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Climate-Smart Agriculture in Yemen

Leveraging Resilience for Sustainable Food Production

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List of Acronyms

AREA	Agricultural Research and Extension Authority
CBO	Community-based organization
CSO	Civil society organization
CARPO	Center for Applied Research in Partnership with the Orient
DRR	Disaster Risk Reduction
EPA	Environmental Protection Authority
ERRY	Enhanced Rural Resilience in Yemen
ESCWA	United Nations Economic and Social Commission for West Asia
FAO	Food and Agriculture Organization
GBV	Gender-based violence
GCC	Gulf Cooperation Council
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
HDP	Humanitarian-development-peace
IASC	Inter-Agency Standing Committee
ICARDA	International Center for Agricultural Research in the Dry Areas
ICBA	International Center for Biosaline Agriculture
IDP	Internally displaced person
IFAD	International Fund for Agricultural Development

ILO	International Labor Organization
INGO	International non-governmental organization
IOM	International Organization for Migration
IPM	Integrated pest management
IRG	Internationally Recognized Government
LDA	Local Development Association
MAIF	Ministry of Agriculture, Irrigation, and Fisheries
MEL	Monitoring, evaluation, and Learning
MWE	Ministry of Water and Environment
n.d.	No date
ND GAIN	Notre Dame Global Adaptation Initiative Index
PDRY	People's Democratic Republic of Yemen
RYE	Rethinking Yemen's Economy
SFD	Social Fund for Development
SMEPS	Small And Micro Enterprise Promotion Service
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UNHCR	United Nations High Commissioner for Refugees
USAID	United States Agency for International Development
WFP	World Food Programme
WHO	World Health Organization
WUA	Water user association
YAR	Yemen Arab Republic
YER	Yemeni Rial

Yemen's rich agricultural heritage has been severely weakened by low productivity, urbanization, labor shortages, and the expansion of qat *cultivation. The use of chemical fertilizers and pesticides has degraded soil and harmed bee populations, disrupting traditional farming practices. Since 2015, agriculture has suffered further due to conflict, poverty, food insecurity, and climate change, making Yemen one of the most vulnerable countries to environmental crises. This report explores climate-smart agriculture in Yemen, emphasizing the decline of indigenous water management and rainwater harvesting structures. Strengthening sustainable farming with modern interventions can enhance water management, productivity, and food security. Women play a crucial role in agriculture and livestock rearing, making their involvement essential. Engaging civil society, water user associations, cooperatives, young entrepreneurs, the private sector, and government actors is also critical. Reviving traditional water management alongside modern techniques like drip irrigation and greenhouses can improve efficiency and reduce conflicts. The agricultural sector needs investment in seed banks, drought-resistant crops, organic composting, and urban farming, while post-harvest loss reduction should integrate green technologies, particularly for women farmers. Strengthening local fodder production, veterinary services, and rangeland rehabilitation is vital for livestock rearing, with targeted support for women in the dairy sector. Additional challenges include threats to the honey sector, coffee's economic potential, and the decline of medicinal and culinary foraging. The report calls for coordinated action among donors, international organizations, civil society, and government actors to advance climate-smart agriculture and food security in Yemen.*

1 Introduction

1.1 Framing of the Report

This CARPO Report seeks to share indigenous traditions in sustainable agriculture and highlight challenges and opportunities in climate-smart agriculture in Yemen. Agriculture is at the heart of Yemeni history as well as central to the contemporary context. The country is facing myriad challenges in the sector, including those posed by climate change, weak governance, conflict dynamics, poverty, and unsustainable practices. These factors are driving food insecurity, diminishing food sovereignty,[1] and undermining household and communal

1 The right of communities to control their food systems, including how food is produced, distributed, and consumed.

resilience in Yemen. While there is a significant body of literature on related topics (see resources consulted in the literature section on page 69), this report brings together insights from this rich local heritage strengthened with modern approaches and technologies with the goal to further climate-smart agriculture in the country.

Sustainable farming practices underpinning climate-smart agriculture are ancient, although the term was first used in 2010 by the Food and Agriculture Organization (FAO). This concept emerged from discussions on national food security, international development goals, and the impact of climate change. The adjacent FAO definition will be used in this report.

Definition

"Climate-smart agriculture contributes to the achievement of sustainable development goals. It integrates the three dimensions of sustainable development (economic, social, and environmental) by jointly addressing food security and climate challenges. It is composed of three main pillars:

1 – Sustainably increasing agricultural productivity and incomes;
2 – Adapting and building resilience to climate change;
3 – Reducing and/or removing greenhouse gases emissions, where possible."

FAO (2013): *Climate-Smart Agriculture Sourcebook*. Available at https://openknowledge.fao.org/server/api/core/bitstreams/b21f2087-f398-4718-8461-b92afc82e617/content (29.03.2025).

Research for this report comprised primary data collection with 180 key informant interviews, an extensive literature review, input from a workshop convened in Amman, Jordan, in January 2025, and the expertise of the research team. Interviews were conducted both remotely and via field work in Aden, Hadhramawt, Lahij, and Ta'iz between May–October 2024. Among the interviewees, 30 percent were female and 92.5 percent were Yemeni, including 35 farmers and livestock producers from the targeted areas. Due to sensitivities in the local context the names of interviewees are not shared. Additionally, while there are many promising initiatives in climate-smart agriculture being implemented by individual Yemenis and local organizations in all locations, names are not specified as a result of risks in the current context.[2]

1.2 Ancient Yemeni Agrarian Traditions

The roots of Yemeni agriculture date back thousands of years. In the Hadhramawt there is evidence of the domestication of goats, sheep, and cattle approximately 8,000 years ago, with areas around Sana'a and in the highlands from around 7,000 years ago (Martin, McCorriston & Crassard 2009). These age-old agrarian traditions were further developed by various indigenous kingdoms in different areas that built sophisticated water management systems, developed flourishing agriculture, and had strong governance

2 Please contact CARPO (heinze@carpo-bonn.org) to ask about organizations encountered during the research.

systems enabling luxury trade to connect peoples, cultures, and goods in diverse parts of the world. The cadence of life in Yemen was shaped by agriculture that is reflected in songs and poetry. Traditions maximized arable land and promoted security by building settlements on peaks, and stone-by-stone building terraces, constructing check dams and creating water movement and rainwater storage structures (e.g. *birka* open reservoir, *majil* covered cistern).

1.3 Contemporary Agriculture Challenges

Despite such ancient practices, in the latter half of the 20th century, agricultural practices were transformed by various factors. Labor migration from rural areas to cities, to Gulf Cooperation Council (GCC) countries, and beyond interrupted the inter-generational transmission of agricultural knowledge. Remittances replaced agricultural incomes and changed food consumption patterns. Additionally, the increased cultivation and consumption of *qat* was a significant shift. Traditionally, crops were primarily rainfed or irrigated by *wadi* flows, but since the 1950s in the South and 1970s in the North tube well irrigation has skyrocketed resulting in the over-extraction of groundwater resources (Ali & Lackner 2003). Furthermore, over the past 70 years, food imports and food aid have undermined local farmer incomes and local crop variants.

In 2023 the World Bank estimated that 60 percent of Yemenis live in rural communities,[3] and that approximately 73 percent of the population rely on agriculture for their livelihood (World Bank 2023a). In 2021 it was estimated that arable land is only 2.2 percent of the total land area,[4] with only 44.42 percent used for permanent crops or pasture.[5] Other structural factors contributing to low agricultural productivity include, but are not limited to, the following: decreasing size of farms among small landholders (USAID 2016)[6]; labor shortages due to migration out of rural communities; rugged topography that limits agricultural mechanization; weak infrastructure (i.e. roads, electricity, connectivity, marketing infrastructure, etc.); and an increasing number of absentee landholders and high levels of sharecropping. Moreover, conflict dynamics since 2015 have further constrained productivity with the destruction of key infrastructure and lack of government support to the agriculture and water sectors. Additionally, mobility constraints and plummeting income in farming households have limited the ability to purchase inputs such as seeds, fertilizers, or veterinary services. The end result is that an estimated 85 percent of food is imported, including 90 percent of wheat consumed (UNDP 2024a).

3 See *https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=YE* (29.03.2025).

4 See *https://www.theglobaleconomy.com/Yemen/arable_land_percent/* (29.03.2025).

5 See *https://www.theglobaleconomy.com/Yemen/Percent_agricultural_land/* (29.03.2025).

6 62 percent of farms are less than 2 hectares (4.94 acres) and 4 percent of farms are more than 10 hectares (24.7 acres).

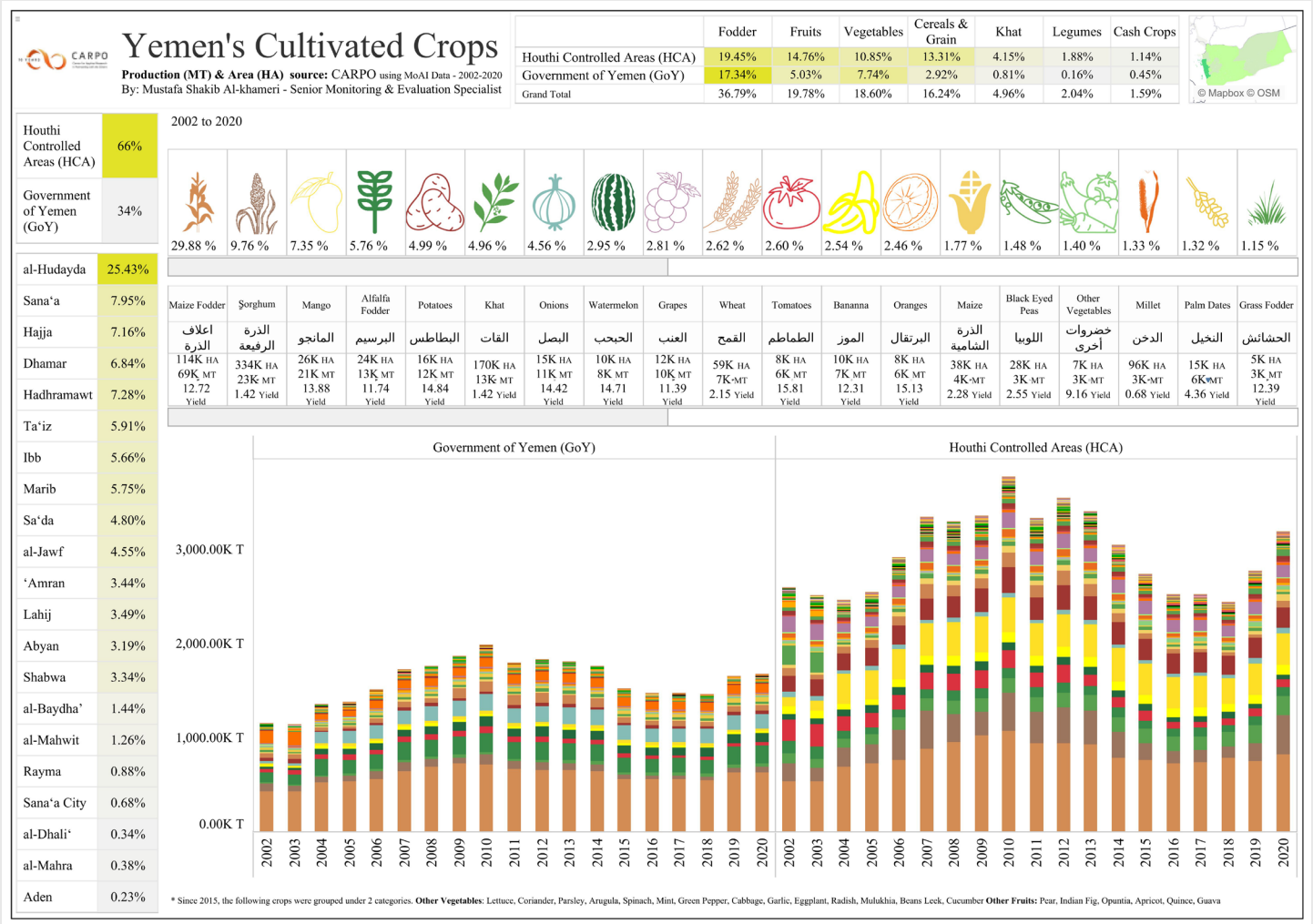

Figure 1: Yemen's cultivated crops (above 1%) between 2002 and 2020 in government- and Houthi-controlled areas

1.4 Climate Change

Currently, Yemen is considered one of the most vulnerable countries to the climate crisis, according to the Notre Dame Global Adaptation Initiative Index.[7] In recent decades increasing water scarcity, desertification (al-Aghbari 2023),[8] drought, erratic rainfall, biodiversity decline, loss of agricultural land, and flooding have negatively impacted agriculture and individual, household, and community resilience (World Bank 2023a). Furthermore, ocean warming, rising sea levels, and increasing salinity of water resources (Lackner & al-Eryani 2020) are negatively impacting the lives and livelihoods of nearly one million

7 Yemen ranks 171 out of 187 countries. The ND-GAIN Index ranks countries based on their vulnerability to climate change and their readiness to adapt, assessing factors like health, infrastructure, and governance. *https://gain.nd.edu/our-work/country-index/rankings/* (29.03.2025).

8 According to the General Directorate of Forestry and Desertification, 97 percent of agricultural land is threatened by increased desertification.

Yemenis engaging in fishing (United Nations Yemen 2021). Poverty, displacement, as well as intersectional gender and economic inequalities magnify the impact of climate change. Extreme weather events have become more common and are expected to increase, while at the same time many traditions in sustainable water management have fallen into disrepair (Lackner 2024). Additionally, while Yemen is one of the countries suffering most from climate change, its greenhouse gas emissions and contribution to global warming is disproportionate in comparison to such vulnerability (Yemen Family Care Association 2023).

There are clear gender dimensions to the climate crisis. Women and girls have a primary role in collecting water, wood for cooking, and fodder for livestock, tasks which are increasingly distant from homes and internally displaced person (IDP) camps, heightening the risk of gender-based violence (GBV). Additionally, displaced populations are extremely vulnerable to flooding and other extreme weather conditions, with an estimated 80 percent of 4.5 million IDPs in Yemen being women and children, and approximately 26 percent of displaced households headed by women (UNFPA 2023). The situation in Yemen echoes the global recognition of the gendered-differentiated impact of extreme weather events (UNFCCC 2022).

1.5 Conflict and Weak Governance

Already prior to the conflict Yemen was declared one of the most water scarce countries internationally (Lichtenthaeler 2010). The war has also exacerbated a wide range of environmental challenges including, but not limited to, the trafficking of endangered species, deforestation in the wake of the cooking fuel crisis, and overextraction of groundwater. It was estimated by the UN that in 2024, 91 percent of people supported through the Rapid Response Mechanism were severely affected or displaced by climate-related shocks (UNOCHA 2024). Additionally, the conflict has seen increasing levels of *qat* cultivation consuming scarce water and agricultural land (Tshiband 2019).

While Yemen is party to numerous global agreements of relevance to climate change and sustainable food systems, fractured governance has meant weak or no enforcement of laws promoting sustainable resource management. The government's October 2024 Climate Financing Country Programme for 2025–2030 to the Green Climate Fund includes information and priorities addressing key issues in agriculture, livestock and water management that largely align with recommendations in this report (Republic of Yemen 2024).

Yemen's young population will mature in a much different climate context than their parents, grandparents, and great grandparents.[9] They will also witness the impact of overpopulation, mismanagement of scarce natural resources, as well as devastating global greenhouse emissions from developed countries, which disproportionately impacts poor countries like Yemen (Nasser 2023). This report seeks to document Yemeni traditions and climate-smart agriculture approaches to improve productivity and mitigate the impact of climate change on the sector to contribute to sustainable food production for future generations.

2 Climate-Smart Agriculture in Yemen: Findings and Analysis

This section of the report is divided into four parts – water in agriculture, agriculture, animal husbandry, and additional relevant topics – with multiple sub-topics in each. While the focus of this study is on climate-smart agriculture, the traditions documented and interventions recommended will also touch on challenges to agroforestry and biodiversity. A number of crosscutting issues were identified, including the importance of positive indigenous agricultural traditions, the role of women in agriculture, and prioritizing civil society and localization of interventions. These three themes have been integrated throughout the report.

Interview Quotation

"Rural women remain outstanding in their role in agriculture for their family's subsistence and for the market. Many examples of women involved in climate-smart agriculture can serve as models for others to learn from. However, women still need support with training and capacity building as well as sustainable financial support to enable them secure better results from their efforts. Women's role cannot be ignored, frankly, and I see that they can extend beyond the current status in climate-smart agriculture and food security." **Confidential interview 11 August 2024, male, Yemeni businessman**

By way of introduction, it is essential to point out that women in rural Yemen carry a heavy burden in their productive and reproductive roles, although responsibilities vary with geography, the educational achievements of women and within their families, and social and economic standing. In addition to rearing children, cooking, cleaning and caring for the elderly, they also lead in fetching water, fodder for animals, and providing firewood for cooking. It is estimated that women provide 60 percent of the labor in crop cultivation (IFAD 2011), with a particular focus on

9 68 percent of the population of 35 million under the age of 30 years, with a youth cohort of 29 percent (ages 15–29). Authors' calculations based on the following: *https://www.populationpyramid.net/yemen/2023/* (29.03.2025).

rainfed agriculture (Adra 2013). Additionally, they are responsible for more than 90 percent in livestock rearing (IFAD 2011). However, women have limited ownership of land, particularly agricultural land, where it is estimated that they own less than 1 percent (IASC 2015). Furthermore, female farmers have less access to support from various entities – government, international organizations, and local CSOs – including financial resources to improve the economic situation of their families from micro-finance institutions, banks, and family support.

2.1 Water in Agriculture

Throughout history Yemenis have developed many practices and infrastructure to mitigate against the destructiveness of climate events and contribute to agriculture. Ancient Yemenis harnessed the power of regular rains to cultivate crops, carved terraces from the mountain slopes, were famed producers of frankincense and myrrh, and fostered luxury trade routes. These factors gained Yemen the Roman nomenclature of 'Arabia Felix' (Happy or Fortunate Arabia) in the 1st century B.C. (Retsö 2003).

The country's long coastline and location at the confluence of Indian ocean monsoon and Red Sea weather patterns has also meant that Yemenis were often at the mercy of droughts and flooding. Salient examples include: ancient South Arabian inscriptions note prolonged drought leading to the drying of wells and dropping of the water table (Hehmeyer 2018); the epic flood of 'Arim, mentioned in the Qur'an, and failure of the Marib dam led to the collapse of the Sabaean Kingdom estimated to have occurred in the 5th century AD; prolonged drought in the 6th century AD contributed to the decline of the Himyar Kingdom (Princeton University, Department of History 2022); in 685 AD in the Hadhramawt violent rains and winds destroyed crops and wells (Sergeant 1964); and flooding in 1878 damaged more than 100 homes in the Old City of Sana'a (Bidwell 1983). The Tawila Tanks in Aden, believed to have been built during the Himyar Kingdom, are a prime example of a water management system which harvested rainwater and minimized the destructiveness of flooding (Ben Qadhi & Abdussalam 2008). Currently, this sophisticated system is in disrepair and no longer used for its intended purpose.

Despite this long history in water management, Yemen today is one of the most water-stressed countries globally.[10] With an estimated 90 percent of water consumption by agriculture (van den Berg et al. 2021), the imperative to improve water-use efficiency is critical to address plummeting groundwater

10 Ranked the 12th most water stressed country globally. See: *https://worldpopulationreview.com/country-rankings/water-stress-by-country* (29.03.2025).

levels and the impact of climate change. For example, the Tuban Delta in Lahij governorate is one of the watershed basins in Yemen with the highest concentration of illegal wells (Mourad 2024) and a recent survey conducted by the Ministry of Agriculture, Irrigation, and Fisheries (MAIF[11]) found it is the most water-stressed area in the country.[12]

This section of the report looks at mitigating extreme climate events through reviving indigenous water management, the dangers of solar-powered irrigation pumps, and the critical importance of water-use efficiency, social solidarity and cooperative action, and the increasing incidence of water conflicts.

2.1.1 Climate Change and Extreme Climate Events

With climate change, extreme weather events have become more common. Unfortunately, this pattern has coincided with the deterioration and disrepair of many traditional rainwater harvesting and storage systems – terraces, diversion channels, check dams, among many other indigenous practices – which have for millennia mitigated the impact of flooding and drought.[13] Additionally, conflict, weak governance, deforestation and overgrazing, loss of natural drainage through urban development, a massive humanitarian crisis, displacement, and other factors have magnified the impact of climate change. Furthermore, one challenge in flood mitigation interventions is that of land tenure. While current data is unavailable, a 2008 study on terraces notes that approximately 1/3 of agricultural land in Yemen is sharecropped (owned by one person and farmed by another). The study goes on to observe that terraces farmed by land owners have a much higher rate of

Interview quotation

"The traditional methods of water conservation involved constructing drainage canals for rainwater, with water barriers and tanks at the end of the canals to store the water. During rainy weather, they would direct the water canals toward the lands that received little water. Currently, these canals have been destroyed and not repaired, leading to the ruin and erosion of many lands, with some disappearing completely due to floods." **Confidential interview 10 August 2024, female, farmer**

11 Line ministry in the IRG cabinet, although in the de facto authorities' cabinet it is called the Ministry of Agriculture, Fisheries and Water Resources. For purposes of this research, it will be referred to as MAIF inclusive of line ministries in both parts of the country.

12 Confidential interviews: 15 August 2024, female, Yemeni food industry specialist; 29 August 2024, male, Yemeni irrigation specialist.

13 For select traditional water management resources see: Baquhaizel, Salem Abdullah, Ibrahim Ahmed Saeed and Mohammed Salem bin Ghouth (2011): *Documentary Study on Models of Traditional Irrigation Systems and Methods of Water Harvesting in Hadramout and Shabwah Governorates*, Republic of Yemen, Embassy of the Kingdom of the Netherlands, Water and Environment Centre, MetaMeta Production, Yemen. Available at *https://www.hydrology.nl/images/docs/dutch/yemen/Traditional_irrigation_systems_water_harvesting.pdf* (29.03.2025); Spurlock, Anna (2009): *Case Studies for Terrace Rehabilitation in Yemen: Report Produced as Consultant to the Social Fund for Development (SFD), in Support of the Collaborative World Bank-SFD project, "Assessing local communities and household resilience to adapt to climate change in rain-fed areas of Yemen*. Available at *https://www.sfd-yemen.org/uploads/issues/Case%20Studies%20for%20Terrace%20Rehabilitation%20in%20Yemen-20120924-114305.pdf* (29.03.2025).

repaired broken walls per hectare than those cultivated by tenant sharecroppers (Aw-Hassan, al-Sanabani & Bamatraf 2000).

The frequency of flooding in recent years has taken a massive toll in human life and destroyed productive assets in farming communities. This has included the loss of livestock, crops, orchards, agricultural infrastructure, and the erosion of topsoil and *wadi* banks. The cumulative impact of such extreme events have magnified the destructiveness of each consecutive wave and undermined resilience, particularly among vulnerable populations. One interviewee recalled stories of women wading through flood waters trying to collect their household utensils and belongings.[14] A cogent 2024 study under the auspices of Rethinking Yemen's Economy (RYE) stated that floods present the most significant threat to communities and agriculture in the country (Aklan 2024; see also al-Akwa & Zumbrägel 2021).

2.1.2 Reviving Indigenous Water Management to Mitigate Flooding

Across all categories of interviewees, it was emphasized that reviving and strengthening indigenous water management traditions should be a key element of climate-smart agricultural interventions in Yemen. In the Hadhramawt ancient *shruj* irrigation systems divert rainwater from slopes into natural gullies or rock channels adjacent to agricultural land (McCorriston 2003). *Qudhadh* is a labor-intensive plaster coating used to create a cement-like coating on exterior stone or brick surfaces, with the earliest preserved example found on the sluices of the ancient Marib dam (al-Radi 1997). Terraces, estimated to date back to at least the 3rd millennium BC, not only contribute to food security, but also mitigate against the threat of flooding (Wilkinson 1999). An ancient spate irrigation practice to improve water retention and reduce soil erosion is the construction of bunds or berms, called *sawm* (earthen retaining walls) along the contour lines of fields (UNDP 2022).

Traditional water-use efficiency practices transform Yemen's rain into agricultural productivity. Unfortunately, many interviewees noted that traditional water management infrastructures require restoration and expansion to better cope with the ravages of climate change on agricultural assets. A study from 2022 in the Sana'a basin noted that more than 30 percent of the areas surveyed were found to have a high, or very high level of suitability for various indigenous

Interview Quotation

"Terraces counter the threat of heavy rains and flooding… By renovating those terraces, they can benefit from the surface water which has been depleted by qat *cultivation. An estimated 95 percent of surface water goes to the sea or empty deserts. By improving terraces, we can enhance surface water utilization, which has multiple benefits."* **Confidential interview 30 May 2024, male, Yemeni staff in an international organization**

14 Confidential interview 28 June 2024, female, Yemeni academic.

rainwater harvesting systems (Aklan, al-Komaim & de Fraiture 2022). While levels of precipitation vary significantly in different parts of the country and are changing due to the climate crisis, more efficient use of this asset will improve agricultural productivity. 51 percent of agriculture in Yemen is rainfed, which is highly susceptible to climate change (ESCWA 2021). Thus, strengthening rainwater management for agriculture is a key strategy to improve productivity and mitigate the impact of extreme weather events.

2.1.3 Solar-Powered Irrigation Pumps

In this research the topic of solar-powered irrigation pumps emerged as a central issue. While it is clear that this modern technology reduces reliance on diesel pumps (i.e. greenhouse gas emissions), water scarcity and over-extraction of groundwater resources are in a dire situation. In other words, the short-term benefit from such technology will rob future generations of access to water even for drinking. While a number of interviewees recommended government regulation of this technology, it is unlikely that such oversight will materialize, as even prior to the conflict the government was unable to rationally manage water resources. In the current context such management is even less likely. Additionally, there is a lacuna of research and policies by authorities in Yemen on the use of this technology (Aklan & Lackner 2021). A study conducted by the Conflict and Environment Observatory in 2021 using satellite remote sensing, augmented by other data collection methods, concluded that since 2018 the uptick in the use of solar power in agriculture is accelerating groundwater overextraction (van den Berg et al. 2021). The same report posited that the proliferation of solar-powered irrigation pumps is largely due to international development agencies supporting or subsidizing investment costs (ibid). Conflict dynamics and the lack of government accountability in water resource management are no excuse for international entities to encourage pumping the country dry. Unfortunately, Yemen is not the only arid country where a similar confluence of solar-powered irrigation technology, financing to support farmers, and a weak regulatory environment has led to unhindered access to groundwater. As a 2024 article on the negative consequences of cheap solar powered irrigation states, groundwater depletion in many parts of the world is becoming a global threat to food security, yet the phenomenon is poorly documented (Pierce 2024).

Interview Quotation

"They should stop investing in what they believe is green technology, like solar-powered irrigation pumps, which have little or no regulation or fossil water quotas. When harnessing the free energy from the sun there is always an increase in pumping. We have seen that some farmers double and triple the quantity of water they use, leading to changes in the land with sink holes emerging recently. Regulation should be in place and any solar pump license should be accompanied by a drip irrigation system." **Confidential interview 7 May 2024, male, Yemeni academic**

The majority of farmers interviewed in this research were understandably enthusiastic about this modern technology. However, of the 76 individuals who mentioned solar-powered irrigation pumps, 23 percent were cautious or strongly against using such technology. One agricultural specialist noted that farmers who have purchased solar-powered pumps often irrigate during the day with solar and at night with diesel, with many also expanding cultivated areas. It was shared that this is done in order to pay back loans for the cost of installing such technology, resulting in increasing the rate of groundwater overextraction. The informant went on to add that he has seen few farmers combine solar pumps with drip irrigation.[15]

2.1.4 Water-Use Efficiency

It is imperative that agriculture in arid and semi-arid areas such as Yemen improve efficiency in water usage. This is not a new local condition but is reflected in the Yemeni proverb "*If you are not using the water that you already have, don't pray for rain.*"[16] Islamic traditions also encourage the efficient management of water resources and the conservation of the environment. Utilizing such religious messaging has been successfully used to promote improved practices in communities in Yemen.[17] Strengthening water-use efficiency will mitigate the impact of changing weather patterns and extreme climate events for farmers and increase food security.

Drip irrigation was the most commonly identified modern water-use efficiency technology, mentioned by 44 percent of interviewees. This technology is increasingly popular among farmers and supported by many projects as it conserves water, reduces weeds, and saves labor and time. However, it was noted by 14 percent of informants that its high cost is a significant barrier with limited financing options, particularly for female farmers. As one interviewee noted, while "*women play a significant role in agriculture in Yemen…when it comes to applying for financing, most requests come from men, with only about 30 percent of agricultural financing applications submitted by women.*"[18] While one local company produces drip irrigation systems, most are imported and may not be suited to cultivation with intense heat and aridity seen in many areas. The local company producing these systems noted that among the significant challenges they face are the lack of farmers' knowledge about selecting the system appropriate for their needs and how to operate such systems.

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15 Confidential interview 10 November 2024, male, Yemeni agricultural specialist working with an international organization.

16 Confidential interview 13 November 2024, male, Yemeni agricultural specialist in an international organization.

17 Mohammed al-Duais experience.

18 Confidential interview 20 August 2024, male, Yemeni microfinance specialist.

Coffee seedling nursery greenhouse of the Women's Association, Sabir al-Mawadim District, Ta'iz. Photo: Afrah Abdo, 12 August 2024

Greenhouses were also seen as a highly desirable modern technology. Farmers expressed that it enables increased production, conserves water usage, enhances plant protection from pests, reduces the need for chemical pesticides, and thus contributes to improved income. Greenhouses also enable farmers to grow various crops outside of the normal seasons, thus contributing to food security. However, greenhouses are an also an expensive investment particularly for small-holder farmers to take on independently. Additionally, they require capacity building to maintain and cultivate profitable crops.[19] Further, despite the improved water-use efficiency of greenhouses, irrigating greenhouse crops is challenging, in light of water scarcity. However, some organizations have combined greenhouses with rainwater harvesting and drip irrigation to conserve water. Another challenge is that of landownership for greenhouses, particularly among the most vulnerable. Oxfam GB has addressed this issue through sharecropping arrangements between landowners and IDPs and vulnerable host community members (Delelegne 2018). Additionally, greenhouses for vegetables in areas with high temperatures present a challenge, particularly air conditioning them, given the high cost and unreliability of electricity. However, there are various solar powered air conditioning systems that could be utilized, although such technologies may not yet be available in Yemen. Interviewees noted that there have been cases where materials distributed were sold by beneficiaries when beneficiaries and communities were not significantly involved in planning for greenhouses nor properly trained.[20]

A significant number of international and local organizations are providing greenhouses throughout Yemen, often seeking to support female farmers. FAO and some local organizations are also piloting community-managed greenhouses,[21] some of which engage with groups of women.[22] While there are challenges with group-operated greenhouses, they hold promise to yield

19 Confidential interviews: 19 May 2024, male, Yemeni plant protection academic; 29 August 2024, male, Yemeni government official.

20 Confidential interviews: 5 June 2024, male, Yemeni CEO of a private company; 24 June 2024, male, Yemeni hydrology specialist.

21 Confidential interviews: 11 June 2024, 2 men, Yemeni agricultural specialists; 12 August, male Yemeni agricultural specialist; 13 August, female, Yemeni quasi-government agricultural project manager; 19 August 2024, male, Yemeni agricultural trainer, Ta'iz.

22 Confidential interviews: 27 May 2024, male, Yemeni nursery owner; 14 August 2024, male, Yemeni agricultural specialist; 14 August 2024, male, Yemeni agricultural researcher; 26 August 2024, female, Yemeni agricultural specialist focusing on female farmers.

positive results, building solidarity, resilience, and promoting cooperative agriculture. A further greenhouse innovation is an initiative in Wadi Hadhramawt which uses remote technology to operate greenhouse irrigation systems, an approach which presents opportunities for female farmers.[23] Also, smaller greenhouses on roofs or adjacent to homes were viewed as promising for women.[24]

The issue of financing for water-use efficiency inputs was noted by 48 interviewees, specifying challenges for more expensive investments such as greenhouses, drip irrigation, and rainwater harvesting interventions. Additionally, 15 interviewees mentioned the particular challenge of financing for women and youth. Challenges for women to access funding include: lack of experience engaging with financial institutions; absence of collateral and national identification; and cultural norms encountered in banks and formal lending institutions. Interestingly, this is despite the reality that women have higher repayment rates in microfinance and repay loans faster (Sana'a Center for Strategic Studies 2024). Another key challenge is training farmers on how to operate and maintain modern systems. The lack of spare parts for drip irrigation systems was an obstacle emphasized by seven interviewees, as dealers sometimes don't have a supply on hand. Further, for many farmers farm gate brokers, who distribute their agricultural produce, are often the only source of credit for inputs (e.g. seeds, seedlings, fertilizers, pesticides, tools and nets) that are available in stock and sometimes they will provide modest cash advances.

> Interview Quotation
>
> *"The required funding may be modest because the innovator may not have the funding to bring his innovation to life, particularly for youth. Sometimes the funding required to implement the innovation may be very simple. For example, we started using a float in irrigation water holding tanks (its cost does not exceed USD 100) to avoid wasting water…there are three colors for the person operating the pump to see. If he sees the green color, the water level in the tank is half, and if he sees the blue color, it means that the tank is about to fill up, while the red color means that the tank is full, and the person turns off the pump."* **Confidential interview 18 August 2024, male, Yemeni business owner**

Using date palm fronds to shade crops, Tuban District, Lahij
Photo: Heba al-Absi, 27 August 2024

Mulching and composting are traditional practices that conserve water, as well as improve soil health and productivity. Using greywater or recycling household water (*ghsawil*) in kitchen gardens (*mishqar*) or for rooftop gardens (*naqa'il*) are traditional practices that Yemeni women

23 Confidential interview 20 May 2024, male, Yemeni owner of a technology-driven farm, Hadhramawt.

24 Confidential interviews: 21 May 2024, male, Yemeni farmer; 21 May 2024, male, Yemeni farmer; 27 May 2024, male, Yemeni nursery owner.

use, which can be revived to contribute to climate-smart agriculture. Installing pipes instead of open channels to transport water to fields can improve water-use efficiency in spate irrigation (also known as flood and furrow method). Other techniques mentioned by interviewees include hydroponics (soilless cultivation using water-based nutrition), low tunnel farming, and using shade netting, cloth, or palm fronds to protect plants from the sun and reduce evaporation.

2.1.5 Social Solidarity and Cooperative Action

Yemen has an ancient history of social solidarity (Hehmeyer 2003). An example of cooperation in the water sector is the indigenous traditions of the *al-khayyal* system in the Hadhramawt for managing spate irrigation (Baquhaizel, Saeed & bin Ghouth 2011). Another system managed communally is variously called *ma'ayin*, or *ghayl*, where a subterranean aqueduct transports spring water for irrigation or other purposes (Lightfoot 2000). Another system used in Ibb is called *al-dabab*, a communally owned man-made cave where percolated water is gathered and transferred via canal for use in irrigation, mosques, or municipal usage. The emergence in the 1970s and 1980s in the former Yemen Arab Republic (YAR) of the Local Development Association (LDA) movement was a further manifestation of social solidarity using remittances to build community schools, roads, and water projects (Carapico 1998).[25]

Contemporary community-based organizations (CBOs) such as WUAs have an essential role in improving water management and can contribute to agricultural productivity. However, they are diverse and face a number of challenges (Bruns & Taher 2009). The important role of WUAs emerged in the research, as they are found in many rural areas and hold potential to engage communities in resource management. In Tuban Delta in Lahij governorate alone there are 22 WUAs, of which 16 have agricultural land and are part of the national irrigation program.[26] However, it was stated that to empower women in WUAs gender considerations need to be mainstreamed from the beginning and reflect challenges that rural women face, such as high levels of illiteracy and lack of technical knowledge (Boyer, Shakir & al-Areeqi 2024; Zabara 2018). This point was reiterated in interviews with 31 individuals, who noted the important role of women in water resource management. FAO and many local and international actors are seeking to revive the role of WUAs, and MAIF in the IRG now has dedicated personnel for this purpose.[27]

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25 In 1981, the state construction of roads, schools, and water projects numbered 4,507 and LDAs through remittances built more than 20,000. In 1986, state-sponsored projects totaled 7,821 and LDA projects 23,344.

26 Confidential interview 29 August 2024, male, Yemeni irrigation specialist.

27 Confidential interview 1 September 2024, female, WUA specialist.

2.1.6 Water Conflicts

Conflict and social violence over water have been a significant phenomenon for years in Yemen (Yemen Armed Violence Assessment 2010). Drivers of such conflict include: rapidly growing population; cyclical droughts; unequal access to water resources; diminishing availability of water; introduction of new technologies (water pipes for household and agriculture use, large-scale dams, etc..) disrupting traditional water management practices; a heavily armed population vying for decreasing resources; land grabbing; and external actors, including the government and/or international actors, operating in ways that trigger conflict. Additional factors exacerbating the situation are the current war, displacement, and rising levels of economic vulnerability. Agriculture has been over-extracting groundwater for years in Yemen, with irrigated *qat* fields significantly expanding since 2015 (Tshiband 2019). This unregulated use of scarce water has been fueled by the increasing availability of solar-powered irrigation pumps.

Women are primarily responsible for securing and managing household water resources and there is widespread recognition that it is also essential for them to contribute to fostering solutions to water conflicts. FAO and the International Organization for Migration (IOM) implemented two projects funded by the United Nations Peace Building Fund that supported women and youth in conflict resolution in the water sector (FAO 2022). Building on earlier FAO programming funded by the Kingdom of the Netherlands the projects sought to be more inclusive of their needs and involve women and youth members in WUAs. This initiative and similar projects implemented by other organizations have also trained WUA members in conflict resolution and various other topics. This approach recognizes that rural women often bear the brunt of water conflicts as they struggle to provide water for their families, livestock and land, as well as desalinate drinking water due to increasing salinity with the overextraction of groundwater. However, WUAs reflect the prevailing gender norms in communities; thus, even when women are members, they rarely play decision-making roles (Boyer, Shakir & al-Areeqi 2024) and are often sidelined in resolving water conflicts (Zabara 2018).

2.1.7 Flood Early Warning and Disaster Risk Reduction[28]

Rainfall in Yemen is shaped by various weather patterns and the country's topography, so when it rains it is often in short intense bursts (Aklan 2023), with the earth unable to quickly absorb precipitation. This leads to regular flash floods that careen down dry *wadi*s (stream beds) building up momentum and debris that sweep away animals and cars, wreak havoc on check dams

28 This section greatly benefited from discussions at the workshop convened for this research in January 2025 in Amman, Jordan.

that line *wadi* beds to irrigate crops, and result in the loss of life for those caught unaware. Traditionally, villagers upstream would shoot off their guns in an agreed pattern to warn those downstream of imminent dangerous flash floods.[29] However, the intensity, frequency, and destructiveness of flash floods is increasing due to various factors including climate change. These extreme weather events spread disease and destroy agricultural and fishing assets and settlements, causing fatalities, the loss of livelihoods, and displacement, with vulnerable communities and IDPs hit particularly hard (ibid). Yemen has also been ravaged by cyclones in recent years and these are predicted to become more frequent, with an unprecedented three such dire events in 2018. Climate hazards warrant concerted joint effort among stakeholders to invest in Disaster Risk Reduction (DRR), with a key component being developing early warning systems to mitigate the impact of natural disasters.

Numerous stakeholders in Yemen have sought to support DRR and natural disaster early warning systems (Mercy Corps 2024; Civil Aviation and Meteorology Authority et al. n.d.; REACH 2024). However, one of the key gaps in early warning is the connection between information and predictive analysis and those most vulnerable to the impact, as forecast information is often highly technical and not easily accessible to non-experts (Mercy Corps 2024). In light of this challenge a number of initiatives seek to warn Yemenis of impending floods, including installing a siren system in the city of Sana'a (Pavlik n.d.), and an App called *Taqwim Genoa* (تقويم جنوة, meaning Genoa Calendar) that offers services for farmers and relevant stakeholders in the Hadhramawt.[30] FAO, with support from the European Union, has rehabilitated meteorological substations in various parts of the country and farmers receive real-time weather updates and alerts through an easily accessible WhatsApp application (FAO 2025). *Nafidha Wasl* is another App being piloted in the Hadhramawt; it provides agricultural extension information and two-way communication with farmers and could include an early flood warning function.[31] While there is still work to be done in this area, these initiatives seek to support farmers in meaningful ways and address the issue of early warning of extreme weather events.

2.1.8 Section Conclusion

Addressing climate-smart agriculture water resources should rely on harvesting rainwater, paired with modern water-use efficiency interventions such as drip irrigation and greenhouses, rather than overexploiting groundwater. This sustainable approach will increase agricultural productivity; also, the threat

29 Confidential interview 28 June 2024, female, Yemeni academic.

30 Available at the App store: *https://play.google.com/store/apps/details?id=com.mukallait.calender&pli=1* (29.03.2025).

31 Confidential interview 19 May 2024, male, Yemeni academic specializing in agriculture.

of flooding will be reduced and traditional water resource management reinforced. The importance of rebuilding traditional systems, reviving spate irrigation systems, and expanding modern flood mitigation was emphasized by informants from all categories and participants in the January 2025 workshop in Amman. Additionally, further developing early warning systems to deliver extreme weather event forecasts in an understandable manner to those concerned, particularly farmers, is also much needed. Interventions could be implemented as cash-for-work in agricultural communities and could include, but are not limited, to: forestation and reforestation on hillsides and slopes above agricultural fields; terrace rehabilitation; slowing cascading flood waters by strengthening earthen berms around fields with stones, check dams, surface stone chains (lines of stones on hillsides), piling rocks around the base of trees on hillsides (call "smile" or "halfmoon"), installing gabion cages (wire mesh containers filled with stones larger than the mesh) or using recycled tires in *wadi* beds and at strategic locations around date palm orchards or fields, and strengthening simple rainwater harvesting solutions such as gravity-fed catchment ponds and creating surface rainwater ponds for livestock watering.[32] Another source to harvest rainwater is along roads that have proper drainage and channels to agricultural lands, as this important community asset can also contribute to deteriorating water quality, soil erosion, and flooding (Saleh, al-Abyadh & Zolail 2019). However, it must be noted that such efforts need to be strengthened in their gender impact. According to a 2022 study, women are rarely involved in designing cash-for-work activities and such programming has had limited impact on gender relations in beneficiary families (Shuoaib 2022). A further study in 2019 found that women participating in cash-for-work activities had to travel far to collect their payment and such locations had limited privacy (Grassroots Yemen 2019).

Rainwater harvesting cistern, al-Shamayatayn District, Ta'iz
Photo: Heba al-Absi, 17 August 2024

There are many creative solutions to maximize the benefit of water in agriculture in a context of climate change that can be arrived at with the input of farmers, communities, local CSOs, and Yemenis working in the sector. The central role that women play in water management in the home, on farm land, and in the community is reflected in this section and many local and international organizations are seeking to strengthen capacities and integrate them in developing solutions. Locally developed efforts require the cooperation and support of donors and international organizations.

32 Confidential interview 26 May 2024, two men, international and Yemeni staff with an international organization.

2.2 Agriculture

Yemen's rich agricultural heritage was transmitted for millennia through oral traditions – poetry, songs, proverbs, and stories – and by fathers, mothers, grandfathers and grandmothers mentoring younger generations. Families and communities worked together to plow, plant, harvest, and create agricultural infrastructure. Although in the latter half of the 20th century many age-old practices receded, social solidarity traditions have continued and helped to mitigate the impact of the current conflict on families.

This section highlights the importance of seed preservation, tissue culture propagation, and selecting drought- and disease-resistant crops. Also touched on is investing in soil and plant health through composting and fertilizing, maximizing plant protection, reducing post-harvest losses, supporting urban agriculture, and enabling agricultural cooperatives. A range of indigenous and modern approaches are presented, which pose challenges, as well as opportunities, to climate-smart agriculture.

2.2.1 Seed Banks, Tissue Culture Propagation, and Crop Selection

A perennial farming practice was the preservation of seeds for future crops. Women in Yemen were often responsible for selecting, cleaning, and storing the best seeds. Seeds were preserved in various ways including: sun drying to protect from insects and disease; mixing them with ashes, salt, chili powder (or minging them with a specific type of soil in the Hadhramawt (al-Baity 2003)); and storing them in an airtight, warm environment in barrels, dried gourds, bags made from palm fronds, burlap or jute bags, or in lined underground chambers. A proverb about the importance of seeds shared by an interviewee in Ta'iz is: "*If the rain falls in Oqaqa, make sure that the seeds are in the window sill*" (i.e. getting them ready to plant).[33]

With the war many government-operated seed banks preserving local varieties have been destroyed (al-Jarmouzi et al. 2023). Additionally, displacement has meant the families often fled carrying only the essentials, and yet other families were forced to eat their stored seeds due to poverty. Since 2015, drought and flooding have also contributed to the loss of crops, seeds, and stored food, with resilience negatively impacted by repeated shocks. Moreover, international organizations at times distributed seeds that cannot be saved or require the use of expensive pesticides and chemical fertilizers. One interviewee from Ta'iz noted, "*Some organizations have distributed completely spoiled or unsuitable seeds for the local environmental conditions, which caused the loss of an entire year's crop. The reason was that the seeds were not viable, produced only once, or the plants grew but were completely devoid of grains*."

33 Confidential interview 10 August 2024, male, Yemeni academic.

The preservation of local agricultural genetic diversity is essential, as many Yemeni crop landraces (traditional varieties of a crop selected by farmers for adaptation to local conditions and food preference) are well-suited to the local context and could be important for future research and breeding. Yemen is famed for the wealth of its biodiversity, with many endemic plants; the Indian Ocean island of Soqotra is globally recognized for its unique flora and fauna. Sorghum is the most significant cereal crop in the country constituting 59 percent of grain production (Republic of Yemen 2024; see also Figure 1 on p age 9), with diverse varieties (Varisco 1994).[34] Sorghum stalks are handfed to house cows and used as cooking fuel in traditional ovens and in making mud bricks. There are many cultivars of date palms, pomegranates, grapes, and other indigenous fruits and vegetables (Republic of Yemen 2016). Unfortunately, there has been little effort to improve the performance of these species and varieties.

Due to challenges related to agrobiodiversity several organizations have invested in seed banks and FAO is supporting MAIF's Agriculture Research and Extension Authority (AREA) in seed preservation. Community-based seed libraries are being supported by FAO, the Danish Refugee Council, Oxfam, and numerous local organizations. Government, private, and non-profit nurseries are also instrumental in distributing seeds to farmers. In the Hadhramawt there was a date palm tissue culture laboratory project prior to the conflict; however, unfortunately it is currently not operational. There is a private company in Sana'a propagating tissue culture potatoes, date palms, and other seedlings. This method of locally producing high-quality seedlings saves on expensive imported seeds, seedlings, and reduces the need for pesticides. Additionally, the quality of seedlings impact survival rates; even if a seedling is a drought resilient variety, if it does not have a strong root system it is unlikely to thrive.[35]

The following crops are already cultivated in Yemen but could be scaled up to respond to the vicissitudes of climate change to contribute to food security:

- **Teff** – an ancient grain originating in Ethiopia, but with an indigenous wild version in Yemen, is currently cultivated in Shabwa, Hadhramawt, al-Baydha, and several other regions. It is used for bread and *'aseed* (porridge), is gluten free and highly nutritious. Additionally, the cultivation cycle for this versatile grain is only 45 days from planting to harvest, requiring limited water. Further, in Shabwa and Hadhramawt teff straw is used to make mud bricks for constructing homes and buildings. It is said that the value of the teff straw is close to that of the grain yield.[36]

34 The 13th century agricultural almanac compiled by the Rasulid Sultan al-Malik al-Ashraf describes 21 unique varieties of sorghum.

35 Participant in the 21 January 2025 workshop, female, Arab civil society organization.

36 Confidential interview 1 September 2024, male, Yemeni researcher and environmental specialist in a local CSO.

- **Quinoa** – a plant from the amaranth family that contains all essential amino acids (i.e. a complete protein) and is highly drought and salt tolerant (halyophyte). Testing conducted in Dhamar in 2014 by the International Center for Bio-Saline Research (ICBA) and FAO supporting AREA on a number of varieties of quinoa showed promising results for green forage and grain yields (Daws & al-Moallem 2018).
- **Pearl millet** – is another promising halyophyte crop. Remains of millet cultivation in Dhamar is radiocarbon dated to the 2nd millennia BC and pearl millet was cultivated in the country in the 13th and 14th centuries AD (Mehra 2003). Currently, millet is widely cultivated on rainfed land for fodder and food and there are 20 local landraces; however, some perform better than others (al-Hadi, Ibrahim & al-Kadasy 2023). Pearl millet is particularly drought tolerant and quick growing, making an excellent climate-smart crop.
- **Sesame** – cultivated in Yemen at least since the 9th-14th century BC, as evidenced by charred remains at an archaeological site in Sabir, Wadi Tuban, Lahij governorate (Bedigian 2004). This drought-tolerant rain-fed crop is primed for expansion, valued for the seeds in various recipes and the oil is preferred in many parts of the country over *samn* (clarified butter, or ghee). Additionally, the ground remains after extracting the oil is used as nutritious livestock fodder (Yemen Family Care Association 2024). In a comparative analysis of various sesame varieties in Somalia, the Yemeni variety was the highest performer in terms of yield and growth (Ismaan et al. 2020).

Numerous research informants emphasized that when promoting new or scaling up crops, it is essential to socialize their usage. One interviewee noted that when mealworms were introduced in Kenya as a high protein supplement, competitions were held to develop appealing recipes.[37] Another important aspect of success in introducing new crops or techniques is to ensure adequate training of farmers. One interviewee stated that an international organization in Yemen introduced olive trees to an area with a suitable climate, but failed to properly train and support farmers. Thus, farmers lost the harvest as they lacked knowledge of how to preserve olives and of techniques to extract oil.[38]

2.2.2 Soil and Plant Health

Yemeni farmers traditionally relied on well-honed practices to ensure soil health and contribute to flourishing crops. This included producing organic compost and fertilizers[39] and designating some fields to lie fallow and allowing

37 Confidential interview 13 June 2024, female, Arab sustainable food specialist.

38 Confidential interview 7 September 2024, male, Yemeni head of a training institute.

39 Compost feeds soil and fertilizer feeds plants. Quantities and composition of fertilizers must match the exact needs of the crop being grown.

livestock to graze there. Also, a well-known practice was planting legumes like cowpeas and lentils as cover crops to "fix" nitrogen, particularly important in fields where sorghum, maize, and millet are cultivated. Minimal plowing at specific times and leaving the remains of plant roots in the field after harvesting grain crops provides the soil with nitrogen and improves drainage. Intercropping, also called companion planting, is another traditional practice in Yemen mentioned by interviewees as it contributes to soil health and increases yields. A particularly powerful crop combination to promote healthy soil and crops in Yemen is the three sisters – maize or sorghum, legumes, and squash – and one dirty brother – organic compost.[40]

Numerous interviewees highlighted soil poverty due to various factors, including: erosion of fertile top soil; increasing salinization and sodification[41]; sandy soil; overuse of chemical fertilizers and pesticides; and over-tillage which breaks up dirt particles, but ultimately compacts the soil and impairs moisture retention, particularly when mechanical methods are used. These challenges have led to unsustainable practices such as replacing poor soil with higher quality soil from other areas and farmers applying even more chemical fertilizers thinking this will improve crop yields. Traditionally, organic compost was produced on-farm by fermenting livestock manure and crop residues and applying it while plowing. However, such processes are time-consuming, and informants noted that on larger farms it is difficult to produce sufficient quantities.

Interview Quotation

"The random and unorganized use of pesticides has led to the emergence of secondary insects that have become primary pests. There are beneficial insects whose function is to feed on harmful insects, and pesticides eliminate the biological enemies of harmful insects, leading to an increase in the harmful insects and the spread of diseases. Rising temperatures have also led to the emergence of fungal and bacterial diseases that require large quantities of pesticides to control them. Therefore, an integrated pest management (IPM) approach is needed… as chemical control is but one of the elements in an integrated system." **Confidential interview 29 May 2024, male, Yemeni director of a research station**

There is a clear demand for organic compost, which presents an opportunity. Interviewees noted that there are initiatives to produce compost and liquid fertilizers, which can be delivered through irrigation networks. Producing compost from fish waste and marketing it to farmers introduces no invasive seeds to crops, and it is good for sandy soil, and adding red wiggler worms adds a further improvement. One interviewee in the Hadhramawt stated, however, that the placement of fish waste fertilizer facilities should be away

40 Confidential interview 10 November 2024, male, Yemeni agricultural specialist working with an international organization.

41 Both processes that involve salts in the soil, with salinization being a concentration of salts and sodification being an accumulation of sodium on clay exchange sites leading to structural decline of the soil. *https://www.soilscienceaustralia.org.au/about/save-our-soils/sos-salinisation-and-sodification/* (29.03.2025).

from residential areas due to odors and emissions.[42] The Small and Micro Enterprise Promotion Service (SMEPS) is scaling up a fish fertilizer initiative that holds promise, reactivating a traditional practice (SMEPS 2024). One interviewee noted that an investor in Ta'iz is extracting zeolite,[43] a mineral which increases soil water retention, positively contributes to the growth and yield of plants, and slowly releases nutrients (Jarosz et al. 2022). There are a number of initiatives piloting bio-gas units, producing green energy and generating organic compost. BioTreasure, a social enterprise developed by Omar Badokhon, a young man from the Hadhramawt, won the United Nations Environment Programme (UNEP) Young Champion of the Earth Award in 2017, for its small-scale bio-gas production units.[44] Minimum and no-tillage practices will reduce cost and effort, as well as increase carbon sequestration and contribute to improved soil health.[45]

2.2.3 Plant Protection

As an ancient agrarian society, Yemenis have a wealth of indigenous plant protection practices that includes consuming protein-packed locust as a delicacy (Colburn & Olney 2024).[46] A further practice is placing a type of predatory ant on the canopy of date palms to eat larvae and moths as described in a 13th century agricultural treatise by a Rasulid ruler in Yemen (Varisco et al. 1992 and 2014). This tradition to mitigate the impact of various pests is still found in the Tihama, Ta'iz, and the Hadhramawt (Ba-Angood 2003). Many ancient plant protection practices encountered were preventative rather than remedial, e.g. when and how to plant specific crops, as well as applying various oils to prevent certain pests or cultivating repellent plants near crops (ibid). On rooftop and kitchen gardens in Ibb a succulent plant called *madan* (*Plectranthus barbatus*) is used to repel the common lizard from eating plants.[47]

The most significant plant protection challenge encountered in this research, mentioned in 39 interviews, was the irrational (i.e. excessive, haphazard or random) use of chemical pesticides. It was noted that at times those selling chemical agriculture solutions are ignorant about usage and farmers may also be illiterate, which exacerbates the problem. The rising cost of chemical pesticides was also pointed out, as was corruption and their illegal importation.

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42 Confidential interview 28 May 2024, male, Yemeni environmental specialist.

43 Confidential interview 1 September 2024, male, Yemeni researcher and environmental specialist in a local CSO.

44 See *https://biotreasure.co/* (29.03.2025).

45 An excellent documentary on the importance of soil regeneration is *Kiss the Ground*. Available at *https://kissthegroundmovie.com/* (29.03.2025).

46 Considered *halal* (lawful or permissible) in Islam and eaten fried, roasted, boiled and eaten as a street snack.

47 Mohammed al-Duais experience.

Additionally, the heavy use of pesticides on *qat* negatively impacts adjacent food crops, bee health, biodiversity, and humans. With climate change Yemeni farmers are facing new hazards and challenges to protect crops from insects, invasives, and diseases, as well as from bacteria, nematodes, fungi, and molds. Date palms have importance nutritionally, culturally, and historically in the Hadhramawt, the Tihama, and other areas of the country. One interviewee recounted that *"dates produced in the valley saved the people from famine during World War II."*[48] This heritage is being undermined by the conflict, with the country losing approximately half of its date production since 2015 (Zwijnenburg 2020).

Despite these issues, a variety of plant protection approaches cited by informants included: covering plants with plastic mesh/net/screen; using seeds and crop varieties that are pest, disease, and invasive resistant; planting repellent plants; biological control, such as that noted above from the 13th century; tissue culture propagation that produces disease-free plants; spreading grains of bran to attract a certain pest that overeats and causes their bellies to swell and burst[49]; using organic fertilizers and mulch to make the soil less compact, increase organic matter and humidity, and ease removal of invasive weeds; and using smoke from cow dung or sacred fig trees to eliminate the larvae of the coffee berry borer beetle (*Hypothenemus hampei*).

A promising opportunity identified in the Hadhramawt is a dual trap developed by a researcher that addresses two of the most destructive invasive insects impacting date palm trees – the Red Palm Weevil (*Rhynchophorus ferrugineus*) and the Rhinoceros Beetle (*Oryctes rhinoceros*). The trap works by attracting and capturing the Rhinoceros Beetle via solar light at night, while the Red Weevil is captured during the day through the placement of pheromones and kairomones. Thus, the trap eliminates both species of pests. It is estimated that this innovative IPM solution can address more than 70 percent of pest infestations in date palms.

One common indigenous tradition is using botanical measures to combat pests, including neem oil, called *muraymra* in Arabic. Native to the Indian sub-continent, it is likely that this tree dates in Yemen from the 19th century, when it was also introduced to East Africa. This drought and heat tolerant tree is a source of

Interview Quotation

"One success story is that of a farmer who, after learning about the components of the organic pesticide, collected neem tree leaves, dried them, and produced an organic pesticide, which he then distributed to neighboring farmers. Following his method, other farmers started producing this natural pesticide for their own farms." **Confidential interview 28 September 2024, male, Yemeni nursery owner, Ta'iz.**

48 Confidential interview 20 May 2024, male, Yemeni researcher Wadi Hadhramawt.

49 Confidential interview 2 September 2024, male, Yemeni agricultural consultant working for an international organization.

timber and cooking fuel and is widely recognized as protecting plants from insects and fungal diseases (Campos et al. 2016), as well as being used for medicinal purposes. Numerous interviewees noted that it is used by farmers in plant protection and to combat desertification. Entrepreneurs and farmers collect, dry and grind the leaves and then add it to oil or shampoo to spray this non-toxic substance on to plants.

2.2.4 Post-Harvest and Harvest Losses

Throughout history, Yemen has been plagued by famine,[50] hunger, and food insecurity. As a result, many agricultural and food processing practices were developed to reduce harvest and post-harvest losses. From drying coffee husks and adding spices for a caffeine-free tea called *qishr* (meaning husk) to smoking dairy products for flavor and to ensuring longer shelf life, Yemenis sought to maximize income, efficiency, and preserve their agricultural products. Traditional practices noted by informants included: making storage containers for fermenting dairy products from a dried local pear-shaped gourd (called *dubay*) and covering the top with a lid made from the *qafla* (Arabian balsam tree, *Euphorbia abyssinica*) or *taneb* (*Cordia africana*); salting, smoking, or fermenting foods to preserve them; in the Hadhramawt storing meat in honey, preserving it for up to six months; and in Soqotra packing a sweet date paste into specially prepared goat skins tightly tied at neck and leg openings, where it can remain preserved for years (Colburn & Olney 2024). Famed Yemeni grapes sun-dried into sweet raisins and properly stored grains also reduce food loss. Another local tradition is that of the *madfan* (an underground grain storage chamber carved in rock or solid earth with a cover to preserve the grains for years from air, rain, animals, and insects).[51] A method to preserve meat involves salting and spicing it for

Qishr (dried coffee bean husk) factory, al-Misrakh District, Ta'iz
Photo: Noha Mohammed, 15 August 2024

50 Salient examples include: a severe drought in the 6th century AD weakened the Himyarite kingdom and contributed to its eventual conquest by Aksum; famine and drought struck the whole country in 1723–24; in 1826–27 a plague of locusts resulted in a severe famine; 1905–06 during the siege of Sana'a against the Ottoman occupation, starvation was widespread and it is said that half the population of the city died of hunger; a 1943–47 Wadi Hadhramawt famine was extremely severe, with children and pregnant women sent to al-Mukalla, and an estimated one out of seven dying; and in the 1950s three years of drought led to widespread starvation, with the United States opening a legation in Ta'iz to provide food aid. A proverb from al-Jawf says, "*If you are fleeing death, there is no escape; if you're fleeing hunger, settle in Suhal ibn Naji.*"

51 Ibid.

a long shelf-life version of the slow-cooked dish called *hanidh* for *Eid* (religious holiday). In the absence of refrigeration, other meat preservation practices such as removing internal organs, or drying meat in a cool, dark, ventilated place can preserve highly perishable meat for weeks.

The prevalence of food insecurity is alarmingly high in Yemen, with the 2024 Global Hunger Index ranking the country number 126th out of 127 countries.[52] Estimates of global post-harvest food loss of fresh fruit and vegetables range between 28 percent and 55 percent annually (Karoney et al. 2024). In order to address food insecurity in the country it is critical to minimize unnecessary losses of precious agricultural products. While no Yemen-specific data on post-harvest losses was identified, it is clearly high, given a variety of factors that include, but are not limited to: poor road networks; limited electricity coverage, particularly in rural areas; dire economic circumstance in many farming families with inconsistent availability and high cost of gasoline; low capacity in food preservation and processing in the home, community and private sector; and complexities in accessing markets during the conflict (World Bank 2021).

Various organizations are supporting post-harvest food processing activities, with SMEPS and the Social Fund for Development (SFD), two local quasi-governmental entities, being early leaders in the field. Interventions by local and international organizations targeting women cited by interviewees include: dairy production; drying and grinding spices and produce; pickling; reducing tomato spoilage and making paste, sauce, and powder; processing coffee beans; sorting, preserving, and processing dates; and creating jams, fruit juices, and canning. Establishing or scaling up factories that mechanize food processing was also seen by interviewees as an essential investment to increase efficiency and contribute to food security.[53]

Interestingly, one theme frequently encountered in interviews was the need to strengthen the role of women in food processing and post-harvest activities. This is an important point in light of the increasing role that women are playing in earning income for their families (Sana'a Center for Strategic Studies 2024). With the conflict and the need to contribute to household finances, some

Interview Quotation

"You can't just have a blanket approach working with women. Teaching sewing, tailoring, and food processing can reinforce traditional female roles and stereotypes. There are female landowners and they can be role models. You have to engage women in transformative programming rather than such basic activities where you end up saturating local markets. You need proper market assessments linked directly to interventions… We too often keep our focus at the project level and we don't zoom out." **Confidential interview 21 May 2024, two women, donor agency**

52 See *https://www.globalhungerindex.org/yemen.html* (29.03.2025).

53 Confidential interviews: 23 May 2024, female, Yemeni nutrition researcher; 27 May 2024, two males, farmers; 9 June 2024, male, Yemeni manager in a local corporation; 15 August 2024, female, Yemeni food industry specialist; 30 October 2024, female, Yemeni head of a local women's CSO, Hadhramawt.

women are engaging in opportunities outside their home, and others are relying on familiar tasks to earn money which they can pursue from their homes. Interviewees noted that date palm frond processing can be expanded to create traditional and non-traditional baskets, hats, and useful and decorative items to generate income earning opportunities for women. However, it is essential to support women in rural communities and female farmers to move beyond traditional roles, for example harnessing green technology such as solar dryers/dehydrators or designing agritech initiatives. Transformative interventions should seek to empower women to break into new professions and strengthen their contribution to decision-making in the home.

Post-harvest interventions that focus on expanding cold storage and refrigerated transportation opportunities can also reduce food losses. Additionally, strengthening the marketing of agricultural produce, including directly connecting producers with consumers in urban areas in accessible farmers' markets holds promise. Hermetic bags (air- and watertight) can be used to seal harvested crops by smallholder farmers to prevent losses due to fungi and insects.[54] Finally, utilizing agricultural cooperatives to support post-harvest initiatives is an area ripe for investment and explored in more detail in the following section.

In addition to post-harvest losses, inefficiencies and conditions during harvesting can also result in a loss of crops. Appropriate mechanization is a key aspect of farming that can reduce such harvest losses. However, numerous factors contribute to low levels of mechanization in the country, including: mountainous topography; extensive terracing; fragmented land holdings; high levels of sharecropping; high cost for such equipment; weak road infrastructure; and a lack of technical knowledge for repair and maintenance of equipment, as well as a weak supply line for spare parts in rural areas (al-Shamiry 2020). One interviewee described a simple threshing machine that consists of a barrel fitted with ball bearings on both sides and a central shaft that is attached to a generator or tractor, which can thresh all cereal crops.[55] The International Center for Agricultural Research in the Dry Areas (ICARDA) has worked in a number of countries in the region supporting smallholder farmers with simple mechanization designed to reduce manual labor and increase efficiency for various agricultural harvesting processes. Support they provide also includes developing local production, maintenance, and spare part supplies for these machines. Agricultural cooperatives present an opportunity for farmers to jointly own and maintain mechanical equipment. The rental of such equipment to non-cooperative members can also contribute

54 Participant in 21 January 2025 workshop, male, German senior agricultural specialist.

55 Confidential interview 17 August 2024, male, Yemeni independent agricultural consultant.

to the financial solvency of the cooperative. Alternatively, individual farmer entrepreneurs can provide mechanized services to others in their area.

2.2.5 Agricultural Cooperatives and Producer Associations

In Yemen age-old practices in agricultural communities brought together families to support one another in the aftermath of flooding, drought, or natural disasters. *Jaysh*, for example, refers to communities working together to harvest a family's crops or repair agricultural infrastructure after flooding. *Al-'ana'* and *al-shamla* are other local traditions of voluntary working to construct wells, dams, and other social assets. Yemeni oral traditions, including proverbs, reinforce collective action principles. Religious and tribal practices also play a role in affirming cooperative approaches in the face of crises and addressing broader social needs.

Yemeni Proverbs on Cooperation

When men carry something together, it will be lighter (*ma shulthu al-rijal khaf*).

God's hand is with the group (*yad Allah ma'a al-jama'a*).

The first formal cooperatives were established in the 1950s in the South during the British colonial era and in the former YAR in the 1960s (ILO 2009). In the South cooperatives were encouraged for the production of cotton, and following independence the People's Democratic Republic of Yemen (PDRY) expanded these institutions. During this period the state provided operational support to cooperatives to manage canals, supply tools, seeds, and funding to farmers, and in return they received half of the harvest (Aklan 2024). By 1982 31 percent of agricultural production and 34 percent of fishing outputs were conducted by cooperatives (Carapico 1998). After unification, in 1996, the Agricultural Cooperative Union was created and by 2010 there were 1,410 cooperatives registered with the Ministry of Social Affairs and Labor, of which 60 percent were agricultural in nature (Polat 2010). In 2009 it was reported that out of 427 cooperatives registered with the Agricultural Cooperatives Union, ten were women-only (ILO 2009). However, since 2015 most agricultural cooperatives disappeared for various reasons.[56] Additionally, localization of interventions implemented by international organizations has been particularly weak in Yemen, with only a small number of local CSOs playing a leadership role in the water and agriculture sectors, despite significant capacity in local civil society (Colburn 2021). Producer associations are found in various parts of the country, with those supporting coffee farmers common in areas cultivating this precious bean.

Social capital, cooperation, and civil society are of critical importance to climate-smart agriculture, particularly in the face of the increasing impact

56 Confidential interview 12 November 2024, female, Yemeni trade union specialist.

from climate change. Strengthening the role of this aspect of Yemeni society will contribute to communal resilience and deepen the impact of livelihood and agricultural interventions, particularly when such efforts are led by women, youth, and minorities. Moreover, working through CBOs such as agricultural cooperatives or producer associations will magnify the impact of interventions beyond supporting individual farmers. These community-based entities can reduce farmer expenses for inputs (i.e. purchasing seeds, drip irrigation systems, and/or greenhouse materials in bulk at reduced prices), support capacity building efforts, enhance marketing, improve flood mitigation, and contribute to food processing that reduces post-harvest losses. Numerous international and local organizations have begun investing in agricultural cooperatives and producer associations to maximize impact. However, more can be done.

2.2.6 Urban Agriculture and Gardening

A prime example of urban agriculture in Yemen is that of the *maqashim* (sing. *maqshama*) found in the Old City of Sana'a, as well as similar traditions in 'Amran, Dhamar, Ibb, Sa'da, Ta'iz, Zabid, Hadhramawt,[57] and other areas, although they are often in disrepair. In Sana'a for over 500 years this ingenious mosque-bath-garden system has utilized greywater from ablutions and bathhouses to irrigate adjacent gardens usually hidden behind mud-brick walls growing vegetables, fruits, herbs, and animal fodder (al-Nozaily et al. 2014). Additionally, these gardens benefited from human excrement collected from public toilets and private homes and burnt as fuel in bath houses, with the ashes spread as fertilizer in the gardens. In 2014 a survey identified 45 of these urban green spaces and proposed ways to improve water-use efficiency and inject climate-smart agriculture practices (ibid). A further horticultural tradition in cities and rural areas throughout the country are rooftop gardens, where women cultivate herbs, vegetables, and flowers. Another practice is that of flocks of goats and sheep foraging in cities, with goats particularly adept in finding sustenance among garbage and kitchen scraps. Family practices also include maintaining a goat or sheep on the rooftop, which is fattened with kitchen scraps prior to *Eid*. In parts of Yemen families raise pigeons on balconies and rooftops for meat and use their droppings as a source of nitrogen in organic fertilizer.

Interviewees suggested turning fallow land around universities, schools, health facilities, and on *waqf* (religious endowment) land into community gardens. One local CSO had used university land adjacent to the women's dormitory to raise food and teach climate-smart agriculture techniques to female students

57 Many mosques have an adjacent *hayt*, a garden sounded by mud wall, where dates, citrus, papaya and vegetables are cultivated.

to take back to their rural communities. With the conflict and increasing food insecurity, some entrepreneurial families have expanded urban agriculture and created small farms on their flat rooftops, sometimes including chickens, and even goats and sheep. Another promising urban agricultural idea is to use fabric grow bags to cultivate different vegetables on balconies and rooftops or create small greenhouses on rooftops. However, many urban dwellers lack gardening experience and knowledge, so one interviewee suggested creating an advice-hotline for city dwellers wanting to learn about plant protection, composting, greywater, and other relevant topics.[58] Urban nurseries can also be supported to serve as hubs to introduce new crops and provide advice to those seeking to grow food. Backyard or keyhole gardens in urban and peri-urban areas could utilize perma-gardening techniques. One interviewee shared key-hole garden best practices to include creating a berm around the edge to protect plants from wind, digging down 20 centimeters, putting a layer of organic compost, covering it with a layer of soil and then planting trees for shade – and watered it with greywater and harvested rainwater.[59]

Historically, in many parts of the country agricultural produce, livestock, and crafts were sold directly from farmers and producers to consumers on specific days of the week in a *suq* (market). This strong tradition resulted in towns in various parts of the country being named after these weekly events – *suq al-ithnayn* (Monday Market), *suq al-khamis* (Thursday Market), etc. While many urban areas continue to have large markets on the outskirts of town, these are often located far from residential areas and operate more as wholesale markets. Establishing farmers markets close to densely populated areas could improve farmers' income and reduced costs paid by consumers.

2.2.7 Section Conclusion

Researching, expanding, and adapting indigenous Yemeni traditions in plant protection and soil health, and exploring ways to enhance age-old agricultural practices with modern technologies emerged as a key approach in the research. Interventions that focus on rainfed or spate-irrigated agriculture are particularly relevant, as this will avoid overextraction of groundwater, and echo millennia of agrarian practices. Facilitating the transition from chemical fertilizers and pesticides to organic composting, mulching, and other permaculture practices is essential. International organizations must work in partnership with local civil society to further the localization agenda, including supporting agricultural cooperatives. Such investments can improve impact and contribute to program efficiency. Female farmers and farm laborers, as well as rural women in general, are key target groups to improve food security,

58 Confidential interview 3 September 2024, female, urban gardener in Aden.

59 Confidential interview 26 May 2024, two men, international and Yemeni staff with an international organization.

although understanding their needs and aspirations takes an investment of time and energy. In early 2024, ROWAD Foundation (a leading youth-led local CSO) and the Hayel Saeed Anaam Corporation joined forces to support a pilot social innovations lab highlighting agriculture and agritech solutions.[60] This event brought together competing teams of entrepreneurs and creatives (mostly young people and including women-led teams) sharing many innovative ideas from 22 governorates (with 420 applicants).[61] In the Hadhramawt an App called *Nafidha Wasl* is being piloted that provides agricultural extension information and two-way communication with farmers.[62] Other initiatives in Yemen seek to expand urban horticulture utilizing greywater and permaculture principles to contribute to household and communal resilience. Increasing food security in Yemen requires creative problem solving and contextual knowledge to foster interventions designed in partnership with beneficiaries and communities and implemented in a conflict- and gender-sensitive manner.

2.3 Animal Husbandry

The first remains of sheep, goat, and cattle bones in Yemen date from the 6th century BC (Martin, McCorriston & Crassard 2009). While the chicken arrived much later on the scene, though when is unclear (Woldekiros & D'Andrea 2017[63]), poultry has become the most common source of protein for poorer families (UNDP 2020). Fat-tailed sheep, goats, and chickens play a central role due to limited arable land, being well-adapted to the country's rocky and arid landscape, requiring limited water, and grazing effectively, even in urban areas. Additionally, goats and sheep provide a dependable source of cash for sale during *Eid* and are viewed as a form of mobile savings; chicken meat and eggs are also valued with *baladi* (local) breeds highly sought after. Traditionally, livestock manure was a source of organic compost and dung patties for cooking, and was even used in mud building construction. Traditionally, women are responsible for rearing their chickens, sheep, goats,

Interview Quotation

"Traditional agricultural practices included al-mahjur, *land surrounding an agricultural field where grazing and gathering wood is prohibited seasonally or permanently. Also, common was* al-'alifiya, *raising a couple of lambs or goats in the kitchen, where women feed them kitchen scraps. One animal will then be sold to purchase clothing for* Eid *and the other will be slaughtered by the family to eat."* **Confidential interview 5 September 2024, female, retired international expert in smallholder agriculture in Yemen**

60 See *https://rowad.org/en/events/32* (29.03.2025).

61 Confidential interview 9 June, male, Yemeni manager in a local corporation.

62 Confidential interview 19 May 2024, male, Yemeni academic specializing in agriculture.

63 It is hypothesized that the earliest presence of the chicken in Africa (Ethiopia dating from the 1st century BC) arrived from South Arabia.

and house cows, as well as for processing animal products such as dairy, with men primarily caring for camels, horses, donkeys, and herds of cattle.

The massive influx of remittances in the 1970s deeply impacted local diets, including increased meat consumption. While this resulted in positive nutritional outcomes for Yemenis, it also contributed to deforestation, overgrazing, and rangeland degradation. However, since 2015, meat consumption has dropped dramatically for many Yemenis with the diminished economic status among families. Many households that used to serve fish, chicken, or red meat sauces or stews over rice are now making a dish called *sanunat hawa'* (literally "air sauce") meaning vegetable sauce made without protein.

An FAO survey in 2021 found that among vulnerable households, 70 percent of respondents engaged in rearing livestock, with the sale of livestock food products being a primary or secondary source of income for an estimated 25 percent of respondents (Hanna et al. 2023). However, livestock are vulnerable to many issues, with a 2023 survey conducted in IRG-controlled areas noting that the farming asset most severely affected by climate change were livestock (32 percent), followed by crops (26 percent) and farming equipment (25 percent) (al-Hamdani, Porter & al-Meida 2023). Additionally, the conflict has put at risk income from livestock for many families, with the rising cost of fodder, imported feed and supplements, as well as road blockages increasing animal transportation costs, and lack of veterinary services. The loss of life among herding families and their animals due to conflict has also been significant, particularly in areas with landmines (Masam 2022). The IRG government has recently produced a strategy on animal health in the country, which has many strengths and provides an overview of issues and plans to address challenges (Republic of Yemen and FAO 2024).

This section examines a variety of topics that emerged from the research related to animal husbandry, highlighting indigenous traditions, challenges, and opportunities to improve incomes. Topics include fodder, rangeland challenges, veterinary services, livestock varieties, and dairy production.

2.3.1 Fodder

A wide range of traditional livestock fodder/forage practices were highlighted in interviews including:

- "*One cow eats her sister*," a local proverb from Dhamar governorate, stating that sometimes one cow needs to be sold to buy fodder for a second one, reflecting the high cost of feeding livestock. Traditionally, farmers would leave some of their fields fallow with stubble and post-harvest waste, and

then send their animals there to graze. This practice would yield a better harvest.[64]

- Drying and storing of rainfed crops provided fodder throughout the year, particularly during the dry season, with dry fodder stored at the top of trees.[65]
- Dry season fodder supplements include *sanaf* (*Acanthus arboreus*) used to enhance the taste and nutritional value of the milk produced.[66]
- Maize and sorghum are staple crops, with *saif* (summer harvest) used for both food and fodder.[67]
- Women prepare daily *ghuruz* for their cows, where they wrap different types of fodder, like fresh alfalfa or dried foliage, around dry sorghum stalks to make it more nutritious and palatable.

> Interview Quotation
>
> *"Many people don't see feed/fodder as a matter of food sovereignty or food security, but it is indeed. Many rearing livestock have to reduce their herds as they can't afford to feed them at the right time. Many governments subsidize farmers to buy feed from the black market. Governments like Oman have purchased farms in other countries like Argentina to grow soy for poultry feed for in Oman."* **Confidential interview 27 June 2024, female, Arab scientist researching livestock feed**

It is estimated that there are over 21 million livestock in the country, close to 10 million sheep, a similar number of goats, 1,8 million cattle, and 450,000 camels (Republic of Yemen 2024). In the current conflict, the availability, cost, and quality of feed ranks high on the list of challenges cited by interviewees. A UNDP study found that the high cost of fodder is particularly challenging for meat and poultry producers during the dry season (UNDP 2020). Fodder production is the highest in terms of metric tons produced of all crops (see figures 1 and 2), yet it is insufficient to meet the needs of the livestock sector (Republic of Yemen 2024). One interviewee noted that stakeholders should focus on producing concentrated livestock feed domestically, as Yemen imports quantities worth millions of dollars annually.[68]

Women are primarily responsible for rearing poultry. A 2021 study found that the flock size among 360 households in six northern districts ranged from 4–12 birds (78 percent) to 13–20 birds (19.6 percent) (al-Bial & al-Olofi 2021). The study also found that 66 percent of families ranked their poultry as a source of nutrition, rather than income (34 percent). 62 percent of respondents fed their birds by scavenging and 33 percent respondents practice scavenging systems with supplementary feeding (wheat or sorghum), while only 4.5 percent relied

64 Confidential interview 26 May 2024, two men, international and Yemeni staff with an international organization.

65 Confidential interviews: 5 September 2024, female, retired, international expert in smallholder agriculture in Yemen; 19 August 2024, male, Yemeni agricultural trainer, Ta'iz.

66 Confidential interview 22 May 2024, male, Yemeni animal feed and foliage company.

67 Confidential interview 31 August 2024, male, Yemeni chairman WUA.

68 Confidential interview 5 June 2024, male, Yemeni manager in a quasi-governmental entity.

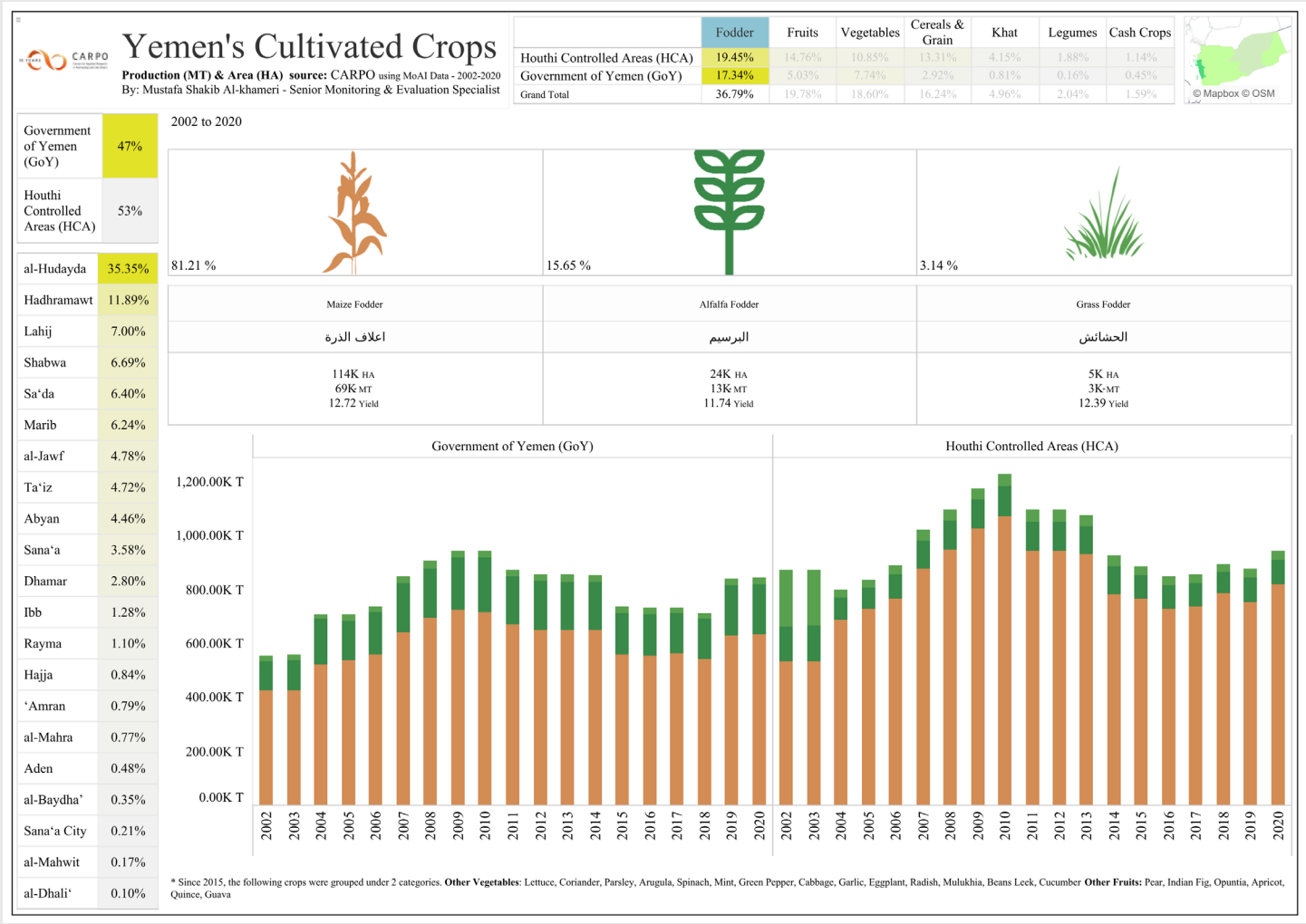


Figure 2: Yemen's fodder production between 2002 and 2020 in government- and Houthi-controlled areas

on commercial feed. Respondents stated that the most significant challenges were disease (45 percent), predators (20 percent), and lack of veterinary services (18 percent).

Table 1 lists the most commonly identified themes of importance to livestock fodder and foraging. The most significant issue identified was that of locally produced fodder. As another research informant shared: *"Animal feed production and enhancement are crucial to the Yemeni economy and agriculture as we are a culture that enjoys meat and dairy products more than any other food."*[69] This topic was followed

Table 1: Common livestock fodder themes

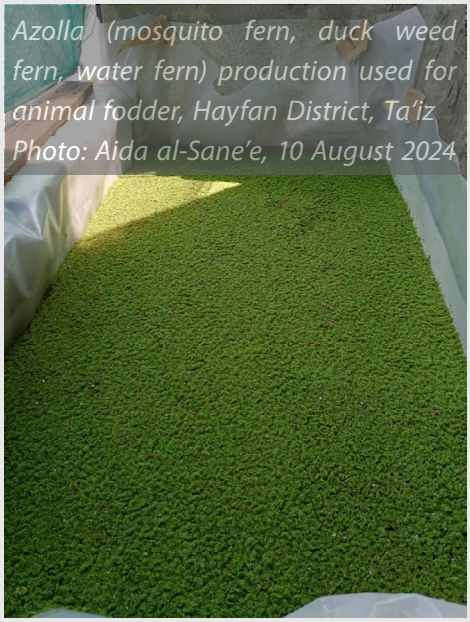
Theme	Frequency
Scaling up local livestock production	15 mentions
Challenges with overgrazing	14 mentions
Role of women in livestock rearing	11 mentions
Importance of feed supplements	11 mentions
Lack of fodder in the market	9 mentions
Rising/high cost of animal feed	7 mentions

69 Confidential interview 22 May 2024, male, Yemeni animal feed and foliage company.

by the challenge of overgrazing. Overgrazing is a key factor contributing to environmental degradation and deforestation, along with the lack of cooking fuel that has resulted in overcutting of firewood. Research participants also recognized the importance of nutritional supplements in livestock feed and experts in the field reiterated this point and the importance of inputs such as salt blocks (UNDP 2024b).

While traditional practices in fodder production and pastureland are important knowledge for climate-smart agriculture, this research also highlighted new insights and opportunities shared by interviewees. These include:

- Animal feed projects are increasing in Yemen, although many of them need scaling up, and by being locally produced could greatly benefit farmers and also present opportunities for entrepreneurs to generate sustainable income.[70]
- Three interviewees noted that *Azolla* is a species of aquatic fern high-quality livestock fodder often produced using greywater.[71] This highly nutritious fodder is starting to be used in Yemen as an economical way to produce feed for birds, chickens, goats, sheep, rabbits, and cows.
- Prickly pear cactus (*Opuntia ficus-indica*; *tayn shawki* or *balas turk* in Arabic) was likely introduced by the Ottoman Turks during their occupation of Yemen. This pernicious invasive is found throughout much of the country, destroying pastureland. However, it is prized for its highly nutritious fruit, and oil from the fronds can be used to make soap and for cosmetics. Three interviewees mentioned that the fronds of this cactus can be de-thorned



Azolla (mosquito fern, duck weed fern, water fern) production used for animal fodder, Hayfan District, Ta'iz
Photo: Aida al-Sane'e, 10 August 2024

Livestock yard, Dar Sa'ad, Aden
Photo: Heba al-Absi, 3 September 2024

70 Confidential interview 24 June 2024, male, Yemeni academic hydrologist.

71 Confidential interviews: 10 August 2024, female, Yemeni farmer in Ta'iz; 8 June 2024, male, agricultural entrepreneur; 15 August 2024, male, Yemeni farm owner Ta'iz.

and used as livestock fodder, stating it is an ideal source of fodder as it grows throughout the year, thus generating continuous feedstock.[72]

- Two informants were involved in bioconversion technology using black soldier flies whose larvae transforms organic waste into high-quality poultry feed (Veolia 2022). One individual, who is piloting this approach in Yemen, has seen a 30 percent increase in poultry production.[73] The second interviewee rolled out small-scale units operated by women in Kenya, which generated income by selling poultry feed in their communities.[74]
- One interviewee noted that saltbush (*Atriplex nummularia*), a drought-tolerant quick-growing shrub that desalinates the soil (reaching maturity in 3–5 years), is a promising forage/foliage source for livestock for Yemen. Successful tests were conducted using it as sheep fodder in Dhamar and to combat rangeland destruction and desertification (Kessler 1990). In light of climate change challenges, saltbush holds potential to address a number of issues.
- One interviewee noted that he has introduced new fodder crops adapted to Tihama conditions. The process uses invitro microbes to breakdown cellulose materials like straw and sorghum stems and then make this substance into fodder pellets. This company has developed a rapid probiotic process for feed that only takes 17 hours, resulting in more absorbable protein and eliminating the need for feed concentrate. The initiative is poised to scale up soon by adding a new production line.[75]
- Other sources of fodder that could be explored, or scaled up, include: seaweed harvested from Yemen's extensive coastline (CARDI 2015); spirulina, a highly nutritious edible microalgae; and elephant grass, a noninvasive cover crop, that also is a source of animal foliage moreover preventing soil erosion. There are currently test plots in Yemen showing great promise.
- Mushrooms can be used to generate high-quality organic compost from agricultural residue such as banana leaves, maize cobs, and vegetable leaf matter (Kazige et al. 2022). While there is not a local tradition in cooking with mushrooms, in cities there could be a market for consumers. However, mushrooms grown in this way can also be used as nutritious animal fodder.

2.3.2 Rangeland Protection and Rehabilitation

Conservation of rangeland was a strong tradition in Yemen. Interviewees highlighted various practices including prohibiting shepherds from grazing

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72 Confidential interviews: 5 June 2024, male, Yemeni manager in a quasi-governmental entity; 13 June 2024, female, Arab sustainable food specialist; 26 June 2024, male, UN international livestock specialist.

73 Confidential interview 3 September 2024, male, Yemeni black soldier fly breeder, Ta'iz.

74 Confidential interview 27 June 2024, female, Arab scientist researching livestock feed.

75 Confidential interview 22 May 2024, male, Yemeni fodder entrepreneur.

animals close to agricultural fields and assigning grazing rights to groups or families in a particular geographical area.[76] Also, pruning (removing smaller twigs or branches) and looping (cutting larger branches) stimulated tree growth at certain times of the year, as well as providing firewood and fodder.[77] Such customs ensured that plants or grass reach maturity to provide a fodder reserve and enable reseeding the rangeland with windblown seeds.[78] When sustainably managed, informants viewed the value of such communal assets as fostering the production of meat, milk, and honey, as well as producing firewood for cooking and mitigating the impact of flooding.

Systemic challenges to rangeland conservation include overpopulation, ever increasing numbers of grazing livestock, spread of invasives such as prickly pear and mesquite (*Prosopis*), and the breakdown in conservation traditions. However, with the conflict one of the most significant challenges in rangeland preservation has been the cost and absence/inconsistent supply of cooking gas, with bakeries and restaurants in cities requiring huge quantities of wood. The resulting destruction of trees has been worsened by the availability of electric saws which have all led to a booming firewood trade.[79] Skyrocketing poverty was also noted as a source of rangeland destruction with desperate families earning income through overgrazing their livestock or selling firewood. Additionally, IDPs also play a role in deforestation as wood is needed for construction and cooking in camps (McFee 2021). Furthermore, overgrazing as a result of blanket livestock distribution under short-term livelihood interventions is trading temporary beneficiary income for long-term sustainability.[80] In the Hadhramawt livestock are being allowed to graze when sidr trees (*Ziziphus spina-christi*, *'ilb* in Arabic) are flowering, thus destroying blossoms and negatively impacting honey production.[81] Furthermore, in light of deforestation, the responsibility of women and girls to secure cooking fuel and livestock fodder has meant that they have to roam

Interview Quotation

"I remember in my youth in the 1980s in Ibb that the whole mountain was so green, because the farmers would send their livestock to one area for six months and afterwards to another area. Thus, rotating the land and allowing shrubs and trees to grow and flower. If someone broke the rules they were put in jail and became the enemy for the whole village… I saw that they took the men to jail if their wives cut the green trees for cooking." **Confidential interview 26 May 2024, male, Yemeni agricultural specialist with an international organization**

76 Confidential interviews: 15 August 2024, male, Yemeni farm owner Ta'iz; 28 August 2024, male, Yemeni academic, Aden.

77 Confidential interview 10 August 2024, male, farmer, Ta'iz.

78 Confidential interview 19 August 2024, male, Yemeni agricultural trainer, Ta'iz.

79 Confidential interview 28 August 2024, male, Yemeni academic, Aden.

80 Confidential interview 26 May 2024, two men, international and Yemeni staff with an international organization.

81 Confidential interview 22 May 2024, female, farmer in the Hadhramawt.

further and further from home putting them at increasing risk of GBV, particularly among IDP women and girls.[82] The end result of rangeland destruction is increasing the intensity of flooding and the erosion of precious top soil.

At a policy level it is essential for all stakeholders to seek to address the bottlenecks in cooking fuel availability and cost. A number of ideas to address the challenge of deforestation include: providing bakeries or restaurants with solar-powered stoves or panels to operate their ovens and/or fuel coupons for gas cylinders; distributing fuel-efficient stoves, solar dryers, or solar-powered stoves to households; and subsidizing bio-gas units for clean cooking. Traditionally in rural areas dried dung patties were used for cooking, although improved techniques to minimize negative health and environmental consequence could be explored. A number of local organizations have been exploring various fuel-efficient stoves and United Nations High Commissioner for Refugees (UNHCR) has piloted energy-efficient stoves with IDPs. Experience in Jordan in rejuvenating overgrazed rangeland highlights that utilizing seedlings of native drought-resilient perennial rangeland plants with robust root systems is essential for their survival.[83]

2.3.3 Livestock Health and Veterinary Services

There is a high mortality rate among livestock in Yemen, with numerous informants highlighting that this is due to limited veterinary services in rural areas and poor livestock health as a result of economic hardships among farmers. With the conflict there are numerous challenges with veterinary services including limited MAIF livestock and extension staff, partially due to inconsistent payment/absence of civil servant salaries and greatly diminished budgets. Consequently, authorities lack the ability to monitor, quarantine, and respond to the spread of zoonotic disease outbreaks. Additionally, there is a lack of veterinary supplies and equipment to support livestock health (Republic of Yemen and FAO 2024). These factors have contributed to upticks in endemic diseases such as sheep and goat pox, and foot-and-mouth disease (Conflict and Environment Observatory 2020b). Nine interviewees emphasized the importance, and challenges, of vaccinating livestock and accessing veterinary services. However, even when livestock owners know what medicine, vaccination, or treatments their animals need, they are unable to afford such inputs. Furthermore, access to such veterinary services is limited by gasoline shortages, poor roads, conflict dynamics impacting mobility, and the long distances to service points. A 2021 study on backyard poultry rearing in rural Yemen found that 18 percent of respondents found the lack of veterinary services a significant challenge (al-Bial & al-Olofi 2021).

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82 Confidential interview 28 June 2024, female, Yemeni academic.

83 Participant in the 21 January 2025 workshop, female, Arab civil society organization.

Despite significant weaknesses in veterinary services in Yemen, a wide variety of organizations are supporting those rearing and breeding livestock. These initiatives include capacity building to veterinarians and engaging with the private sector and local civil society to provide needed services. Some interventions have sought to provide basic veterinary skills to women and youth to provide preventative care, disseminate care information, and dispense with vaccinations in local communities. Many interviewees noted that there is a lack of knowledge and background in livestock husbandry among beneficiaries of animals distributed by implementing organizations. A number of interviewees suggest having community-based livestock pharmacies or community animal health workers trained to treat commonly encountered diseases. FAO, working with a local CSO specializing in veterinary services, has been engaging in such efforts and numerous local CSOs are providing mineral blocks and veterinary service to livestock rearers and breeders. A participant in the January 2025 workshop noted that the One Health approach emphasizes the interdependence of the health of humans, domestic and wild animals, plants, as well as the wider environment.[84] Addressing livestock diseases is essential to promote human health and vice versa.

Interview Quotation

"In our village of approximately 70 households we face numerous challenges including a lack of animal feed… during the dry season when grazing is not worthwhile, we have to feed our animals twice daily on fodder that we purchase. Despite the fact we have a large number of animals, there is no veterinary clinic in our village, even though we have 1,500 camels, about 10,000 sheep and goats, 150 cattle and chickens, rabbits and pigeons."
Confidential interview 3 September 2024, male, Yemeni livestock breeder

2.3.4 Livestock Varieties

Yemen has a strong heritage in livestock breeds well-adapted to local conditions, thus conserving agricultural biodiversity is essential (Wilson 2003). However, with climate change there is a need to explore opportunities to introduce more drought- or disease-tolerant animals. The authors recognize the risks of introducing new animal breeds to Yemen, as there are many lessons learned and best practices in this regard. Challenges include lack of biosecurity measures for livestock and the transmission of zoonotic diseases, negatively impacting local livestock biodiversity, and resulting in economic losses for farmers. For example, the tendency to slaughter male calves requires breeding local cows with the bulls imported from Africa. This has resulted in low quality offspring ill adapted to the local environment and this is also negatively impacting milk production for dairy. Despite such challenges, with high levels of food insecurity in the country and climate change, it is worthwhile exploring livestock and poultry varieties that can augment local animals to contribute to both income and household nutrition.

84 Participant in 21 January 2025 workshop, male, German senior agricultural specialist.

In urban areas on balconies, rooftops, and backyards families could raise pigeons, quail, ducks, rabbits, and chickens. Ostriches, once present in Yemen and depicted in rock art (Jung 1991), are low maintenance birds producing high-quality lean meat and are more drought tolerant than most livestock and could be appropriately raised in drier areas of the country.

2.3.5 Dairy Production

A key livestock output in Yemen are various dairy products produced by women from cow, goat, or sheep milk. Popular dairy products include, but are not limited to: *samn* is an important culinary ingredient; *haqin* (buttermilk) is often smoked with herbs added; *hamdiher* is a Soqotri curd cheese made of buttermilk that is boiled until it thickens; *laban* (fermented milk); *zabadi* (yoghurt), commonly made in Lahij; *labna* (strained yoghurt); *tharib* is a type of yogurt drink made by adding curdled milk to fresh milk; and *jubn baladi* (local cheese) is a salted smoked cheese common in the central highlands, with Ta'iz being famed for this savory dish. The maintenance of livestock on homesteads was essential for producing these essential derivatives, consuming considerable time and effort by women for the nutritional and culinary preferences of their families.

Critical issues in dairy production include: poor animal health negatively impacting milk production; lack of marketing channels and skills; unhygienic milking and storage conditions[85]; and sub-standard housing for animals. Traditionally dairy was smoked, salted, and/or fermented for preservation, or consumed daily. Currently, one of the most significant challenges for dairy is the lack and expense of refrigeration for storage and transportation to processing factories or markets. This limits productivity in the sector and contributes to food spoilage, particularly as animals require milking twice daily.[86] When women participate in training activities in many parts of the country the need for a *mahram* (male family escort) also presents a challenge. One interviewee noted that supporting small-scale female dairy producers is important, but that at times some women have difficulties meeting agreed quotas of milk due to various factors.[87] In Ta'iz one project working with women producing cheese has successfully introduced pasteurization to reduce harmful bacteria.[88] It was noted in the workshop in January 2025 that even with pasteurization, if other quality standards and refrigerated

85 Confidential interviews: 15 August, female, Yemeni food industry specialist; 3 September 2024, male, Yemeni livestock breeder; participant in 21 January 2025 workshop, female, German senior project manager.

86 Participant in 21 January 2025 workshop, female, German senior project manager.

87 Confidential interview 13 June 2024, female, Yemeni gender specialist.

88 Confidential interview 15 August 2024, female, Yemeni food industry specialist.

transportation are not met, consumers may not like the flavor, as with yoghurt it can have a sour or acidic taste.[89]

One livestock specialist noted that the lack of sterilization is a key source of dairy spoilage, thus their project trains female dairy farmers on best practices, along with other support activities.[90] Proper storage containers for milk can prevent spoilage; in Tunisia, for example, working with GIZ, ICARDA has tested solar cooling milk cans preserving milk between twice daily milkings and then mixing them to reduce spoilage.[91] One SMEPS project worked with shepherds who signed a contract with a dairy processing factory, providing veterinary services, capacity building, and other inputs, and the factory would send a refrigerated truck directly to farms to collect the milk for processing.[92] FAO, through local partners, works with women in the dairy value chain, while also engaging men in various aspects including fodder production.[93] Solar-powered small-scale cold storage facilities operated by agricultural cooperatives could support female dairy farmers. In al-Hudayda a group of women is developing a solar-powered fridge to keep milk fresh while being delivered from farmers to factories.[94] However, more research is necessary to understand challenges and how to address these to benefit the women producing dairy products.

2.3.6 Section Conclusion

Livestock husbandry in Yemen is an essential component of livelihoods for women producers and the nutrition of their families. This key sector is facing incredible challenges, and yet there are many opportunities that emerged with female livestock rearers and breeders expanding traditional practices and forging ahead with creative solutions. It was reiterated across all categories of informants that investing in fodder production can empower women as well as contribute to food security and rangeland protection. The One Health approach integrates the health of humans, livestock and wild animals, plants, and the wider environment (including ecosystems) as closely linked and interdependent. Additionally, the research identified many local and international organizations supporting various aspects of animal husbandry. While government capacities have been dramatically reduced during the war, with the support of FAO and others, the IRG's 2024 strategy in animal health holds promise to yield positive results (Republic of Yemen and FAO 2024).

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89 Participant in 21 January 2025 workshop, male, Arab livestock scientist working for a regional research organization.

90 Confidential interview 15 August 2024, female, Yemeni food industry specialist.

91 Participant 21 January 2025 workshop, male, Arab livestock scientist working for a regional research organization.

92 Ibid.

93 Confidential interview 26 June 2024, male, livestock specialist in an international organization.

94 Confidential interview 9 June 2024, male, Yemeni manager in a local corporation.

2.4 Further Key Climate-Smart Agricultural Topics

The following section contains a number of additional topics that warranted addressing due to their relevance to the topic of climate-smart agriculture. This includes pollinators and honey, coffee, and medicinal and culinary foraging.

2.4.1 Pollinators and Honey

Yemen has been famed for honey at least since the 1st millennium BC (Khanbash 2002) and the Greek geographer Strabo (62 BC–24 AD) wrote that the Hadhramawt had an illustrious history in apiculture (Nasher & al-Muslimi 2023). This heritage was enshrined in a Sabaean inscription from the 5th–6th century AD noting that honey was provided to workers repairing the Marib dam (Lewis 2007). Al-Hamdani, the Yemeni 10th century historian, stated that a variety of honey called *shahd* from Jabal Hadur in 'Amran produced honey so thick it could be cut with a knife (Varisco 1994). This long history translates into rich traditions in cherishing these industrious pollinators that make agriculture possible. The native Yemeni honeybee (*Apis mellifera jemenitica*) is a subspecies well-adapted to the country's climate and during extreme heat they adapt foraging activity, particularly during midday, to conserve energy and maintain colony productivity (Al-Attal 2024). Bees that forage on the sidr tree produce the most sought-after honey, with those feeding on acacia trees in summer also being highly valued. Sidr honey commands a high price domestically and abroad with the governorates of Hadhramawt, Shabwa, and 'Amran being significant producers. Yemeni honey has great cultural value and is a common ingredient in delicious recipes from around the country (Colburn & Olney 2024).

Table 2: Common beekeeping themes

Theme	Frequency
Preserving forage lands	34 mentions
Modernizing beekeeping	23 mentions
Corruption	9 mentions
Increasing women in the sector	8 mentions
Strengthen government framework/ cooperation with CSOs & private sector	8 mentions
Bees wax and cosmetics	6 mentions

Climate change has had a significant impact on beekeeping in Yemen. Many beekeepers in Yemen migrate seasonally to different areas of the country seeking blossoms for their bees to forage. When rains are unpredictable, coming too early or late, flowering times vary, and diseases, fungi, ticks or decay result impacting honey production.[95] The conflict has also deeply affected the sector with the lack of petrol, more checkpoints, and rising insecurity making

95 Confidential interviews: 20 May 2024, male, Yemeni academic specializing in apiary sciences; 30 May 2024, male, Yemeni manager with an international organization; 17 August 2024, male, Yemeni farmer and beekeeper, Ta'iz; and 26 August 2024, male, Yemeni government staff focusing on climate change.

it difficult for beekeepers to move their hives around.[96] High levels of pesticides used on *qat* also drastically lower honey production and the fitness of the bees.[97] Despite significant investments in the sector, honey production has been negatively impacted in recent years and exports have plummeted by 50 percent (ICRC 2024).

Table 2 presents common beekeeping themes emerging from the interviews. The top challenge identified was the importance of preserving forage lands, including planting sidr trees, combating overgrazing, and reducing pesticide usage affecting the bees, the health of Yemenis, and the whole ecosystem.[98] The second most important priority identified is modernizing beekeeping practices with suggestions to build capacities and improve hive models and equipment. Rising corruption was seen as the 3rd most important theme, with interviewees noting that the one YER honey tax for every liter of diesel or petrol sold has not gone to beekeepers. Additionally, arbitrary fees and taxes are often levied on honey, as well as allegations that honey from Kashmir, Pakistan and China is being sold on the local market as *baladi*.[99] The importance of increasing women's role in the sector was also noted. Furthermore, it was also stated that on occasion too many implementing organizations have proliferated beehives in a particular area, limiting income for targeted beneficiaries.

Although beekeeping is traditionally a male occupation, some projects have successfully integrated female beekeepers as beneficiaries. However, simply distributing hives is insufficient to generate income, as beneficiaries have to be trained, and supplies provided. Also, noted were the 30–40 beekeeping cooperatives across the country, which were seen as essential for honey production quality and capacity to improve.[100] A revolving loan fund for beekeepers could be established as a feature of beekeeping cooperatives, to provide members with equipment, training, or support in marketing. Cooperatives could also assist in marketing honey products, an issue noted by three interviewees. A beekeeping specialist interviewed shared an initiative in which customers wanting honey paid a set subscription fee. Unfortunately, the experiment failed because

96 Confidential interviews: 20 May 2024, male, Yemeni academic specializing in apiary sciences; 22 August 2024, female, Yemeni beekeeping technician.

97 Confidential interviews: 29 May 2024, male, Yemeni environmentalist; 7 September, 2024, male, Yemeni head of a training institute.

98 Confidential interviews: 19 May 2024, male, Yemeni academic specializing in apiary genetics; 5 June 2024, male, Yemeni manager in a quasi-governmental entity.

99 Confidential interviews: 19 May 2024, male, Yemeni academic specializing in apiary genetics; 20 May 2024, male, Yemeni academic specializing in apiary sciences; 30 May, male, male, Yemeni manager with an international organization.

100 Confidential interview 20 May 2024, male, Yemeni academic and head of a cooperative umbrella organization.

the organizers did not to listen to the experts, who said that the area could only sustain 200 hives and instead put in 2,000 hives.[101]

Yemeni honey has a strong brand domestically, regionally, and in the diaspora. There is an emerging local market for high-quality cosmetics produced by female entrepreneurs, including those made with honey and beeswax. These two factors could provide a unique opportunity to capitalize on developing a line of cosmetics utilizing honey and beeswax that could be branded similar to Burt's Bees, a large American-based multinational corporation whose cosmetics originally were all based on honey and beeswax. There is a new App called *Yemen Living*[102] that sells high-quality locally produced items inside Yemen that could be used to market such a line domestically. *Bazzarry* (https://bazzarry.com/) is the first professional Yemeni online shopping platform that could also be utilized as a marketing platform for honey and beeswax products, as well as for other items.

2.4.2 Coffee

The origins of the coffee plant (called *qahwa* or *bunn* in Yemen) lie in the highlands of Ethiopia, but it was in Yemen where the bean was first brewed as a hot beverage and from where it was launched into global popularity. In the 15th century it was Sufis (Muslim mystics) who used this stimulant, as well as *qat*, to enhance their spiritual life. *Qahwa* soon spread to Istanbul, Cairo and Mecca via the Ottomans (who occupied the country 1538–1636 AD and again 1849–1918 AD) and then to Europe. Coffeehouses soon spread in the Middle East and Europe, with its consumption becoming a social phenomenon. The bustling port of al-Mokha became a hub for coffee trading beginning in the 15th century, peaking in the 17th, and continuing until the 18th century. The term 'Mocha coffee,' a dessert-like coffee beverage, evokes this Red Sea port and the rich, almost chocolate-like taste of Yemeni coffee.

Given the deep historical and cultural record of coffee in Yemen it is not surprising that it was the most commonly referenced crop in this research. Traditional coffee growing practices shared by interviewees included: cultivating coffee on terraces using traditional plowing methods with oxen[103]; shading coffee with other trees and intercropping[104]; mulching the trees to retain

101 Confidential interview 20 May 2024, male, Yemeni academic specializing in apiary sciences.

102 This App can be downloaded at *https://play.google.com/store/apps/details?id=com.yemen.living&hl=en*.

103 Confidential interview 26 August, male, Yemeni public sector water and climate specialist.

104 Confidential interviews: 29 May 2024, male, Yemeni head of an international organization; 17 August 2024, male, Yemeni chair local community committee, Ta'iz.

moisture[105]; specific practices in pruning and harvesting berries[106]; utilizing irrigation from rainwater storage based on traditional distribution[107]; and selecting the best coffee trees for the size of the bean and ability to thrive in difficult conditions, such as low or excessive rainfall.[108]

Table 3: Common coffee themes

Theme	Frequency
Lack of water, need for rainwater storage	18 mentions
Reliance on organic cultivation methods	10 mentions
Replacing *qat* with coffee	9 mentions
Need for marketing support	9 mentions
Controlling invasives	8 mentions
Importance of women in coffee cultivation	8 mentions
Need for quality control	8 mentions
Engaging governments in coffee sector	6 mentions

Table 3 highlights some traditional practices, as well as salient challenges, mentioned by interviewees. The most significant theme noted was that coffee is traditionally and remains today primarily a rainfed crop, with many highlighting the importance of expanding rainwater storage capacities. Additionally, the second most common topic mentioned was that coffee cultivation continues to be almost exclusively organic, with no chemical fertilizers or pesticides. Replacing *qat* with coffee, the two leading cash crops in the country, was identified as essential to reduce groundwater depletion and increase sustainability. In Haraz, south of Sana'a, there has been a movement to replace *qat* with coffee, a process encouraged by the Ismaili Bohara community, including issuing several *fatwa* (religious legal ruling) proscribing chewing *qat*. "*There are many places in Ta'iz where coffee is grown alongside* qat *trees. Unfortunately, when using chemical fertilizers or pesticides on* qat *trees, the coffee trees are contaminated. Therefore, we avoid dealing with anyone who grows coffee near* qat *trees, as these chemicals significantly impact the beans, trees, and soil.*"[109] The lack of marketing support for coffee farmers, along with controlling invasives, and the lack of quality control for coffee were also key themes. One interviewee mentioned that in visiting coffee processing and exporting facilities in Yemen, he witnessed cheaper coffee from Ethiopia and other countries being labeled as Yemeni.[110]

A number of challenges were shared by research participants related to coffee cultivation. A significant one cited was the reality that coffee as a cash crop takes years to produce income. One interviewee noted: "*It is a long-term*

105 Confidential interview 17 August 2024, male, Yemeni farmer, Ta'iz.

106 Confidential interview 29 May 2024, male, Yemeni head of an international organization.

107 Confidential interview 17 August 2024, male, Yemeni member, local community committee, Ta'iz.

108 Ibid.

109 Confidential interview 31 August 2024, male, Yemen chair of a private company.

110 Confidential interview 17 August 2024, female, Yemeni chair of a women-led local CSO, Ta'iz.

investment for the farmers themselves with an eye to their children and grandchildren, thus it contributes to a sustainable future." [111] A further challenge is that of climate change, with irregular and decreasing rainwater and groundwater, reiterating the most common theme emerging from the interviews (Table 3), the need for expanded rainwater storage capacity. It was noted by an interviewee that although drip irrigation is an important climate-smart practice, it doesn't work with coffee cultivation, as plowing fields destroys the pipes and irrigation heads.[112] A further issue identified was that of coffee trading, noting that farmer incomes suffer from the many intermediaries in marketing coffee.[113] It was noted that by selling green coffee, farmers receive a much lower price than if they were to roast it cooperatively.[114] Lack of roasting, peeling, and milling machines was therefore another issue.[115] Loss of traditional knowledge about cultivating coffee was noted by sources, with one mentioning that traditionally coffee seedlings are companion planted with other trees, but inexperienced farmers plant them in the hot sun.[116] Finally, the lack of roads and basic services increases the expense and complexities of growing coffee and the conflict in Ta'iz has divided the governorate, which is challenging for coffee growers.[117]

Interview Quotation

"Unfortunately, conferences convened by the government and local authorities regarding agriculture and coffee are merely formal events that do not target real farmers. For instance, just the day before yesterday, I attended the economic exhibition in Ta'iz, which an international organization supported (estimated between $20,000 to $30,000) with funding shared among the implementers, and nothing reaching the farmers. If it does, it is just crumbs. They present fictional plans and strategies only on paper that are always the same with no new initiatives. I left the exhibition halfway through because the plans were grand, but the implementation was zero."
Confidential interview 21 October 2024, male, Yemeni chair of a local agricultural cooperative

Fortunately, the coffee sector has received support from international and local organizations and companies, seeking to highlight the historic and contemporary importance of Yemen's history of coffee. One organization combines women's literacy classes to teach students about climate-smart agriculture and coffee cultivation and provides them with free coffee seedlings.[118] Another organization is seeking to support some coffee farmers to become

111 Confidential interview 29 May 2024, male, Yemeni head of an international organization.

112 Confidential interview 10 October 2024, male, Yemeni researcher working for a donor agency.

113 Confidential interviews: 17 August 2024, female, Yemeni chair of a women-led local CSO, Ta'iz; 1 September 2024, male, Yemeni head of research and environment in a local CSO, Aden.

114 Confidential interview 17 August 2024, female, Yemeni chair of a women-led local CSO, Ta'iz.

115 Confidential interview 21 October 2024, male, Yemeni chair of an agricultural cooperative, Ta'iz.

116 Confidential interviews: 29 May 2024, male, Yemeni head of an international organization; 17 August 2024, male, Yemeni chair local community committee, Ta'iz.

117 Confidential interview 21 May 2024, 21 May 2024, two women, staff of a donor to Yemen.

118 Confidential interview 29 August 2024, male, Yemeni head of a youth-led diaspora organization focusing on coffee.

traders.[119] It was noted by a number of informants that enhanced cooperation around coffee would be beneficial, including cooperatives, local CSOs, local authorities, donors, UN agencies, and INGOs, driven by bottom-up consultative design and implementation processes.[120] Fortunately, in the coffee sector there are numerous cooperatives and CSOs which are active in supporting farmers, including women engaging in the sector.

2.4.3 Medicinal and Culinary Plant Foraging

Yemen's rich biodiversity offers a wide array of medicinal and culinary plants that have been foraged since ancient times (al-Duais & Jetschke 2012). The country's varied climate and topography, ranging from coastal plains to highland mountains to desert, create unique habitats for diverse flora. Foraging for medicinal and culinary plants remains an integral part of Yemeni culture, as a traditional practice and means of sustenance and healing. Many of the flora have been scientifically studied for therapeutic properties, or for use in the pharmaceutical, cosmetic, and nutraceutical (foods intended for preventing or treating disease) industries. While the list is long, notable examples include Frankincense (*Boswellia sacra*), Myrrh (*Commiphora myrrha*), Dragon's Blood (*Dracaena cinnabari*) unique to the island of Soqotra, and a number of varieties of Aloe.

Plant foraging in Yemen is deeply rooted in history and traditions. Many Yemeni families and traditional healers have transmitted knowledge about local plants across generations. This expertise includes identifying plants, understanding their seasonal availability, and recognizing their medicinal and culinary uses. Herbal remedies are still widely used, especially in rural areas where access to modern healthcare may be limited (Ali et al. 2017). Additionally, culinary dishes often use foraged plants such as *maraq hamidh* which contains *halqa* (*Cyphostemma digitatum*), a quintessential herb in many Yemeni kitchens. Truffles for food and medicinal purposes sought in the desert and central highlands was documented from the 13th century AD in Yemen (Varisco 1994). Mushroom foraging for medicinal purposes is also commonly practiced (al-Fatimi et al. 2006), with the foragers knowing the time and location to find specific mushrooms.

Interview Quotation

"I would like to research shadhab *(rue herb),* uzab *(marjoram) and other Yemeni aromatic plants. I also like to research the medicinal effects of consuming prickly pear and tamarind.* Datura *(thornapple) is a widely spread weed, and an industry could emerge from its collection and extraction."* **Confidential interview 1 September 2024, male, Yemeni academic pharmacist**

119 Confidential interview 15 October 2024, male, Yemeni head of an agriculture focused local CSO.

120 Confidential interviews: 21 May 2024, two women, staff of a donor to Yemen; 22 May 2024, 1 man and 1 woman, staff of a donor to Yemen; 18 August 2024, 8 women, Yemenis working in a food processing factory; 15 October 2024, male, Yemeni chair of an agricultural local CSO; 21 October 2024, male, Yemeni chair of an agricultural cooperative, Ta'iz.

A number of interviewees noted that foraged medicinal and culinary plants are a tradition which currently faces many challenges. Overharvesting and habitat destruction due to urbanization, agriculture, and climate change threaten the availability of wild culinary and medicinal plants. The dire economic situation of many families due to the conflict is another factor that has contributed to overgrazing by livestock and overharvesting of wild forage plants. Additionally, foragers in conflict zones face the threat of landmines. An IRG report from 2016 notes that the ongoing conflict in Yemen has exacerbated these issues, disrupting traditional practices and access to foraging areas (Republic of Yemen (2016). The report goes on to list a number of endangered wild foods, both flora and fauna, and states that there are no projects seeking to support and maintain such sources.[121] Furthermore, the loss of traditional knowledge poses a significant risk. Younger generations are increasingly disconnected from the practice of foraging, as modern lifestyles and migration to urban centers has reduced their exposure to these customs (Ali et al. 2017). Efforts to document and preserve this knowledge are critical to ensure the survival of this rich resource.

Women take the lead in medicinal and culinary plants gathering and processing. They are the stewards of Yemeni ethnobotany, and they train their children and even adult men to assist in plant and habitat recognition, harvest timing, and processing. Women process and store plants in their kitchens and storage rooms. Over the course of a normal day in a traditional family home, a mother may ask her eight-year-old son to collect the succulent leaves of *khidhrab* (*Senecio hadiensis*) to cover the bed of his newborn sister to soothe her inflamed skin to help her sleep. She may also ask her husband to cut and dry some branches of *qaradh* (*Acacia etbaica*) to prepare a baby powder. The grandmother may ask her husband to bring *dhadah* (wild amaranth) and *qunayqala* (common purslane or *Portulaca orlaca*) from the field to use in a luncheon stew. The daughter-in-law will go to collect fuel for cooking and her mother-in-law may request she bring back some *shahth* (*Dodonaea viscosa*) to smoke the *haqin* and fresh *halas* (*Cissus rotundifolia*) leaves to use for breakfast the next day. The mother-in-law may also ask for her to find some *'ithrub* (*Rumex nervous*) to prepare a poultice for her husband's sprained ankle. The list of foraged plants goes on and on according to the daily needs of the family and the knowledge of the women of the household.

Promoting sustainable foraging practices is essential to preserve Yemen's biodiversity, human wellbeing, food security, and cultural heritage. Initiatives in community-based conservation programs and educational campaigns can help address overharvesting and habitat loss. Encouraging the cultivation of wild plants, such as aloe vera, *halqa*, and *al-wars* (*Flemingia grahamiana* – a

121 Ibid.

traditional plant use for medicinal purposes and for dying fabric), can also reduce pressure on natural populations and provide economic opportunities for local communities. Maintaining a healthy habitat for culinary and medicinal flora also provides honeybees with forage plants. This rich ethnobotanical cultural knowledge of women needs further research and support as an alternative for market dependency.

2.4.4 Section Conclusion

In conclusion, the topics covered in this section are key elements of climate-smart agriculture in Yemen relevant to many aspects of daily life and livelihoods. It is estimated that bees are essential to pollination of an estimated 35 percent of crops globally,[122] yet these busy creatures face significant threats in the country. The cultural and economic importance of both honey and coffee in the country warrant attention to bolster habitats, practices, and capacities. Medicinal and culinary foraging help keep Yemenis healthy through herbal healing practices and by providing important micro-nutrients for families. Pollinators and wild foraging both require action to address challenges, mitigate negative impacts, and arrive through consultation at creative solutions.

3 Conclusion and Recommendations

3.1 Conclusion

The global phenomenon of climate change is impacting all countries, but conflict-torn countries with long littorals and high levels of poverty such as Yemen are bearing a disproportionate impact of the crisis. Despite the country's low global per capita greenhouse gas emissions, ranked 181st out of 191 nations,[123] this has not spared Yemenis from suffering as a result of the climate crisis. Insidious changes have been impacting the country for decades, and the cumulative impact of such forces is leading to an increase in dramatic and devastating climate events. While the trajectory of this trend is unknown, evidence-based predictions hold that such challenges will only increase.

Interviews were conducted with 35 individuals working for the IRG government in various roles, with many other informants emphasizing the important role of the government. This included highlighting the work of MAIF, and AREA, as well as the Ministry of Water and Environment (MWE) and the EPA. While it

122 See *https://www.weforum.org/stories/2019/12/protect-pollinators-food-security-biodiversity-agriculture/* (18.05.2025).

123 See *https://www.emission-index.com/countries/yemen* (18.05.2025).

was recognized that these entities faced many challenges before 2015, since then their role has significantly decreased with severe budgetary shortfalls, increasing allegations of corruption, and a loss of many qualified staff. However, despite such issues, the government was viewed by many informants as essential to further climate-smart agriculture in the country. Interviews illustrated that there remain many highly qualified agricultural specialists who have continued in their positions despite difficult circumstances. Bright spots identified by interviewees included the work of AREA, support from MAIF for agricultural cooperatives and WUAs, and opportunities presented by international climate-funding mechanisms.

The IRG's October 2024 Climate Financing Country Programme for 2025–2030 submission to the Green Climate Fund seeks to address critical issues in agriculture, livestock and water management, although translating such ideas into action remains to be seen (Republic of Yemen 2024). Bold initiatives such as the Great Green Wall in eleven countries across the center of Africa seeking to combat desertification, address livelihoods, and mitigate the impact of climate change are cautiously inspiring (Transparency International 2023). The strategic vision and benefits of this coordinated effort could be a model for furthering climate-smart agriculture in Yemen. While such an undertaking would require significant investments it is incumbent on Yemenis, supported by the international community, to explore similar largescale visionary actions.

Climate crisis challenges facing Yemen will continue to have an increasing impact on the agriculture sector including severe repercussions in water availability and livestock. This context dictates the essential transition to more climate-smart agricultural practices in the country. Yemeni farmers and rural communities will face considerable obstacles, but they have ancient traditions in creative problem solving and deep resilience to draw on. Moreover, there are many initiatives striving to implement strategic interventions, halt unsustainable practices, and craft cooperative action and coordination. These initiatives are the only way forward and relevant stakeholders need to work together on cooperative efforts, including furthering a humanitarian-development-peace (HDP) nexus approach.

3.2 Recommendations

The following recommendations emerging from interviews, extensive literature review, and the knowledge of the research team are directed at various stakeholders. As much as possible, the authors have sought to present actionable recommendations that integrate the inputs provided by the 180 interview participants and the feedback from the January 2025 workshop.

3.2.1 Donors

1. Request implementing partners to immediately cease support for solar-powered irrigation pumps and shift to sustainable rainwater harvesting investments supporting water-use efficiency in agriculture, such as drip irrigation and greenhouses.
2. Explore providing technical support to the IRG in order to access green climate funding via bi-lateral and multi-lateral instruments. This could include large-scale interventions such as the Great Green Wall initiative in Africa mitigating desertification, flooding, and drought, as well as expanding local agricultural production to contribute to sustainable food systems. Strategic initiatives could also include establishing a small grants fund for local civil society to incubate, accelerate, and scale up promising climate-smart agriculture initiatives.
3. Hold implementing partners accountable to their global localization commitments with a specific focus on climate-smart agriculture. As a cross-cutting approach interventions should strengthen engagement with local CSOs, WUAs, agricultural cooperatives and producer associations, with a particular focus on those with strong female leadership. This will broaden the impact of interventions from supporting individual farmers to fostering community-wide impact. Ideally this would include engaging with the IRG and de facto authorities to strengthen agricultural cooperatives and producer associations as mechanisms to support farmer investments in greenhouses, drip irrigation, rainwater harvesting, and storage capacities, as well as to facilitate post-harvest processing, marketing, and capacity strengthening for farmers.
4. Ensure private sector engagement in relevant aspects of climate-smart agriculture and invest in improving the enabling environment for agricultural entrepreneurs and businesses. Engage with the private sector to foster local solutions and support Yemeni entrepreneurs, including women and youth, to address challenges and contribute solutions to climate-smart agriculture.
5. Strengthen coordination efforts among donors and international organizations to consult with local stakeholders, including civil society and farmers, to develop higher-level strategies in climate-smart agriculture by addressing needs from the bottom up. Utilizing an HDP nexus approach around climate-smart agriculture could improve outcomes and maximize impact.
6. Support locally driven programming that addresses needs in the water, environment, and agriculture sectors in specific locations, an approach that holds promise to contribute to climate-smart agriculture. However, area-based programming should be evaluated, including the impact of such efforts in the 1980s in the country when this was a significant development approach.

7. Support efforts to address the cooking fuel crisis in Yemen, as the situation is causing grave damage to pasturelands and deforestation, which is resulting in soil erosion and contributing to the intensity of flooding in agricultural lands.

3.2.2 International Organizations

8. Create opportunities supporting farmers with various types of climate-smart financing, ranging from pilot interventions to largerscale investments. This could include support for expensive agricultural investments such as drip irrigation, greenhouses, and rainwater harvesting and storage systems, with a particular focus on financing for female farmers. However, this support should exclude solar-powered irrigation pumps that contribute to overextraction of groundwater.
9. Utilize an integrated approach to water resource management that strengthens climate-smart agriculture, agroforestry, and biodiversity. This could prioritize renewable water resources relying on rainwater harvesting, storage, and water-use efficiency through drip irrigation, and greywater reuse, halting overexploitation of groundwater. This sustainable approach will increase agricultural productivity, reduce the threat of flooding, and reinforce traditional water resource management practices. Invest in initiatives to meet the demand for organic compost and fertilizers, and further permaculture approaches. Initiatives in livestock fodder production and alternative cooking fuel will preserve threatened culinary and medicinal foraging practices and contribute to improved rangeland health.
10. Support cash-for-work interventions to contribute to flood mitigation and water-use efficiency, possibly including but not limited to: planting trees on slopes above agricultural fields; rehabilitating and establishing check dams, surface stone chains, and barriers near fields and orchards; terrace rehabilitation; installing gabion cages or recycled tires in *wadi*s and strategic locations; and strengthening inexpensive and simple rainwater harvesting solutions. Ensure such efforts are gender-sensitive and integrate women in the design of activities and payment mechanisms.
11. Contribute to localization by shifting the focus of interventions from the individual to the community level. This should actively engage local civil society, including WUAs, agricultural cooperatives, and producer associations, in designing, implementing, monitoring, and evaluation programming. Additionally, this approach should include a specific focus on initiatives that are led by and actively engaging women, youth, and minorities. Gender considerations need to be mainstreamed from the beginning and reflect challenges that rural Yemeni women face such as high levels of illiteracy and lack of technical knowledge. Engagement with CSOs and

CBOs should avoid blanket beneficiary selection processes and deepen the impact of interventions, particularly important in livestock distributions which can contribute to overgrazing and market saturation, at times resulting in poor animal health and limiting benefits to women livestock owners. This approach should be accompanied by robust monitoring, evaluation, and learning (MEL) systems seeking to measure community level impact, and generate lessons learned that can benefit scaling up interventions. Additionally, when introducing new crops or livestock breeds first pilot activities along with strong MEL efforts to assess challenges and document lessons learned and ensure that farmers are trained on essential information and skills for success.

12. Foster veterinary service in rural areas potentially including community-based livestock pharmacies or animal health workers trained to treat commonly encountered diseases. In peri-urban areas veterinary vouchers could be utilized for immunizations, medicines, and other services. Ensure that a high proportion of animal health workers are female, who are better able to provide services to women rearing and breeding livestock.
13. Engage with the private sector in climate-smart agriculture. This could include incentivizing local nurseries to cultivate and disseminate heat-, drought-, and salt-tolerant plants and disseminate advice and information on climate-smart agriculture topics. Invest in expanding small-scale nurseries, or farmer operated sales points, with a focus on women-operated nurseries and female farmers. This should include working with MAIF nursery services and female extension agents to support women farmers with climate-smart seeds and seedlings, supplies, and information on fodder options such as Azolla, elephant grass, and black soldier fly production units, among others.
14. Facilitate micro-, small-, and medium-sized initiatives to scale-up post-harvest activities among women utilizing transformative approaches. This could include developing a Yemeni signature brand of local honey/beeswax-based cosmetics to be marketed domestically, regionally, and among the Yemeni diaspora. This could also support female farmers and rural women to use green technologies to process juices, jams, pickles, and drying fruit, legumes, and spices.
15. Foster opportunities for young men and women to innovate and develop creative solutions to agricultural challenges, including agritech initiatives. This approach could engage with the private sector, local civil society, and entrepreneurs to address deforestation by scaling up and piloting fuel-efficient stoves powered by green or alternative energy source for bakeries, restaurants, homes, and in IDP camps.

3.2.3 Local Civil Society

16. Catalyze young people and broader society to engage in conserving water, as well as promote environmental protection through tree-planting campaigns in rural and urban areas, water conservation awareness, and seeking to foster enthusiasm for climate-smart agriculture. This could include disseminating halophyte plants and trees in urban areas to provide animal fodder and shade, and combat desertification and soil salinity.
17. Promote gender equity in the management of water resources in agriculture with a focus on WUAs, agricultural cooperatives, and producer associations as important partners in rural communities. This would foster partnerships and strengthen capacities in CBOs and shift the focus of interventions from individual farmer level to the community. This could also include establishing networking opportunities among such CBOs as a way to strengthen the civil society sector.
18. Invest in female and youth livelihood entrepreneurial opportunities in rural communities. This could potentially include providing grants and diverse lending instruments prioritizing food processing initiatives to reduce post-harvest food losses including dairy, coffee, honey/beeswax, and other activities. This approach could also address the challenge of the cooking fuel contribution to deforestation and rangeland destruction.
19. Support home gardening efforts targeting women to cultivate vegetables and breed chickens, rabbits, pigeons, and quail on balconies, rooftops, in window boxes, and backyards to contribute to food security and potentially earn income. Additionally, in urban areas pilot community or collective gardens, and demonstration plots on fallow land, as well as locate farmers markets close to populations echoing the tradition of weekly markets.
20. Create advice hotlines and support Apps for various target audiences, including urban farmers to address common challenges, as well as provide advice to farmers on marketing livestock and agricultural produce. This could be carried out potentially in collaboration with cooperatives and MAIF staff. These services could also provide early warning mechanisms for cyclones and extreme weather events.
21. Explore the possibility of community-based livestock pharmacies and primary care veterinarians, as well as community operated nurseries and seed banks. These locally operated community initiatives could potentially be operated by agricultural cooperatives or other CBOs.
22. Invest in local nurseries, CBOs, CSOs, and universities to build their capacity to disseminate information about the impact of climate change on agriculture and climate-smart agricultural initiatives. Such partnerships can also seek to promote community seed banks to facilitate farmer access to this critical input.

3.2.4 Private Sector

23. Banks and micro-finance institutions: Recognize the important role of women in climate-smart agriculture, expand the number of female lending officers, and adjust procedures to facilitate lending to female farmers. This could include waiving the need for national identification or fees. Explore the possibility of roving female finance officers who are able to facilitate applications and collect payments for women engaging in post-harvest processing, fodder production, or agritech initiatives.
24. Nurseries: Scale up cultivating and disseminating heat-, drought-, and salt-tolerant plants, and provide advice and information services to farmers engaging in climate-smart agriculture. This could also include improved livestock fodder plants, supplies, and production information on Azolla, elephant grass, black soldier fly production units, among others.
25. Support innovation and creative problem with various local entities to address climate-smart agriculture challenges through strategic partnerships with local civil society, quasi-governmental entities such as SFD and SMEPS, and government/local authorities. This could include supporting the production and marketing of post-harvest products such as honey/beeswax products locally and for export. This could also include supporting the production and sale of *baladi* (local) products.
26. Cooperate with private sector initiatives such as *Yemen Living* App (https://play.google.com/store/apps/details?id=com.yemen.living&hl=en) and *Bazzarry* (https://bazzarry.com/), both selling high-quality locally produced items inside Yemen as a way to strengthen the income earning potential of Yemeni entrepreneurs. These initiatives could potentially be scaled up to market Yemeni products internationally.
27. Explore ways to address the environmental destruction caused by the cooking fuel crisis in cooperation with key stakeholders. This could include providing bakeries or restaurants with solar-powered stoves or panels to operate their ovens and/or fuel coupons for gas cylinders, distributing fuel efficient stoves, solar dryers, or solar-powered stoves to households, and subsidizing bio-gas units for clean cooking.

3.2.5 Quasi-Government Agencies

28. Expand rainwater harvesting efforts in rural communities for climate-smart agriculture infrastructure, including the rehabilitation and construction of terraces and rainwater channeling and storage capacities. Also, improve road networks and drainage to direct rainwater for agricultural purposes, and other interventions discussed in more detail in the body of the report. Initiatives could utilize cash-for-work modalities to strengthen water-use efficiency, climate-smart agriculture, and flood mitigation in rural farming communities.

29. Foster home-gardening initiatives to provide fresh vegetables in rural and urban areas, potentially utilizing water from rooftop rainwater harvesting systems. This could include supporting entrepreneurs to produce fabric grow bags for crops and other inputs such as seeds, seedlings, tools, and organic compost.
30. Invest in reducing post-harvest food losses at the community level including supporting cold storage facilities and transportation. At the individual level this can include green technologies such as solar food dryers and small-scale solar cold storage containers for farmers, with a focus on female farmers, to transport dairy products and other perishables for processing or to access markets. Expand marketing support for produce and post-harvest products, specifically targeting female farmers and rural women, to improve their access to marketing channels.
31. Support diverse funding mechanisms for micro-, small-, and medium-sized enterprises to invest in private sector climate-smart agriculture initiatives. This could include expanding existing loan guarantee programs to rural areas to benefit women and youth, potentially working in partnership with local CBOs to expand local fodder production. Scale up Azolla and elephant grass production or de-thorning prickly pear fronds for fodder in partnership between local cooperatives and women-led CSOs in targeted communities. Additionally, such mechanisms could explore various approaches to bioconversion technology utilizing black soldier fly larvae, meal worms, and super worms for poultry fodder. Women engaging in small-scale black soldier fly larvae production units has been piloted in Kenya with promising results.
32. Promote protection of rangeland and address overgrazing through various initiatives in medicinal and culinary foraging, honey production, and mitigation of the impact of flooding in rural communities. This could include community-based conservation and educational cultivation of indigenous wild flora, as well as research on the rich ethnobotanical cultural knowledge of women.

3.2.6 Government and Local Authorities

33. Invest in early flood-warning mechanisms to facilitate the ability of IDPs and farming communities to protect human life, livestock, agricultural tools, infrastructure, homes, and household goods.
34. Strengthen policies and regulations that: limit groundwater overextraction, including the use of solar-powered irrigation pumps; promote water-use efficiency in agriculture; and mitigate the impact of flooding in agricultural communities.

35. Improve the enabling environment and regulatory context for agricultural cooperatives, producer associations, and WUAs to expand the impact of their activities in support of food security and climate-smart agriculture.
36. Create/reactivate the distribution network of high-quality seedlings, saplings, and seeds to community seed banks, nurseries, and agricultural cooperatives, accompanied by information on water-use efficiency, plant protection, and other key themes.

Annex A: Gender Dimensions of Select Findings and Recommendations

The table below presents select findings and recommendations and articulates relevant gender dimensions. It is not comprehensive in addressing all recommendations included in the previous section but presents those with strong gender dimensions. In the final right-hand column, the following abbreviations/acronyms indicate the category of stakeholder recommendations: donor=D; international organization=IO; local civil society=LSO; PS=private sector; quasi-governmental entities=QG; government/local authorities=G/LA.

Select Finding	Gender Dimensions	Select Recommendation
Water in Agriculture		
WUAs were seen by interviewees as community-based institutions that have potential to improve water-use efficiency. However, there are numerous factors limiting their effectiveness (Bruns Taher 2009) and with the conflict these CBOs have been weakened. There are initiatives underway to strengthen them including providing conflict-resolution training to address water conflicts.	There have been a number of initiatives to strengthen the role of women and youth in WUAs. However, interviewees noted that female members face significant challenges to meaningfully engage in decision-making and water resource management in general, reiterated by several studies (Boyer, Shakir & al-Areeqi 2024; Zabara 2018). Women and girls suffer from the consequences of water conflicts and often play an informal role in mediation, which can be enhanced.	Contribute to localization shifting the focus of interventions from the individual to the community level by working through local civil society, including WUAs. This should include a specific focus on initiatives that are led by and actively engage women, youth, and minorities. Gender considerations need to be mainstreamed from the beginning and reflect challenges that rural Yemeni women face, such as high levels of illiteracy and lack of technical knowledge. (D, IO, LCS, G/LA)
Lack of funding for farmers to purchase water-use efficient farming equipment such as greenhouses and drip irrigation systems was identified as an issue. Although 51% of agriculture is rainfed, investment in rainwater harvesting and storage infrastructure for crops is expensive with few financing options.	Women in general face many more challenges in accessing all types of funding than their male counterparts (Sana'a Center for Strategic Studies 2024). Further, although women bear considerable responsibilities for many aspects of rain-fed agriculture there is limited recognition and support for such efforts (Adra 2013).	Strengthen mechanisms for farmers to access funding for expensive investments such as drip irrigation, greenhouses, and rainwater harvesting infrastructure, with a particular focus on financing for female farmers. (IO, PS, QG)

Select Finding	Gender Dimensions	Select Recommendation
Informants noted that rural communities in areas prone to flooding lack early warning systems that would save lives and preserve agricultural assets.	Flooding disproportionately affects women in Yemen, as an estimated 80% of all IDPs in Yemen are women and children (UNFPA 2023). IDPs often reside in sub-standard shelters in areas prone to flooding.	Explore ways to support early flood warning systems to provide farming communities with the time to protect human life, livestock, agricultural tools, and other portable assets. (LSO, G/LA)
In agricultural communities susceptible to flooding traditional structures and practices that mitigate flood damage have deteriorated. Additionally, it was noted across all categories of informants that with climate change the intensity and likelihood of flooding is increasing requiring strengthened mitigation efforts.	According to a 2022 study, women are rarely involved in designing cash-for-work activities and such programming has had limited impact on gender relations in beneficiary families (Shuoaib 2022). A further study in 2019 found that women participating in cash-for-work activities had to travel far to collect their payment and such locations had limited privacy (Grassroots Yemen 2019).	Support cash-for-work efforts possibly including but not limited to: planting trees on slopes above agricultural fields; rehabilitating and establishing check dams, surface stone chains, and barriers near fields and orchards; terrace rehabilitation; installing gabion cages or recycled tires in *wadi*s and strategic locations; and strengthening inexpensive and simple rainwater harvesting solutions. Ensure such efforts are gender-sensitive and integrate women in the designing of activities and payment mechanisms. (IO, G/LA)

Select Finding	Gender Dimensions	Select Recommendation
Agriculture		
Yemeni civil society has a long history, including decades of experience and capacity among agricultural cooperatives. However, the conflict has had a negative impact on cooperatives. Additionally, the localization agenda of international organizations working in partnership with local entities has been extremely weak in Yemen, including implementation of agricultural interventions.	Yemeni women have played a significant role in local civil society across sectors, including as members and at time leaders in mixed gender cooperatives, and a few women-only cooperatives. Cultural traditions in many parts of the country often sideline women, even when they are elected/appointed to community committees, WUAs, or cooperatives. Additionally, with the conflict it is unclear if any women-only cooperatives are still operational.	Work through local CBOs and CSOs in climate-smart agriculture to shift the impact of interventions from supporting individual farmers to community-level impact. This should include support to agricultural cooperatives, particularly those with strong female membership and/or women-led organizations and initiatives. This will contribute to localizations efforts and further opportunities to reduce post-harvest losses, improve water-use efficiency, strengthen agricultural yields, and thus increase food security. In such efforts seek transformative approaches that support female farmers and rural women not just as laborers. (D, IO, LCS, QG, G/LA)
There is a need for innovation and engagement of young people and women in climate-smart agriculture.	Women provide an estimated 60% of labor in crop cultivation through wage labor and as unpaid family members (IFAD 2011). Issues such as rural female illiteracy, lack of connectivity,[124] and cultural norms often prevent women from accessing innovative opportunities, particularly in climate-smart agriculture and water.	Foster opportunities for young men and women to innovate and develop creative solutions to climate-smart agriculture challenges, including agritech initiatives. (IO, LSO, PS)
A variety of international and local entities are engaging in activities reducing post-harvest losses, with SFD and its subsidiary SMEPS being pioneers in this area.	Yemeni women play a significant role in post-harvest processing, including leading in dairy production. Most implementing organizations seek to ensure that at least 30% of beneficiaries are female, although participation varies. Women face more challenges than their male counterparts in securing raw materials and marketing their products, among other issues.	Support communities to reduce post-harvest losses including cold storage facilities and transportation. At the individual level this can include green technologies such as solar food dryers and small-scale solar cold storage containers for female farmers to transport dairy products and other perishables for further processing or to the market. (LCS, PS, QG)

124 Only 17.1 percent of Facebook users were female in December 2024: *https://napoleoncat.com/stats/facebook-users-in-yemen/2024/12/.*

Select Finding	Gender Dimensions	Select Recommendation
Many farmers lack seeds, seedlings, and saplings that are climate-smart, as well as more general information on the impact of climate change and potential mitigation measures. Unfortunately, nurseries are often located in urban or peri-urban areas, far from rural agricultural areas that lack roads and are in mountainous terrain. Additionally, with the conflict, MAIF nursery services and extension agents have halted or significantly diminished.	Women face cultural and economic constraints to travel outside their area, making it difficult for them to access agricultural services, including nurseries. Additionally, in some conservative areas interacting with male extension agents or nursery owners can be a limiting factor.	Invest in expanding small-scale nurseries, or farmer-operated sales points, with a focus on women-operated nurseries and female farmers. This should include working with MAIF nursery services and female extension agents to support female farmers with advice and climate-smart seeds and seedlings, including fodder plants, supplies, and production information on Azolla, elephant grass and black soldier fly production units, among others. (IO, PS, G/LA)
In many parts of the country soil degradation is increasing due to unsustainable agricultural practices. There is a lack of high-quality organic compost on the market, and chemical fertilizers are expensive. Thus, there is a high demand for locally produced compost. Investments in this area will generate income for producers and contribute to climate-smart agriculture and food security in targeted areas.	Women are responsible for more than 90% in livestock rearing (IFAD 2011), particularly on small-holder farms. Thus, they have access to animal manure that could be used in the production of organic compost, which could provide them with income and contribute to plant protection.	Invest in initiatives to meet the demand for organic compost and fertilizers, also furthering permaculture agricultural practices. (IO, QG)
Urban agriculture and gardening have a long history in Yemen, with many homes in urban and rural areas having gardens. However, with the crisis there is an increasing need to strengthen and improve such traditions, and many urban residents are unaware of climate-smart practices to enhance food security and provide income.	Women cultivate gardens on rooftops (*nakael*), kitchens (*mishkar*), balconies, and backyards. These gardens cultivate herbs, vegetables, and flowers and are often watered with greywater or recycling household water (*gsawel*).	Support home gardening efforts targeting women to cultivate vegetables and breed chickens, rabbits, pigeons, and quail on balconies, rooftops, in window boxes, and backyards to contribute to food security and potentially earn income. This could include an advice hotline or App for gardeners in urban and rural areas or supporting entrepreneurs to produce fabric grow bags for crops and other inputs such as seeds, seedlings, tools, and organic compost. (LCS, QG)
There is a lack of information about climate change and climate-smart agriculture more broadly in the country and among farmers.	High levels of illiteracy and lack of engagement in the public sphere means that women, including female farmers, are less informed than their male counterparts on the impact of climate change and climate-smart agriculture.	Invest in local nurseries, CBOs, CSOs, and universities to build their capacity to disseminate information about the impact of climate change on agriculture and climate-smart agricultural initiatives. (LCS)

Select Finding	Gender Dimensions	Select Recommendation
Livestock Husbandry		
Livestock fodder is very expensive and often unavailable. Commercial livestock businesses are forced to rely on imported feed. During the dry season small-scale feed options are limited by cost and availability, particularly in rural communities, negatively impacting sustainable homestead livestock production.	Women are usually responsible for feeding small-holder livestock, often foraging for cow fodder or providing kitchen scraps to backyard poultry. However, livestock assets have been deeply impacted by climate change, with a survey in 2023 conducted in IRG-controlled areas finding that the farming asset most severely affected by climate change were livestock (32%) (al-Hamdani, Porter & al-Meida 2023).	Scale-up Azolla and elephant grass (a noninvasive soil protection foliage) for fodder production in various parts of the country, refining production methods. The fronds of the prickly pear, a pernicious invasive that grows wild throughout Yemen, can be de-thorned and prized for its delicious fruit. Explore various approaches to bioconversion technology utilizing black soldier fly larvae, meal worms, and super worms for poultry fodder. Women small-scale production of black soldier fly larvae has been piloted in Kenya with promising income earning results. (IO, LCS, PS, QG)
Conservation of rangeland was identified as a critical issue for livestock production, community health, and agroforestry. A variety of systematic factors have been contributing to the deterioration of rangeland, exacerbated by additional challenges posed by the conflict with dire consequences. Two key factors are the lack of consistent cooking gas supply and overgrazing through blanket distribution of livestock under short-term livelihood interventions.	Women are responsible for securing cooking fuel and livestock fodder. In light of rangeland deterioration, the responsibility of women and girls to secure cooking fuel and livestock fodder has meant they have to roam further and further from home putting them at increasing risk of GBV, particularly IDP women and girls.	Move away from blanket distributions of livestock, which can lead to overgrazing (see additional livestock fodder recommendations in the point above). Foster opportunities for young men and women to innovate and develop creative solutions to climate-smart agriculture challenges, including agritech initiatives. This approach could include engaging with the private sector, local civil society, and entrepreneurs to address the challenge of deforestation by supporting various types of stoves that are fuel-efficient or powered by green or alternative energy in bakeries, restaurants, homes, and IDP camps. (IO, LCS, PS)

Select Finding	Gender Dimensions	Select Recommendation
The high mortality rate among livestock in Yemen was noted by numerous informants, who pointed out that this is due to various factors including: limited veterinary services in rural areas; economic hardship preventing access to medicine or vaccination; and access constraints due to gasoline shortages, poor roads, conflict impacting mobility, and the long distances to service points.	Women are primarily responsible for livestock rearing and a 2023 study found that among vulnerable households, 70% of respondents engaged in rearing livestock (Hanna et al. 2023). Women struggle with economic and cultural constraints limiting their mobility and access to veterinary services.	Foster veterinary service in rural areas potentially including community-based livestock pharmacies or animal health workers trained to treat commonly encountered diseases. In peri-urban areas veterinary vouchers could be utilized for immunizations, medicines, and other services. Ensure that a high proportion of animal health workers are women, who are better able to provide services to women rearing and breeding livestock. Such efforts can be provided in partnership with agricultural cooperatives or other CBOs. (IO, LCS)
Critical issues in dairy production include: poor animal health negatively impacting productivity; lack of marketing channels and skills; and sub-standard housing for animals. One of the most significant challenges is the lack of and expense of refrigeration for storage and transportation to processing factories or markets of dairy products. Such factors limit productivity in the sector and contribute to food wastage.	Women are responsible for producing dairy products for household consumption and sale made from cow, goat, or sheep milk. A 2023 study found that among vulnerable households the sale of livestock food products was a primary or secondary source of income for an estimated 25% (al-Hamdani, Porter & al-Meida 2023). When participating in training to improve dairy production or market their produce, women face mobility restrictions, in many areas requiring a *mahram* (male family escort).	Invest in reducing post-harvest food losses at the community level including supporting cold storage facilities and transportation. At the individual level this can include green technologies such as solar food dryers and small-scale solar cold storage containers for farmers, with a focus on female farmers, to transport dairy products and other perishables for processing or to access markets. Expand marketing support for produce and post-harvest products, specifically targeting female farmers and rural women, to improve their access to marketing channels. (LCS, QG)

Select Finding	Gender Dimensions	Select Recommendation
Other Climate-Smart Interventions		
Beekeeping in Yemen faces considerable challenges related to climate-change, overuse of pesticides on *qat* and crops, oversaturation of hives in some areas, and conflict dynamics. Interviewees noted that despite significant investment in the sector, honey production and export have dramatically decreased (ICRC 2024).	Traditionally a male-dominated activity, in recent years there has been increasing support for women beekeepers. Additionally, local female entrepreneurs are creating opportunities in the cosmetics industry using honey and beeswax catering to a growing local market.	Facilitate micro-, small-, and medium-sized initiatives to scale up post-harvest activities among women utilizing transformative approaches. This could include developing a Yemeni signature brand of local honey/beeswax-based cosmetics to be marketed domestically, regionally, and among the Yemeni diaspora. (IO, LCS, PS)
Yemen's rich biodiversity offers an array of culinary and medicinal plants foraging since ancient times. However, with the conflict habitat destruction threatens the availability of wild culinary and medicinal plants and poverty has contributed to overgrazing by livestock and overharvesting of wild forage plants.	Women take the lead in medicinal and culinary plants gathering and processing. They are the stewards of the Yemeni ethnobotany, and they train their children and even adult men to assist in plant and habitat recognition, and knowledge of harvest timing and processing. Women process and store plants in their kitchens and storage rooms.	Initiatives in agroforestry, biodiversity, livestock fodder production, and alternatives to cooking fuel initiatives will preserve threatened culinary and medicinal foraging practices and contribute to improved rangeland health. Such efforts will contribute to medicinal and culinary foraging, honey production, and mitigation of the impact of flooding in rural communities. This could include community-based conservation and educational programs, cultivation of indigenous wild flora, and research on the rich ethnobotanical cultural knowledge of women. (IO, QG)

Annex B: List of Resources

This literature list offers additional resources beyond those cited in the report.

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About the Project

Over the past decades, the negative impact of the climate crisis has become increasingly evident in Yemen. Challenges such as increasing water scarcity, desertification, drought, erratic rainfall, damage to biodiversity and flooding also impact the livelihoods of Yemenis negatively impacting communal, household and individual level resilience. Against this backdrop, this project seeks to contribute to improved programming on food security in Yemen by providing evidence from climate-smart agricultural initiatives in the country that are promising, and conservation approaches that present opportunities for livelihoods opportunities for Yemenis; and by engaging relevant actors in an exchange on these findings. The project is implemented on behalf of Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH Yemen with funding from the German Ministry for Economic Cooperation and Development (BMZ).

About CARPO

CARPO is a Germany-based think tank with a focus on the Orient that works at the nexus of research, consultancy and exchange. Our work is based on the principles of partnership, inclusivity and sustainability. We believe that a prosperous and peaceful future for the region can best be achieved by engaging the creative and resourceful potential of all relevant stakeholders. Therefore, CARPO opens enduring channels for trustful dialogue and interactive knowledge transfer.

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