Farming units Crops and irrigation Land tenure	Profiling of establishments (type and size), farming practices (main crops grown and irrigation, etc.) and land tenure (ownership and use). <i>Insight is extracted from surveys and field research conducted by third parties and might not be exhaustive.</i>	FAO (2020a), FAO (2020b), FAO and IR (2014), World Bank and FAO (2012)	IDMC, SI and NRC (2020), World Bank and FAO (2012), IFAD (2017), NRC (2018), Republic of Iraq (2016)

Insight into key production systems

Indicator	Description	Source	
		Northern Iraq	Central and southern Iraq
Tomatoes (vegetables) Dairy Poultry	Deep dive into SAAVI production systems in relevant governorates, including farmer profile, cropping practices, input access and technology adoption, etc. <i>Insight is extracted from surveys and field research conducted by third parties and might not be exhaustive.</i>	FAO (2021), FAO (2020a), FAO (2020b), FAO (2018), FAO (2016), GOAL and Big Heart (2016), SREO and Cordaid (2020)	DRC and SREO (2020), IDMC, SI and NRC (2020), IOM (2020), Kshash and Oda (2019), NRC (2018), IFAD (2017)

Mapping of climate and environmental risks

Indicator	Description	Source	
		Northern Iraq	Central and southern Iraq
Key hazards	List of key climate and environmental hazards in the macro region.	Expert knowledge based on literature reviews and project evidence.	Expert knowledge based on literature reviews and project evidence.
Top value chain risks and impact	Overview of top climate and environmental risks in the value chains, and their impact on business from input supplies to retail through to agricultural production. <i>Insight is extracted from surveys and field research conducted by third parties and might not be exhaustive.</i>	DRC and SREO (2020), FAO (2021), FAO (2020a), FAO (2020b), GOAL and Big Heart (2016), IR (2020a), IR (2020b), SREO and Cordaid (2020), Price (2018)	DRC and SREO (2020), IDMC, SI and NRC (2020), IOM (2020), Kshash and Oda (2019), Makka (2019), Mohammed (2011), Morshed et al. (2018), NRC (2018), IFAD (2017), World Bank and FAO (2012)
Top issue focus	Sea level rise and salt water intrusion: Land projected to be below tideline by 2100 on a 2°C temperature increase.	Not available	Author analysis on data from Climate Central (2021). Maps generated with Climate Central's Surging Seas Maps and Tools

Green market opportunities

Indicator	Description	Source	
		Northern Iraq	Central and southern Iraq
	Overview of market opportunities identified in local, organic and certified product markets, environmental services and climate-proofing innovation.	FAO (2021), FAO (2020a), FAO (2020b), GOAL and Big Heart (2016), SREO and Cordaid (2020)	DRC and SREO (2020), NRC (2018)

Knowledge and practices of farmers and SMEs in climate change adaptation

Indicator	Description	Source	
		Northern Iraq	Central and southern Iraq
Overview of obstacles to climate resilience and main adaptation practices	Visual summarizing obstacles to building resilience faced and adaptation practices undertaken by farmers and SMEs at each value chain stage	Author analysis based on expert knowledge and literature reviews	Author analysis based on expert knowledge and literature reviews
Obstacles to resilience building	Institutional constraints faced by firms in adopting climate and environmental risk-mitigating measures before project. <i>Insight is extracted from surveys and field research conducted by third parties and might not be exhaustive.</i>	Author analysis based on literature reviews and expert knowledge, unless otherwise specified	Author analysis based on literature reviews and project evidence, unless otherwise specified
Climate-smart agricultural practices	Review of climate-smart agricultural practices implemented in SAAVI value chains before project. <i>Insight is extracted from surveys and field research conducted by third parties and might not be exhaustive.</i>	FAO (2021), FAO (2020a), FAO (2020b), FAO (2016), GOAL and Big Heart (2016)	DRC and SREO (2020), IDMC, SI and NRC (2020), IOM (2020), Morshed et al. (2018), NRC (2018), World Bank and FAO (2012)

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