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Livelihood Resilience and Adaptation Practices Among Agricultural Communities in Yemen

By: Musaed Aklan, Raidan Bassah, and Maryam Abdulrahman

July 16, 2026

A female farmer works on her orchard, Taiz, August 6, 2020 // Sana'a Center photo by Ahmed Al-Basha

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How to cite

Aklan, M., Bassah, R., and Abdulrahman, M. (2026) *Livelihood Resilience and Adaptation Practices Among Agricultural Communities in Yemen. Research Report.* Sana'a Center. sanaacenter.org/publications/policy-research/27659

Acknowledgements

This research report is published under the Supporting Pastoralism and Agriculture in Recurrent and Protracted Crises (SPARC) programme, which is supported by the United Kingdom's Foreign, Commonwealth and Development Office (FCDO).

The authors wish to express their gratitude to the expert advisory members and peer reviewers, Dr Steve Wiggins, Senior Research Associate at ODI Global, and Dr. Abdullah Nasher, Professor in the Faculty of Agriculture at Sana'a University. Special thanks are also extended to Dr. Guy Jobbins for his support throughout the study, and for reviewing an earlier draft and this final report.

We are grateful to the SPARC teams and experts for their support and follow-up, including Pauline Njiraini, Fund Manager; Elizabeth Daley, who discussed the research's gender aspects; Julie Grady Thomas, Publications Production Lead; and the Communication team, represented by Emily Workman and Emma Gogerty.

Our sincere thanks also go to the Sana'a Center Team; Yasmeen Al-Eryani for her oversight and leadership, Yazeed Aljeddawy for coordinating fieldwork, Bilqees Al-Lahabi for ensuring the integration of women's perspectives, and Ashwini Mubarak for her follow-up and coordination with our partners at SPARC. We also thank Lara Uhlenhaut for her insightful editing and for ensuring the report's linguistic quality and consistency. Appreciation is extended to the finance team—Khaled Monassar, Sahl Al-Gunaid, and Yousef Alshawthabi—for their follow-up and adherence to all financial procedures. Our thanks also go out to Khadiga Hashim for the report's design and layout.

Last but not least, we extend our sincere gratitude to the Yemeni farmers and local community members, key informants, and focus group participants whose willingness to share their experiences and perspectives made this research possible. We are especially grateful to the late Iftihan Al-Mashhari, former General Manager of the Cleaning and Improvement Fund in Taiz, for generously sharing her expertise and insights. Her contribution remains invaluable, and we remember her with deep respect.

By grounding this research in local knowledge and lived realities, we hope this report helps address critical evidence gaps on the environmental impacts of conflict and climate change on agricultural communities in Yemen and contributes to more informed, locally responsive policies that support resilient livelihoods and sustainable recovery.

Table of Contents

Executive Summary

"Conflict, climate change, and governance gaps have left huge impacts on rural livelihoods... yet local initiatives and traditions remain the seeds of resilience and peace."[1]

Yemen's ongoing conflict and severe climate shocks have deeply disrupted rural livelihoods, further exacerbating food insecurity, water shortages, and socio-economic instability. While existing literature addresses water and agriculture issues, its ability to inform practical policy recommendations is often hindered by a lack of field data and localized insights into adaptation and governance mechanisms, especially in conflict-affected areas. This study bridges this critical gap by using grounded field data and localized analysis.

Using both qualitative and quantitative methods, the study assesses the livelihood resilience of rural agriculture communities by examining local adaptation practices, with a focus on indigenous agricultural methods and traditions. The research aimed to (i) investigate primary water sources used by Yemeni farmers and determine who controls access to these water sources; (ii) identify local initiatives, adaptations, and external support for farmers that have proven effective at building resilience; (iii) understand current social dynamics, particularly how internally displaced people (IDPs), women, and marginalized groups impact agricultural and water practices and reshape social power structures; and (iv) through its recommendations, determine the social and governance steps necessary to promote and sustain effective water management practices.

To achieve these objectives, the study employed a mixed-methods approach including a desk review of published and unpublished materials, field surveys with 164 individuals from rural areas in Hadramawt, Taiz, Abyan, and Marib, and semi-structured interviews with 20 key informants. Additionally, six focus group discussions were conducted with farmers and experts between July and October 2025.

The paper argues that reviving traditional, locally rooted water systems offers a cost-effective strategy to climate resilience. However, this potential is currently undermined by misguided state policies that favor top-down irrigation and unequal water control, disproportionately harming small farmers, IDPs, and women. In areas where conflict has created a void in state governance, local actors have stepped in—reshaping social hierarchies through traditional tribal mediation, women's economic agency, and innovation led by IDPs. The study concludes that sustaining this important indigenous resilience requires a governance model that combines traditional knowledge with modern methods, provides context-specific support, and respects local norms. Specifically, the paper recommends institutionalizing community-driven frameworks to ensure equitable access to water and agriculture, providing targeted support to marginalized groups, and implementing social and governance measures to promote long-term climate change adaptation and sustainable livelihoods for Yemenis.

[1] Interview with a Yemeni academic and senior officer working with the FAO, July 8, 2025.

1. Introduction

Seventy percent of Yemen's population relies heavily on agriculture for their livelihoods, which is dependent on seasonal rainfall and groundwater resources.[2] The country is facing a historic crisis, marked by declining groundwater levels — a crisis exacerbated by protracted conflict, poor water governance, diminishing social cohesion, and increasing natural disasters, including heavy rains, floods, cyclones, and droughts. Furthermore, climate change has led to significant disruptions in rainfall patterns, adversely affecting agriculture and crop production. As a result, Yemen's rural population is facing severe challenges to their livelihoods.

> Despite Yemen's heavy reliance on food imports, local agriculture remains the main source of employment and income for around 70 percent of the population.

Over the last five decades, irrigated farm lands have expanded nearly tenfold while the total area of agricultural land has decreased significantly by 37 percent.[3] This trend points to desertification along with the long-term retreat of sustainable ancestral practices across vast regions of Yemen. Governmental policies to address the depletion of agricultural land, water supplies, and livestock continue to be insufficient and inadequate.[4] International interventions have broadly failed to engage thoughtfully with the local context,[5] and have prioritized short-term humanitarian interventions, overlooking Yemen's urgent and lasting environmental problems.[6] Amidst the prolonged war, worsening climate impacts, and the difficult economic situation, many local communities have been forced to adapt.

Against this backdrop, this study examines adaptation practices, paying particular attention to indigenous agricultural and water management practices. It explores the social power structures in which these shifts are taking place, the role of marginalized groups (including IDPs and women), the power dynamics of those who benefit or do not from these water practices, how conflict and environmental degradation affect water and agriculture reliability, and which local or externally supported initiatives effectively mitigate climate and conflict-related impacts. By addressing these connected issues, the study aims to find pathways to strengthen water and food security, social equity, and climate resilience in Yemen's war-torn rural communities.

[2] Musaed Aklan, "The Impact of Flooding on Agricultural Communities in Yemen," Sana'a Center for Strategic Studies, March 21, 2024, https://sanaacenter.org/publications/main-publications/22143

[3] "Water availability in Yemen: Literature review of the current and future water resources and water demand in Yemen," Acacia Water, October 1, 2021, https://www.undp.org/sites/g/files/zskgke326/files/migratiocommunitiesn/ye/Water-Availability-Study-in-Yemen.pdf

[4] Ibid.

[5] Simon Levine and Adam Paine, "Ten traps to avoid if aid programming is serious about engaging with context: Lessons from Afghanistan," SPARC, January 24, 2024, https://www.sparc-knowledge.org/publications-resources/ten-traps-to-avoid-aid-programming-context-afghanistan; Maia Baldauf and Musaed Aklan,"Cultivating an Equitable Recovery: A Political Ecology Approach to Agricultural Interventions in Yemen," Sana'a Center for Strategic Studies, December 31, 2023, https://sanaacenter.org/publications/policy-research/21634

[6] Helen Lackner, "Yemen's Vulnerability to Climate Change: How to Strengthen Adaptation," Sana'a Center for Strategic Studies, February 21, 2024 https://sanaacenter.org/files/Yemens_Vulnerability_to_Climate_Change_How_to_Strengthen_Adaptation_en.pd

To accomplish this, the authors conducted an extensive desk review with targeted field surveys across rural communities in Hadramawt, Taiz, Abyan, and Marib. Primary qualitative and quantitative data were gathered through a series of semi-structured interviews, key informant interviews, and focus group discussions to capture diverse stakeholder perspectives (see *Methodology*). While the target of approximately 50 individual surveys per governorate was achieved in Hadramawt, Taiz, and Abyan, security constraints in Marib resulted in only 13 individual surveys.

2. Background and Study Rationale

Historically, Yemen's agricultural systems were self-sufficient, founded upon rich and sophisticated indigenous irrigation systems and local agroecological traditions.[7] For centuries, Yemeni farmers cultivated the land using mountain terraces, intricate water-harvesting systems, and community-managed flood-and spring-irrigation systems. These sustainable approaches enabled the country to support its population[8] despite its semi-arid climate. However, over the past five decades, water and agriculture management in rural Yemen — where the majority of the population lives — has evolved through a complex interplay of historical, environmental, and socio-political factors that have influenced how water and land resources are accessed and governed.

Since the 1970s, most national agricultural policies have been heavily influenced by international and development organizations. Some of these policies were misguided and encouraged groundwater extraction for crop cultivation through subsidizing diesel and facilitating the import of agricultural inputs and deep tube well technologies. Yemen's reliance on external support for staple crops began earlier. The first shipment of wheat entered Yemen in 1959, as a gift from the United States, totaling 14,000 tons. More deliveries followed and locals started relying more and more on the imports coming from abroad.[9]

Oil exploration and income remitted by migrants in the Gulf also contributed to the expansion of groundwater well drilling. This led to large-scale investments in well drilling and the rapid depletion of aquifers, drying up of natural springs and underground qanats,[10] posing a growing threat to both agricultural livelihoods and the water supply of major Yemeni cities.[11] The shift away from traditional grains such as sorghum and barley, driven by falling market prices, the influx of subsidized wheat imports, and rising production costs, was further compounded by labor shortages due to male out-migration during the Saudi economic boom (1973–1991).[12] In 1981, imported grains surpassed domestic production, and in 1985, the rate of groundwater extraction exceeded the rate of recharge (equilibrium points).[13] This transformation paved the way for increased irrigation of fruits and vegetables, and particularly qat, a water-intensive cash crop grown for domestic consumption.[14] In the 1990s, the government, in concert with its international partners, recognized the mistake in addressing food security without water

[7] Zaid Ali Basha, "The agrarian question in Yemen: the national imperative of reclaiming and revalorizing indigenous agroecological food production," The Journal of Peasant Studies, 50 (3), 879–930, January 27, 2022, https://doi.org/10.1080/03066150.2021.2002849

[8] About 6.2 million individuals were supported according to the United Nations. See: "Population Division (2017). World Population Prospects: The 2017 Revision, Volume I: Comprehensive Tables," United Nations, Department of Economic and Social Affairs, https://population.un.org/wpp/assets/Files/WPP2017_Volume-I_Comprehensive-Tables.pdf

[9] Interview with an agricultural academic at the College of Agriculture, Sana'a University.

[10] Qanats are subsurface tunnels that tap, using gravity, an upslope aquifer into targeted lower land areas or reservoirs. Qanats date back more than 3,000 years.

[11] Martha Mundy, "The war on Yemen and its agricultural sector", Elikadura, April 24, 2017, https://www.elikadura21.ehnebizkaia.eus/wp-content/uploads/2017/04/50-Mundy.pdf

[12] Ibid.

[13] "AQUASTAT-FAO's Global Information System on Water and Agriculture," FAO, 2021, https://www.fao.org/aquastat/en/

[14] Martha Mundy, "The war on Yemen and its agricultural sector", Elikadura, April 24, 2017, https://www.elikadura21.ehnebizkaia.eus/wp-content/uploads/2017/04/50-Mundy.pdf

security and began a primary water reform process by gradually lifting diesel subsidies.[15] In 2005, a National Water Sector Strategy was adopted, aiming to decentralize water management and delegate authority to local entities, such as Water User Associations (WUAs) and basin committees.

Today, agriculture consumes around 90 percent of the country's water resources, most of which is used for qat cultivation. Groundwater is being depleted at twice the rate it is being replenished.

The above strategy, though outdated, remains the country's primary strategy to this day. It was designed to build on other policies and strategies introduced to address water management challenges. These include the Water Resources Policy and Strategy (1999–2000), Watershed Management Policy (2000), Agricultural Sector Reform Policy (2000), and Irrigation Water Policy (2001).[16] In addition, Water Law No. 33 of 2002 was promulgated to promote sustainable water management and regulate groundwater extraction through measures such as the licensing and registration of wells and drilling equipment.[17] The law also laid the groundwork for establishing the Ministry of Water and Environment in May 2003. The water law was amended by Law No. 41 of 2006, and its by-laws were issued in 2011.[18] Despite these crucial steps and some progress, successive governments failed to implement related strategies and enforce the water law. As a result, the unprecedented expansion of irrigated agriculture stressed aquifers, causing groundwater levels to drop by 2-7 meters per year.

2.1 Indigenous Practices

Yemen, a country without lakes or permanent surface water, historically relied on traditional rainwater-harvesting techniques for irrigation, such as spate irrigation, check dams, agricultural terracing, ponds, and groundwater harvesting through the natural flow of springs and underground qanats.

In a predominantly arid and semi-arid country with high temperatures and high evaporation rates, traditional decentralized water management techniques are well-suited to the Yemeni context. Along the wadis, these systems (Table 1), including spate irrigation systems[19] and check dams,[20] directed water into agricultural fields while simultaneously facilitating groundwater recharge. Different types of rainwater harvesting

[15] "Event Summary: Water Security in the Middle East," Center for Strategic and International Studies (CSIS) Middle East Almanac Blog, July 5, 2023, https://www.csis.org/blogs/middle-east-almanac/event-summaexpensive damsry-water-security-middle-east

[16] Qahtan Yehya A. M. Al-Asbahi, "Water Resources Information in Yemen," IWG-ENV, International Work Session on Water Statistics, Vienna (20-22), June 2005, https://unstats.un.org/unsd/environment/envpdf/pap_wasess3a3yemen.pdf

[17] "Republic of Yemen, Water Law No. 33 of 2002," FAOLEX – FAO Legal Database, August 31, 2002, https://www.fao.org/faolex/results/details/en/c/LEX-FAOC046667

[18] Musaed Aklan and Helen Lackner, "Solar-Powered Irrigation in Yemen: Opportunities, Challenges and Policies," Sana'a Center, April 29, 2021, https://sanaacenter.org/publications/main-publications/13849

[19] Spate irrigation is a floodwater diversion system that withstands all or a portion of flash floods and gently guides water from wadi courses to adjacent agricultural areas. Spate irrigation started in Yemen 5000 years ago, and today covers around 3.3 million hectares worldwide. See: Giulio Castelli, Elena Bresci, Fabio Castelli, Eyasu Yazew Hagos & Abraham Mehari, "A participatory design approach for modernization of spate irrigation systems," Agricultural Water Management, Volume 210, 2018, pp. 286–295, https://doi.org/10.1016/j.agwat.2018.08.030

[20] Check dams are small, sometimes temporary dams constructed across the wadis (riverbeds) or waterways to counteract erosion, reduce waterflow velocity (flood control), and divert water to nearby lands through canals/spate irrigation.

(RWH) ponds, known locally as *Bariks*,[21] *Siqyat*,[22] *Niqab*,[23] *Kuruf*,[24] and *Mawajel*,[25] were used to store surplus water for the dry season. When damaged by floods, local communities could easily reconstruct them using affordable local materials and indigenous expertise. In Yemen, 94 percent of precipitation is lost due to evapotranspiration.[26] The Ministry of Water and Environment (MWE) and the Ministry of Agriculture, Irrigation, and Fisheries (MAIF) have, over the past two decades, strongly disagreed over the construction of modern gravity dams, which are implemented and supervised by MAIF. Many costly dams have been planned without sufficient studies, and many pose a risk to downstream areas during extreme floods. Intense storm floods have occurred in recent years, and several dams have collapsed as a result. Large dams do not necessarily capture water that would be lost to the sea as runoffs and floods that reach the sea are limited, and large gravity dams[27] prevent people from living downstream from water. Large dams do not necessarily feed groundwater aquifers because they accumulate sediment and are not maintained. Loss of water through evaporation caused by high temperatures is another source of contention regarding the use of large dams in a largely arid and semi-arid country like Yemen.

2.2 War, Climate, and Water Governance

The ongoing conflict in Yemen has dominated headlines, yet the less talked-about impacts of climate change have significantly worsened the crisis. Yemen is highly vulnerable to climate impacts, including changing precipitation patterns, rising temperatures, and more frequent extreme weather events, which affect water availability and quality. Yemen ranks 171 out of 181 countries in the ND-GAIN Index of climate vulnerability and readiness, indicating extremely high vulnerability and very low adaptive capacity.[28] Since the war, the national regulatory framework, key institutional actors, and the overall economic situation have been significantly weakened, which is impacting water and food security. Vulnerable communities, including women and IDPs, are among those most affected. Governmental policies to address the depletion of agricultural land, water supplies, and livestock remain insufficient. International actors have also failed to engage thoughtfully with the Yemeni context,[29] and mainly focus on short-term humanitarian interventions, neglecting the larger environmental challenges at hand.[30]

[21] Birak (singular birkah) are roofless RWH systems, usually underground ponds.

[22] Siqyat (singular siqaya) are roofed. They are commonly built partly below ground with the roof showing above ground.

[23] Niqab (singular Noqbah) are underground, roofed, man-made cisterns..

[24] Kuruf/karifis (singular karif) are big ponds or roofless man-made cisterns. This pond-type of storage structure is generally bigger than a birkah and formed by damming a simple low-land area and diverting runoff into it from the surrounding areas.

[25] Mawajel (singular majel) is the common name given in the northwestern highlands for a small dam.

[26] Hussain Gadain and Brigadier Libanda, "Agricultural Water Deficit Trends in Yemen," Atmosphere, 14(8), 1263, August 9, 2023, https://doi.org/10.3390/atmos14081263

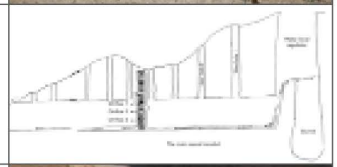
[27] A gravity dam is a dam constructed from concrete or stone masonry and designed to hold back water by using only the weight of the material and its resistance against the foundation to oppose the horizontal pressure of water pushing against it. Gravity dams are designed so that each section of the dam is stable and independent of any other dam section.

[28] "ND-GAIN Country Index (Country Rankings)," Notre Dame Global Adaptation Initiative (ND-GAIN), University of Notre Dame, 2025, https://gain.nd.edu/our-work/country-index/rankings/

[29] Maia Baldauf and Musaed Aklan, "Cultivating an Equitable Recovery: A Political Ecology Approach to Agricultural Interventions in Yemen," Sana'a Center for Strategic Studies, December 31, 2023, https://sanaacenter.org/publications/main-publications/21634

[30] Helen Lackner, "Yemen's Vulnerability to Climate Change: How to Strengthen Adaptation," Sana'a Center for Strategic Studies,

Table 1. Traditional Irrigation Systems in Yemen

Technique	Description	Key Characteristics	Physical Dimensions	Image
Spate Irrigation (Sayl Irrigation)	A flood-based irrigation system that diverts seasonal wadi flows into agricultural fields using earthen bunds and diversion canals.	◦Relies on flash floods. ◦Gravity-based (no pumping). ◦Strong customary water rights (e.g., upstream priority rules). ◦High sediment transport improves soil fertility. ◦Flexible allocation depending on flood size.	Can irrigate small land to large wadi systems (up to thousands of hectares); diversion canals may extend for several kilometers.	
Flood Basin Irrigation (Water Spreading Systems)	Floodwater is spread across fields or basins to improve soil moisture and recharge groundwater. This practice is part of broader spate irrigation practices and recharge systems.	◦Simple and low-cost. ◦Enhances infiltration. ◦High water loss due to evaporation. ◦Often combined with spate systems.	Basin sizes vary widely depending on terrain and flood volume.	
Terraced Irrigation (Mountain Terraces)	Construction of stepped stone platforms on steep slopes to capture rainfall and reduce runoff.	◦Reduces soil erosion. ◦Improves water retention and enables farming. ◦Integrates soil and water management. ◦Requires continuous maintenance.	Terrace width: 2–10 m; extends across parts of or entire mountain landscapes; thousands of km^2 in highlands.	
Traditional Shallow Wells	Hand-dug wells used to extract shallow groundwater for irrigation with manual or animal-powered lifting systems.	◦Low-cost and locally constructed. ◦Limited depth and limited. discharge. ◦Often privately controlled.	Depth typically 5–30 m, depending on aquifer depth.	
Qanat / Subsurface Channel Systems	Underground tunnels that transport water from aquifers or springs to fields using gravity. They are very limited in Yemen.	◦Minimizes evaporation losses. ◦Continuous flow system. ◦High engineering knowledge required. ◦Sustainable in arid climates.	Can extend several kilometers underground with vertical shafts for maintenance.	
Check Dams (Earthen Bunds)	Small barriers constructed across wadis to slow water flow, increase infiltration, and divert water to nearby lands.	◦Reduces flow velocity. ◦Promotes groundwater recharge. ◦Built with local materials. ◦Requires maintenance after floods.	Typically, small-scale structures across wadi beds (meters to tens of meters wide and 1 to 2 meters high).	
Tanks, cisterns, or ponds	Different types of traditional water harvesting structures are used to collect and store overland flow for domestic use, livestock, and irrigation.	◦Collection of rainfall and overland flow. ◦Constructed using locally available materials (stone, clay, lime plaster). ◦Often community-managed and culturally embedded. ◦Adapted to variable rainfall conditions.	Range from small household cisterns to large communal ponds; Storage capacity varies from a few cubic meters to thousands of cubic meters.	

3. Methodology and Data Collection

Six rural study areas in four different governorates, Hadramawt, Taiz, Abyan, and Marib (Figure 1), were identified to provide geographic and contextual diversity. The selection criteria considered agricultural and geographical diversity, degrees of conflict and climate impact/vulnerability, displacement, security and accessibility, and geopolitical location.

a. Hadramawt: Damon, Eidid, and Thibi, Tarim district

Hadramawt is Yemen's largest governorate, covering approximately 190,000 km^2 and home to more than 1.5 million inhabitants, including around 100,000 IDPs. Agricultural production in the Wadi Hadramawt region, where Tarim is located, mainly consists of dates, cereals, and vegetables. Farming depends on a mix of shallow alluvial groundwater, traditional spate flows, and increasingly solar-pumped wells. Rural households have a long agricultural history and rely heavily on agriculture and livestock. Historically, women across Yemen, including in Hadramawt, have been the backbone of agriculture, involved in various activities, though mostly in informal roles. Women's economic contributions are rising through agriculture, home-based processing, and emerging local networks, even though they remain under-represented in formal water-governance bodies.[31] Hadramawt's economy is also substantially bolstered by remittances from the global Hadrami diaspora[32] and fishing along the Arabian Sea coast.

b. Taiz: Wadi al-Dhabab, Sabir al-Mawadim district

Taiz is Yemen's most populous highland governorate, with about 3.1 million people over a relatively small area of 10,000 km^2, combining dense highland farming systems and a coastal strip along the Red Sea.[33] Agriculture is a core employer, with intensive qat and cereal cultivation.[34] Taiz has been a site of enduring long sieges, intense fighting, widespread displacement, destruction of critical infrastructure, and economic deterioration during the conflict. This multifaceted crisis has been exacerbated by climate change and is driven by droughts, altered precipitation patterns, and severe water shortages. Environmental shifts have undermined food security and agricultural livelihoods, with a reported 50 percent drop in agricultural production compared to the pre-war years.[35]

February 21, 2024 https://sanaacenter.org/files/Yemens_Vulnerability_to_Climate_Change_How_to_Strengthen_Adaptation_en.pd

[31] "Local Governance in Yemen: Resource Hub," Berghof Foundation, 2025, https://yemenlg.org/; "Annual Statistical Book 2023," Central Statistical Organization (CSO), Republic of Yemen, 2025.

[32] The Hadrami diaspora is primarily based around the Indian Ocean (Indonesia, Malaysia, Singapore, and India) due to centuries of seafaring trade and migration.

[33] "Local Governance in Yemen: Resource Hub," Berghof Foundation, 2025, https://yemenlg.org/

[34] Yasser Al-Maqtari, "An analysis of the investment climate and prospects in Taiz Governorate," Studies and Economic Media Center (SEMC), July 2024, https://economicmedia.net/en/wp-content/uploads/2024/07/Taiz-Investment-Bulletin-July-2024-CIPE-Edits-EN.pdf?

[35] "Research Study on Climate Changes and Local Preparedness in the Districts of Al-Ma'afer and Al-Shamayatain – Taiz Governorate, Yemen," Tamdeen Youth Foundation (TYF) & Oxfam, December 15, 2022, https://tamdeen-ye.org/upfiles/publications/TYF-2023-02-26-61877.pdf

c. Abyan: Batees, Khanfar district, and Al-Surrah, Lawdar district

Abyan, a coastal governorate, covers approximately 16,000 km^2 and has a population of 600,000. It is one of Yemen's historically significant spate-irrigated agricultural regions, fed mainly by Wadi Bana and Wadi Hassan, supplemented by groundwater.[36] Yet the long-term viability of this system is threatened by upstream water scarcity, sedimentation, and poorly defined water allocation rules.[37] Climate change and conflict have driven an estimated 38 percent decline in cultivated land between 2010 and 2022, sharply worsening food insecurity.[38] Production is concentrated in the coastal and wadi plains, where farmers depend on floodwater (spate) irrigation, supplemented by shallow groundwater and, increasingly, solar-pumped wells. for vegetables, fruits (including banana and mango), cotton, and fodder.[39] Fishing and livestock are key complementary sources of income.

b. Marib: Maneen Al-Haddad, Marib al-Wadi district

Marib governorate was one of Yemen's most important historical agricultural regions. It spans about 17,000 km^2. Due to ongoing conflict and massive displacement from other parts of Yemen, the governorate has experienced substantial population growth and now hosts more than 3 million people.[40] Agriculture is the main traditional economic activity of the region, cultivating fruit, cereals, and vegetables with its farming irrigation systems linked to the ancient and modern Marib dams, which divert seasonal flows to irrigated oases on the desert margin, complemented by rapidly expanding groundwater irrigation.[41] Over-extraction in recent decades, encouraged by fuel subsidies and, more recently, by solar pumping, declining recharge, and rising temperatures, is accelerating groundwater depletion, degrading water quality, and threatening future irrigation potential.[42] The huge inflow of IDPs in Marib is exerting additional pressure on land and water, and fuelling local competition and resource-related tensions.[43]

[36] "Local Governance in Yemen: Resource Hub," Berghof Foundation, 2025, https://yemenlg.org/

[37] Mohammed Hezam al-Mashreki et al., "GIS-Based Assessment of Land Suitability for Industrial Crops (Cotton, Sesame and Groundnut) in the Abyan Delta, Yemen," American Journal of Experimental Agriculture. 8. 384-405, June 12, 2015, https://doi.org/10.9734/AJEA/2015/16572

[38] "Climate change and conflict devastate agriculture in Yemen's Abyan Governorate," field report summary, Barran Press 2024, https://en.barran.press/news/4067

[39] Mohammed Hezam Al-Mashreki et al., "GIS-Based Assessment of Land Suitability for Industrial Crops (Cotton, Sesame and Groundnut) in the Abyan Delta, Yemen," American Journal of Experimental Agriculture. 8. 384-405, June 12, 2015, https://doi.org/10.9734/AJEA/2015/16572; "Local Governance in Yemen: Resource Hub," Berghof Foundation, 2025, https://yemenlg.org/

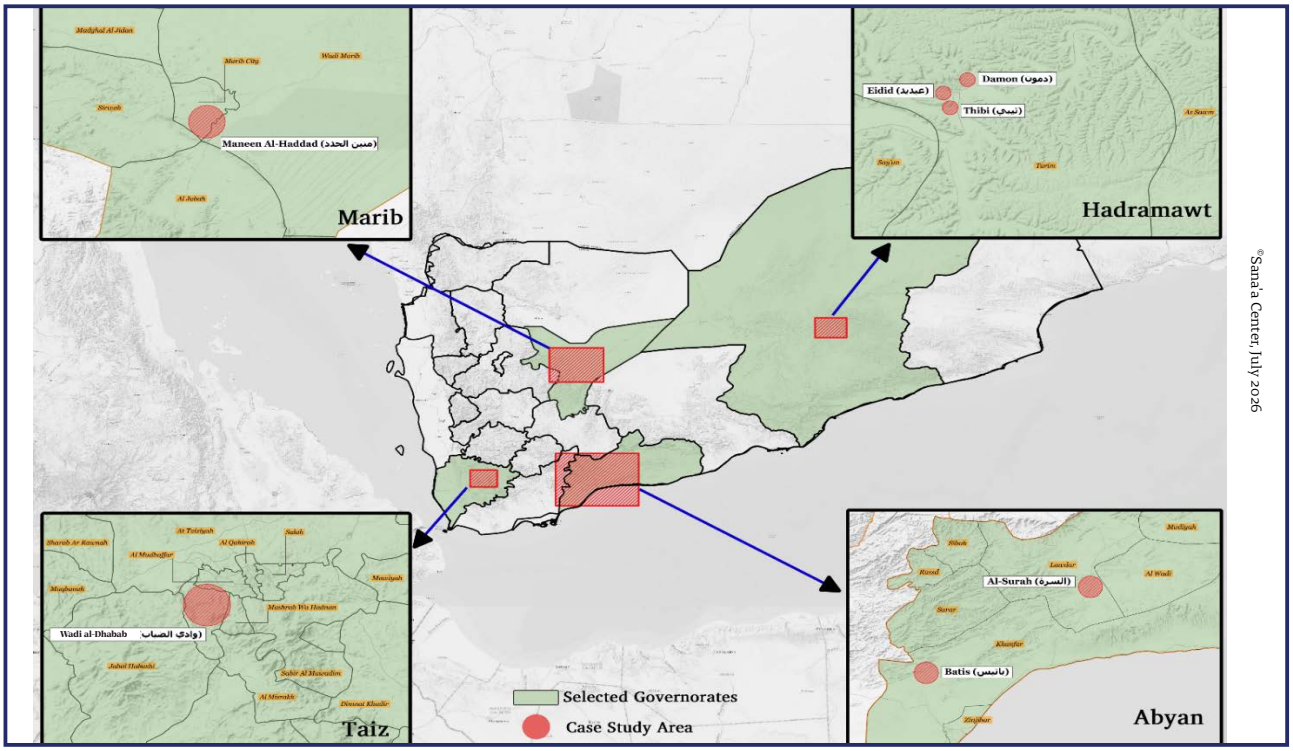
[40] "Marib: Information about Marib governorate and its conflict background from the Yemen Conflict Monitor," Armed Conflict Location & Event Data Project (ACLED), November 17, 2023, https://acleddata.com/region-profile/marib; "Local Governance in Yemen: Resource Hub," Berghof Foundation, 2025, https://yemenlg.org/governorates/marib/

[41] "Local Governance in Yemen: Resource Hub," Berghof Foundation, 2025, https://yemenlg.org/governorates/marib/

[42] Tiago Maciel De Paula et al., "Analysis of groundwater quality for irrigation in Ma'rib, Yemen based on electrical conductivity and sodium adsorption ratio," XXIII Congresso Brresilience, asileiro de Águas Subterrâneas, August, 2024, https://www.researchgate.net/publication/383441832_Analysis_Of_Groundwater_Quality_For_Irrigation_In_Ma%27rib_Yemen_Based_On_Electrical_Conductivity_And_Sodium_Adsorption_Ratio; "Water availability in Yemen: Literature review of the current and future water resources and water demand in Yemen," Acacia Water, October 1,2021, https://files.acquia.undp.org/public/migration/ye/Water-Availability-Study-in-Yemen.pdf

[43] Sinéad Barry et al., "Undercurrents: How conflict, climate change and the environment intersect in Yemen," Weathering Risk / adelphi research in collaboration with the European Institute of Peace (EIP), December 4, 2024, https://weatheringrisk.org/sites/default/files/document/Undercurrents_Yemen.pdf; "Charting the course: A water security diagnostic for Yemen," World Bank, November 19, 2024, https://documents1.worldbank.org/curated/en/099111924095042411/pdf/P180386156c0320eb1913217409bcab5d7a.pdf

Figure 1. Study Areas



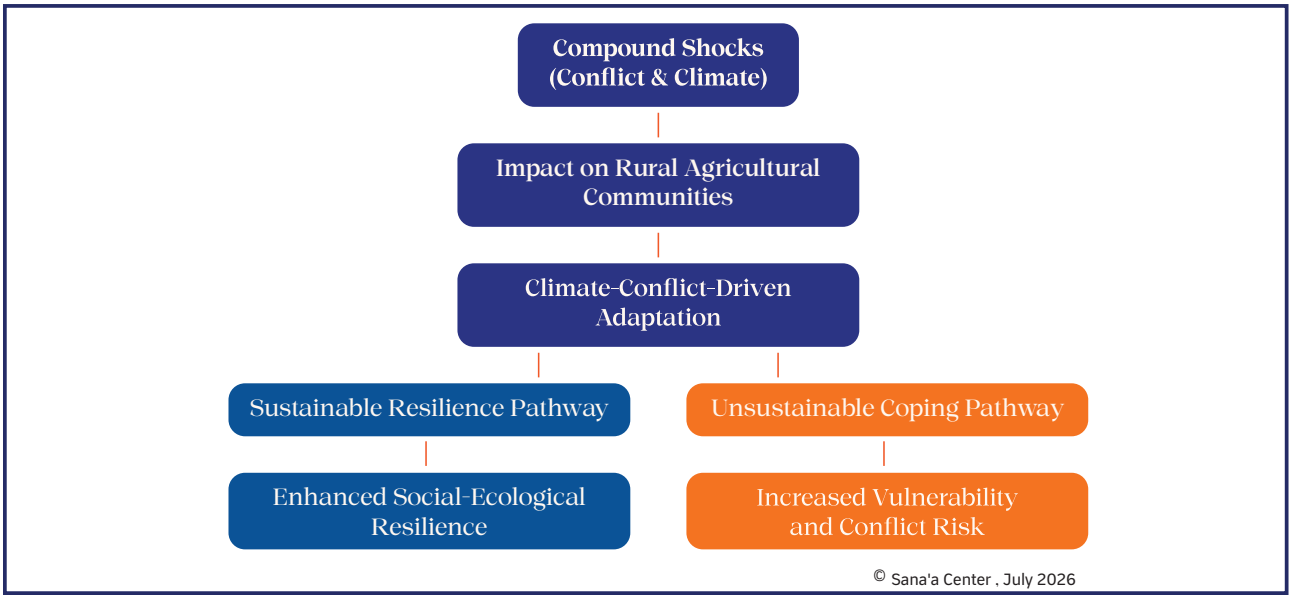
To gather data and understand how local communities adapt to conflicts and climate shocks, this study utilized a grounded theory approach.[44] Data collection and analysis occurred concurrently, with theoretical sampling guiding subsequent data collection in response to emerging themes. This is an iterative process where data collection, analysis, and theory development influence one another. The analytical framework focused on the links between climate change, conflict, resilience, and adaptation. It employed gender and conflict-sensitive approaches to analyze the differential impact of the dual crises. The methodology aimed to expose locally embedded resilience strategies and highlight how communities negotiate conflict and climate shocks.

The data collection process started with 10 Key Informant Interviews (KIIs) with government officials, academics, farmers, and civil society representatives to shape the methodology and survey questions. After the field survey, another 10 KIIs were conducted to help validate data and inform policy recommendations. The survey gathered 164 responses from farmers, pastoralists, and IDPs across four governorates: Hadramawt (52), Taiz (49), Abyan (50), and Marib (13) in three phases, starting with 10 initial questionnaires, followed by 20 more, and ending with a final phase incorporating earlier insights. Six Focus Group Discussions (FGDs) in Hadramawt and Taiz with male and female farmers and experts explored the impacts of the war and climate change on livelihoods.[45] Finally, the field team conducted ethnographic observations to capture local insights and deepen the preliminary findings. Security challenges in Marib restricted data collection, hindering a comprehensive assessment compared with other governorates.

[44] A grounded theory approach ensures that findings are deeply rooted in the lived experiences of rural agricultural communities. It prioritizes participant-driven insights and allows for the emergence of themes related to resource governance, power dynamics, and the impacts of these shifts on water security, livelihoods, and social equity, particularly for marginalized groups.

[45] Among rural farmers, convening men and women together proved difficult due to cultural reservations regarding mixed-gender sessions. In contrast, expert meetings included both male and female participants.

Figure 2. Conceptual Framework Diagram



Social-ecological systems (SES) are integrated, interdependent systems of people and the environment, in which livelihoods, governance structures, conflict dynamics, and natural resources (such as water, land, and agriculture) are linked and influence one another. Within this context, resilience is the capacity of these coupled systems to absorb shocks such as war, drought, and climate change, while maintaining essential functions, or to reorganize and adapt in ways that sustain livelihoods and ecosystem services[46] over time. In contrast, vulnerability describes the degree to which these same social-ecological systems are exposed to harm and lack the ability to cope or adapt effectively, especially among marginalized groups such as women and IDPs, who have fewer resources, weaker institutional support, and limited access to services.

3.1. Socio-Demographic Profile

Participant selection was carried out using a combination of researcher networks and snowball sampling, in line with a conflict-sensitive approach and grounded theory. This method emphasizes selecting participants based on their relevance to the evolving research questions rather than on statistical representativeness. Such an approach allows for in-depth exploration of emerging themes and concepts.

Women's participation in the survey averaged 30 percent but varied substantially across the governorates. It was the highest in Taiz at 39 percent and the lowest in Abyan at 16 percent. The low level of women's participation may be influenced by prevailing social and cultural norms in Yemen that shape women's opportunities and willingness to participate in surveys, particularly in rural areas. The prevalence of respondents aged 35-64 indicates an aging agricultural workforce, while low youth participation may reflect migration or declining interest in farming (Figure 4). Based on the study results, more highly educated participants are more likely to own land and to have greater awareness of water issues, which enhances adaptive capacity and the adoption of sustainable practices.

[46] ecosystem services here means functions and services attached to natural resources such as water and crops provision, flood and groundwater regulation, and cultural activities.

Figure 3. Survey Participation by Gender (%)

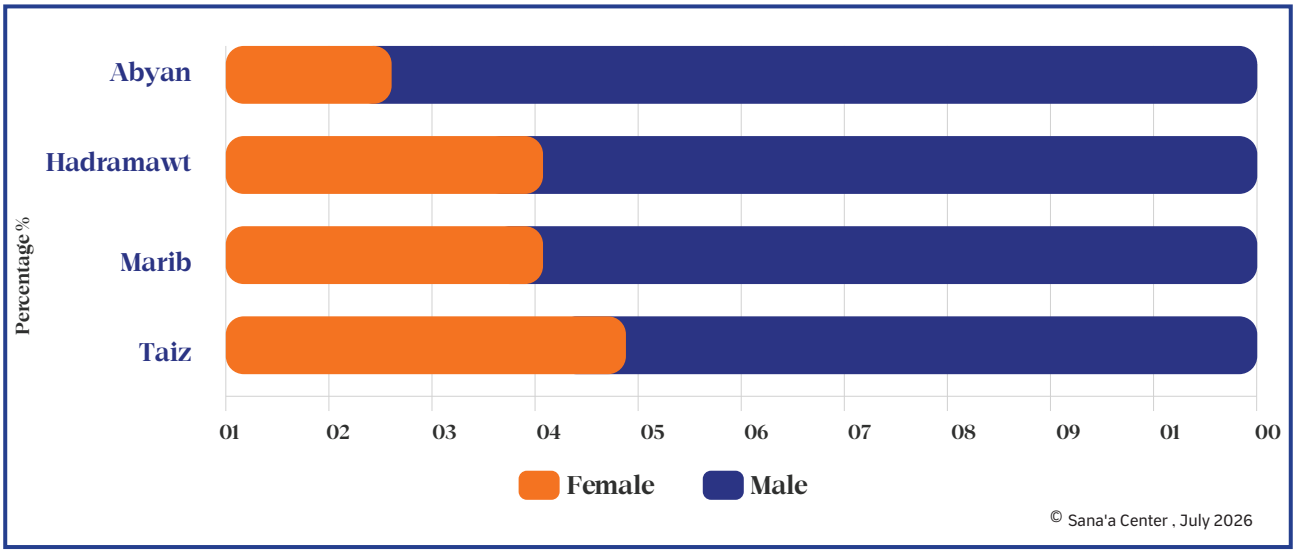
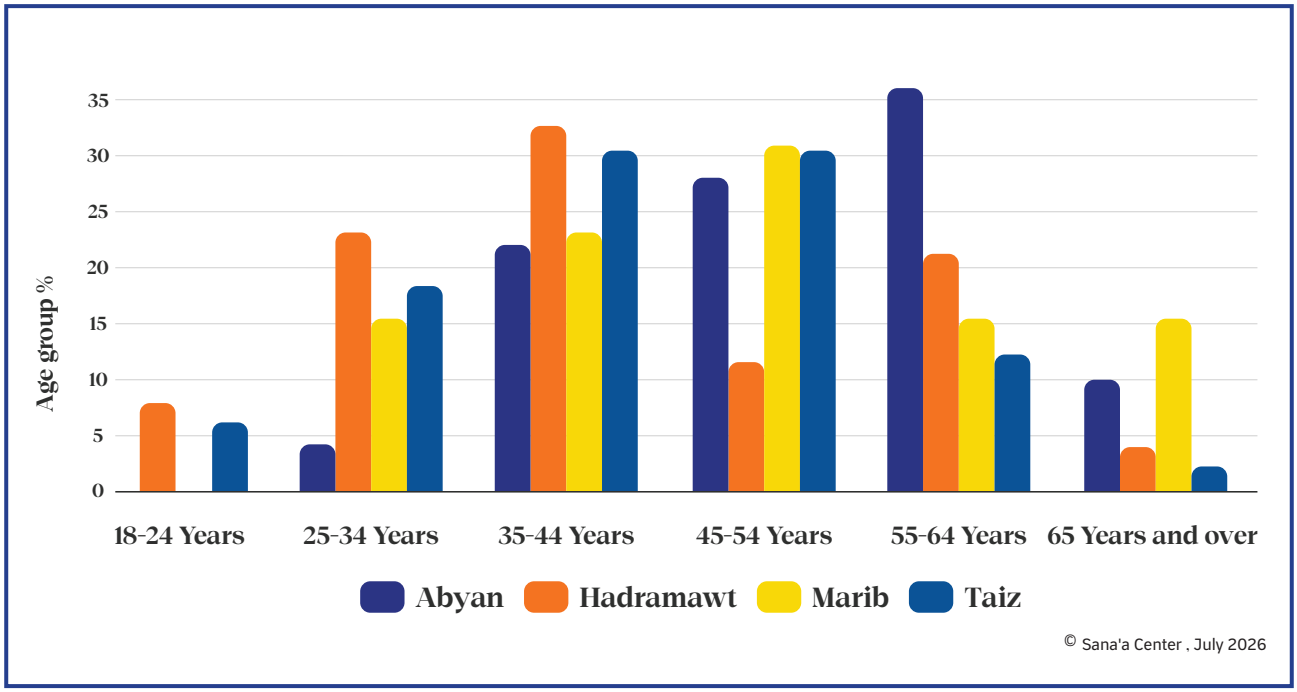


Figure 4. Age of Participants

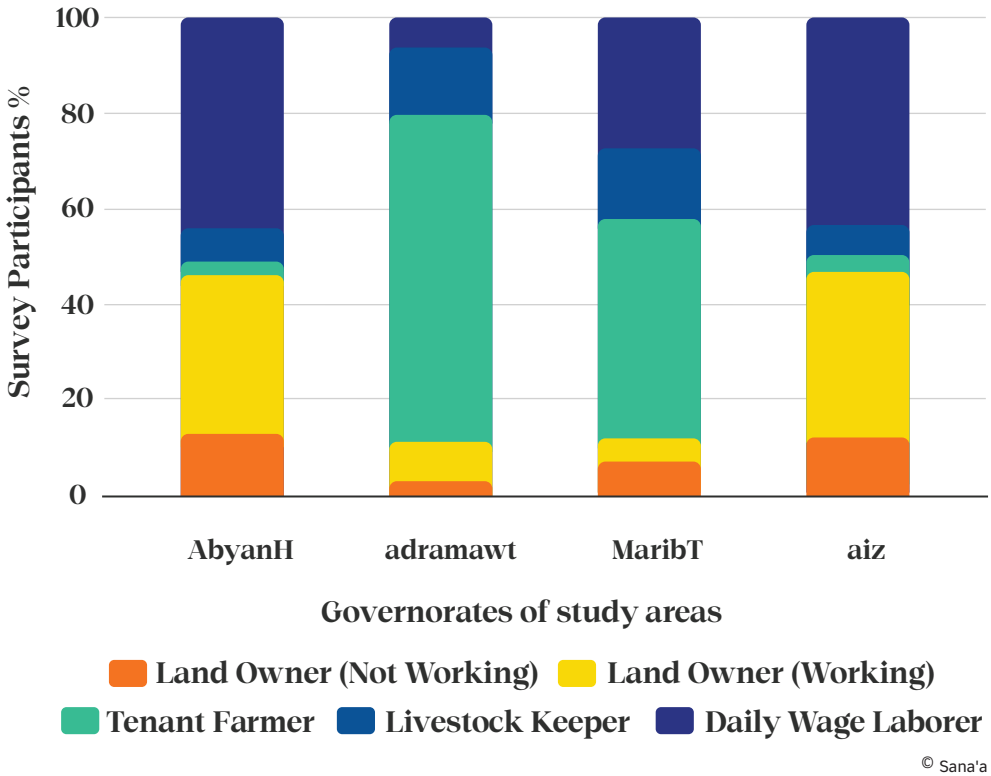


4. Findings: Land Relations, Conflict, and Water Governance

4.1 Land Relations

Land ownership and labor rights varied across the study areas, shaped by regional characteristics, land size, population, and economic conditions. In Hadramawt, tenant farmers make up the majority of those working on the land at 68 percent, and the relationship between farmers and landowners is clearly defined. As showing in Figure 5, wage labor in agriculture is significant in Abyan and Taiz. Illiterate respondents are also more likely to engage in daily-wage agricultural labor (38 percent) and less likely to own land (21 percent).

Figure 5: Agricultural Roles in the Study Areas



The partnership between landowners and laborers typically involves arrangements to share the land's products or profits. The partnership between landowners and laborers or tenants typically involves arrangements to share the land's products or profits. These arrangements can vary widely, often dividing the yield into shares such as one-quarter, one-half, or one-eighth goes to landowners, depending on the specific agreement and the conditions under which the crop is grown. Factors that influence these arrangements include whether the land is irrigated or rain-fed, who owns the water well, and the type of cultivation used. For example, a certain percentage of the yield may be allocated to cover water costs.

> "Customary practices have been greatly affected by new factors, with the most important being the widespread use of irrigation from groundwater."[46]

In some cases, after a specific period, workers may gain ownership of a share of perennial crops, such as fruit trees. Respondents noted how, more recently, leasing contracts have begun to focus[47] on fixed annual payments. However, when land is classified as an endowment (*waqf*), the rents are typically lower. Traditionally, these relationships were governed by long-standing local customs and informal agreements. Tenants usually enjoyed a degree of security and stability, but their rights rested on mutual trust and customary norms rather than written law.

4.2 The Dual Impact of Conflict and Climate Shocks

> "Today, I can assure you that more than 50 percent of small farmers cannot cultivate their land due to the lack of water sources, and due to security risks, including landmines."[47]

Conflict[48] and climate change increasingly threaten local livelihoods, creating a vicious cycle of poverty and food insecurity. "We have 40 hectares of agricultural land that we cannot now cultivate due to lack of rain," noted an official from Taiz, "this includes bananas, which require even more water than other crops."[49] He emphasized that the impact is widespread, but small farmers are the most affected. These developments were echoed in field interviews conducted in Hadramawt. "I have six acres, but due to climate change, I only cultivate half an acre. But it is not economically productive, so the feasibility of farming here means nothing. I don't receive sufficient water quantities, and even if I did, the cost is high and does not align with the income and productivity of the farm."[50]

Agricultural communities have suffered extensively from changes in rainfall patterns and the increasing severity of droughts, impacting both water and farming activities. These shifts have greatly affected the traditional agrarian calendar.[51] The majority of respondents (more than 60 percent across the region) confirmed the impact of climate change on water sources and farming practices. Drought, especially in Taiz, has worsened its longstanding water shortage. The other governorates have also faced successive drought crises. Hadramawt, for instance, is now in its fourth year without its usual rain pattern, along with a rise in temperatures.[52]

[47] Interview with a senior official at the Environmental Protection Agency (EPA), Wadi Hadramawt, July 22, 2025.

[48] Interview with a secretary-general of a local association, Al-Dhabab, Taiz, August 4, 2025.

[49] Ibid.

[50] Interview with an EPA senior consultant, Hadramawt, August 20, 2025.

[51] Interview with Iftihan al-Mashhari, former General Manager of the Sanitation and Improvement Fund in Taiz, July 30, 2025. Iftihan was assassinated on September 18, 2025, less than two months after this interview.

[52] Interview with a farmer and officer at the agricultural office in the Valley and Desert Region, Hadramawt, July 3, 2025.

In Abyan, sudden floods and cyclones have washed away fertile soil, destroyed crops, and damaged vital irrigation infrastructure, including wells, dams, traditional irrigation channels known as "sawaqi", and water intakes. Farmers reported that these changes have become more severe during the years of conflict, reducing their ability to predict and plan for agricultural seasons. Cyclone Chapala destroyed the village of Al-Houta in Mukalla, and about 70 percent of its soil was washed away. The village of Al-Labeeb was destroyed entirely.[53] While these challenges vary from one region to another, the economic effects of the war and climate change remain the most prominent issues facing farmers and livestock breeders.

Compounding the effects of climate change is the profound impact of conflict on water and agricultural sustainability across the surveyed rural areas. Approximately 20-25 percent of participants in Taiz, Hadramawt, and Abyan[54] are directly affected by disruptions to supply roads and destruction of agricultural and water systems. A similar percentage are experiencing indirect impacts, such as a rise in the exchange rate, and an increase in the price of farm inputs, such as seeds, fertilizers, and fuel required to operate water pumps.[55] One respondent from Abyan noted that due to the high cost of diesel, "many farmers used cooking oil and a flammable liquid used in painting walls (thinner), mixed with a small amount of diesel, to run their water pumps."[56] The deterioration of roads, the high cost of transport, and fees imposed at checkpoints, which have become widespread during the war, have made it difficult for agricultural products to reach major markets, reducing farmers' financial returns. Furthermore, during the conflict, middlemen's control of the farming market has led to a significant reduction in agricultural returns.

As with many cases of conflict-affected rural economies, the study areas face significant socio-economic impacts, like the closing of markets and roads, restrictions on movements, and increased the financial burdens on families.[57] Residents and internally displaced communities have lost access to their agricultural lands and water resources.[58] Economic pressures, the loss of agricultural or daily income sources, currency exchange rates, rising costs, and the emergence of investor farmers have led small farmers to sell their land, seek new job opportunities, or move to the city. Many families are forced to send their children to beg, with child labor having substantially increased.[59]

[53] Interview with an official at the Rural Water Authority, Mukalla, Hadramawt, August 5, 2024.

[54] Due to the study's iterative approach, in which data collection, analysis, and theory development occurred simultaneously and informed one another, Marib was not included in key data collection stages due to security concerns.

[55] Interview with a senior official at the EPA, Wadi Hadramawt region, July 22, 2025.

[56] Interview with a farmer in Abyan, July 17, 2025.

[57] Interview with a representative of a Women and Child Support center in Taiz, August 6, 2025.

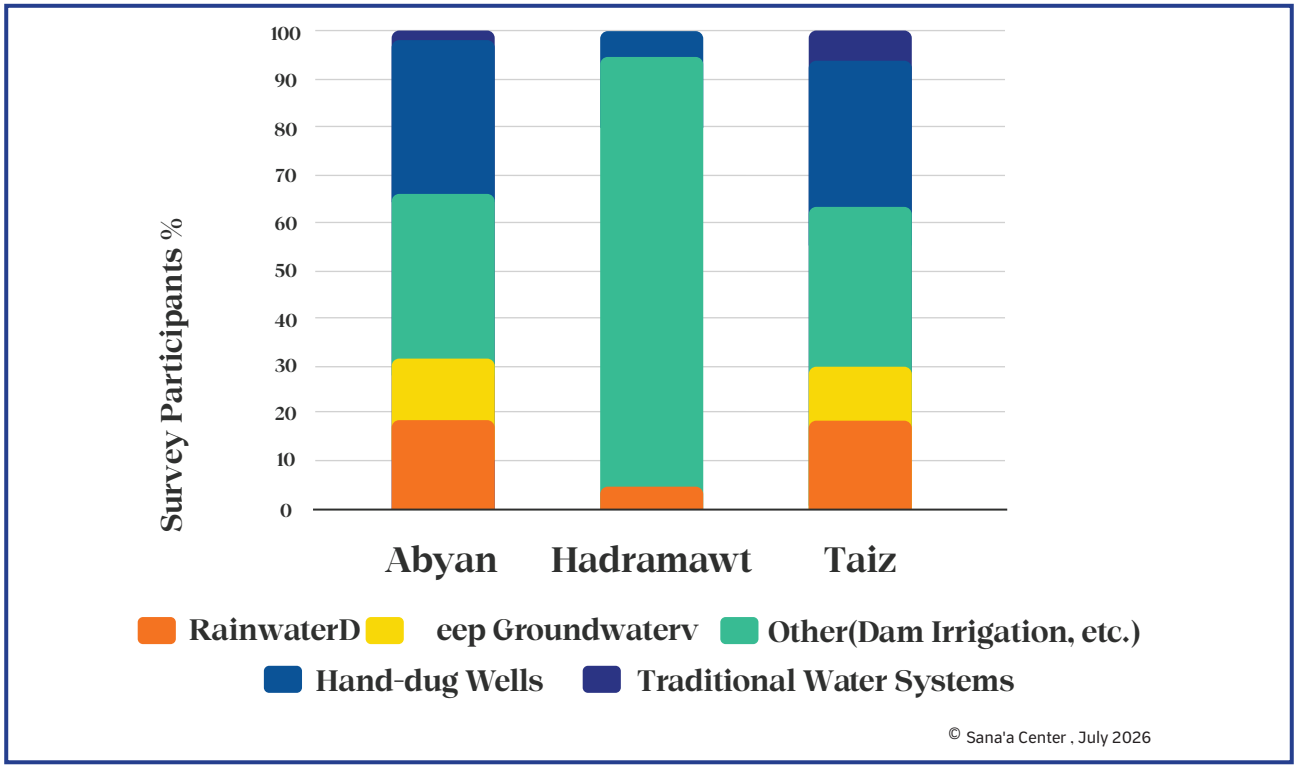
[58] Interview with a senior agriculture official in Taiz, July 30, 2025.

[59] Interview with a director of a local foundation for people with disabilities, July 30, 2025.

4.3 Irrigation Water Sources

Farmers across the four study areas rely on a combination of groundwater, rainwater, and spate (flood) irrigation, though the dependency varies by region. In Hadramawt, farmers rely heavily on deep groundwater wells (89 percent). This trend indicates potential aquifer depletion risks, especially with newly introduced solar pump technologies. Despite Abyan and Taiz still mainly relying on shallow and deep groundwater (more than 40 percent each), they show greater dependence on traditional water systems than in Hadramawt (around 31 percent in both governorates) and on rainwater (19 percent in both governorates). Marib was not included in the initial survey, but key informants indicated that the main water sources for the study area are spate irrigation from the Marib Dam and groundwater. Therefore, traditional water systems (like spate irrigation) remain significant in Marib, Abyan, and Taiz. They offer better resilience in conflict-affected areas due to their decentralized nature and lower reliance on external inputs.

Figure 6. Main Water Sources for Irrigation



Due to the study's iterative approach, in which data collection, analysis, and theory development occurred simultaneously and informed one another, Marib was not included in key data collection stages due to security concerns.

4.4 Water Control and Governance Dynamics

Hadramawt: For centuries, customary laws served as a primary reference in Hadramawt, even during periods of water scarcity. Today, traditional irrigation methods have largely been replaced by modern control systems and groundwater-based irrigation, especially using solar-powered pumps. At least 50 percent of farmers use solar-powered pump technology.[60] This technology has affected deep aquifers, creating a wealth barrier that excludes the vulnerable, including small farmers. While communities still cling to traditions in places like Wadi Do'an and Wadi Amd, the shield of these customary rules is cracking under the weight of unregulated individual use.[61]

Across Hadramawt, water control is closely tied to private ownership. Wells are managed according to ownership or partnership agreements, while floodwater and rainfall are still governed by customary rules. Disputes over water and land in the governorate have intensified with declining water availability, leading to personal conflicts between farmers, landowners, the Endowments Administration (*awqaf*), and influential individuals.[62] Documented cases show influential figures seizing agricultural land despite farmers holding official state contracts, using threats of and imprisonment to force smallholders off their land. The result is a slow, illegal consolidation of water-rich land by local elites.

Abyan: Before the war, an oversight committee from the Agriculture and Irrigation Office oversaw the distribution of floodwater in Abyan, ensuring every farm received water. With the onset of the conflict, this role declined, and decision-making has shifted to those closer to the wadis (dry river beds), those upstream, and those with the capacity to drill for and extract groundwater.[63] This dynamic has grown and led to the birth of some tribal upstream-downstream disputes. Furthermore, the shift toward groundwater-dependent banana cultivation has introduced new challenges to water governance, as wealthy landowners drill unregulated wells, further depleting the shared aquifer without oversight or compensation mechanisms for affected communities.[64] Control thus rests with a class of "capable and influential" landowners whose power stems initially from location and has been amplified by the state's absence and the war economy. The introduction of solar pumps, as a response to soaring diesel prices, has further enabled those with capital to pump longer and deeper, while many downstream cultivators watch their fields parch.[65]

[60] Interview with farmer and an officer from the Agricultural Office, Valley and Desert Region of Hadramawt, July 3, 2025.

[61] Ibid.

[62] Male Farmers Focus Group, Hadramawt, September 27, 2025.

[63] Interview with a local farmer, Abyan, July 17, 2025.

[64] Interview with an official at the MWE, October 14, 2025.

[65] Ibid.

Marib: In Marib's study area, water control is a hybrid of local authority and tribal mediation, reshaped by the impacts of the ongoing conflict. Historically, the Marib Dam's channels were the lifeblood of the region, and the local authority controls the opening and closing of irrigation gates. Farmers believe that this state-led model is a legacy of the dam's strategic and infrastructural importance. However, the war has severely undermined its efficacy. The canals have been closed for extended periods; some have been targeted or rendered inaccessible by landmines and other remnants of war. In response, many farmers shifted to drilling groundwater wells in addition to relying on seasonal rain. Among those sharing a well, communities resort to rotational schedules. This transition to groundwater is largely unregulated and driven by individual necessity, as farmers drill wells to compensate for the loss of dam-fed irrigation, posing a long-term threat to the basin's sustainability in the absence of a comprehensive groundwater management framework.

Taiz: In Taiz, the narrative of water control is more fragmented and weaponized than anywhere else in the country. Under the prolonged siege, Taiz city's water infrastructure has become a battlefield for non-state armed groups and military units.[66] The Houthi group (*Ansar Allah*) controls the most important wells supplying the city. On the pro-government side, state and non-state armed groups have seized control of many other water sources. At the same time, communities turn to them for dispute resolution, creating parallel governance structures.[67] One military unit drilled its own illegal well, placing itself above the law.[68] This pattern of resource capture extends into the heart of the city.[69] Where i influential leaders, backed by government or non-government security forces, have taken over wells and other state resources, granting access only through mediation.[70] This includes many of the Taiz Water and Sanitation Local Corporation's wells, which were taken over by powerful parties/individuals, capturing a public resource for private gain.[71] Ultimately, in Taiz, "water has been seized by influential figures, political actors, large farmers, and state and non-state armed groups."[72]

To[73] address the water deficit in the city, the private sector has increasingly relied on tankers. At the same time, the local authority has imposed restrictions on farm irrigation in Al-Dhabab, the area under study. The use of water tankers has expanded despite their high cost and the questionable reliability of water quality. Although these private services became

> "The government has become heavily focused on the military and politicalaspects, while neglecting other aspects that affect people's daily lives, such as water, agriculture, and the environment."[72]

[66] Interview with Iftihan al-Mashhari, former General Manager of the Cleaning and Improvement Fund in Taiz, July 30, 2025.

[67] Ibid; interview with Center for Women and Child Support center in Taiz, August 6, 2025.

[68] Interview with the Executive Director of the Strategic Studies Center for Women and Child Support in Taiz, August 6, 2025.

[69] Interview with an official at the Water and Sanitation Local Corporation in Taiz, July 31, 2025.

[70] Interview with an official at MWE, October 14, 2025.

[71] Interview with an official at the Water and Sanitation Local Corporation, July 31, 2025.

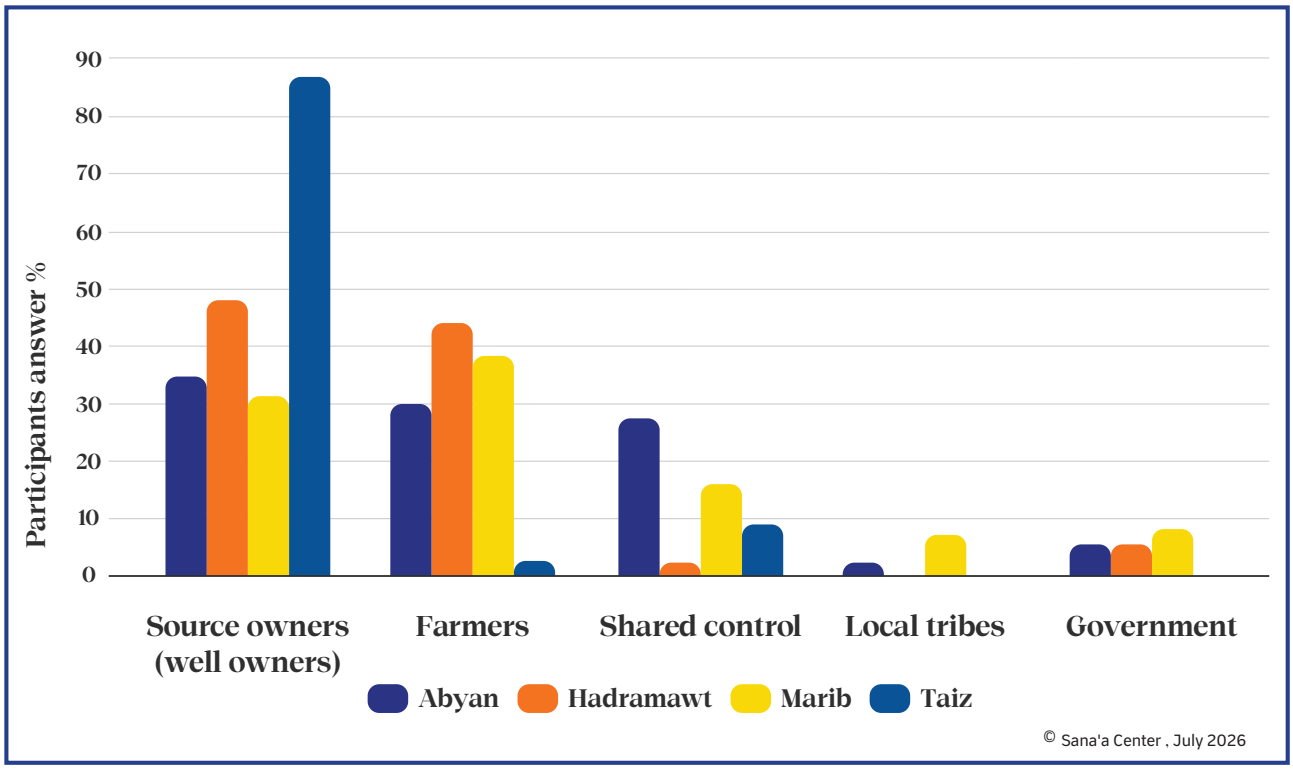
[72] Interview with Iftihan al-Mashhari, former General Manager of the Cleaning and Improvement Fund in Taiz, July 30, 2025.

[73] Interview with a community activist, Taiz, June 24, 2025.

essential, they represented a major burden for low-income and vulnerable households. Private well owners distribute water based on personal relationships and ability to pay, systematically excluding the poor and women.[74] In Wadi al-Dhabab, irrigation was banned, and the water was trucked into Taiz city during acute shortages. When there is a surplus, distribution is based on cultivated area, with priority for Taiz city.[75]

For smallholders in Wadi al-Dhabab, the war and the water crisis are existential threats. Many were unable to farm, and larger farme seized their lands, shifting production toward groundwater-hungry cash crops, particularly qat.[76] A female landowner explained how six months of unprecedented drought destroyed her crops and forced her to sell part of her land, livestock, and gold just to survive.[77] The dxesperation reached such levels that another woman was compelled to marry off her 12-year-old daughter because she lacked the resources to educate or feed her children.[78] In Taiz, force dictates the right to access the necessities of life.

Figure 7. Who Controls the Distribution of Water?



In brief, in Hadramawt and Abyan, most water distribution is the responsibility of owners and farmers, reflecting more decentralized systems in which individual actors assume responsibility for sourcing and distribution. In contrast, Marib is characterized by the heavy involvement of local tribes and a fair level of collective control and government involvement, presumably

[74] Ibid.

[75] Male Farmers Focus Group, Hadramawt, September 27, 2025.

[76] Interview with a director general of a local water corporation, Hadramawt, July 31, 2025.

[77] Interview with female landowner and well-owner, Wadi al-Dhabab, Taiz, September 29, 2025.

[78] Women Farmers Focus Group, Taiz, September 29, 2025.

due to the proximity to the Marib Dam and its collective irrigation infrastructure.[79] Taiz is primarily governed by individual well owners, with limited involvement from the government, tribes, or farmers in managing distribution. This reflects a highly privatized and individualized approach to management. In some areas, denying water access or manipulating distribution functions as a strategic lever, turning basic water services into a tool of power and coercion amid weakened institutions. Individual control remains predominant across all areas, with most relying heavily on groundwater. Governmental oversight is very low, pointing to the systemic retreat of formal institutions and a reliance on local actors, which often lead to fragmented, uncoordinated, and likely inequitable water allocation amidst continued resource pressures.

[79] The study area in Marib is close to the Marib Dam, which provides water to a vast area of agricultural land. The predominant water source for irrigation throughout Marib governorate, however, remains groundwater.

5. Community Adaptation and Local Initiatives

"Yemen has a unique diversity in old techniques that cannot be found elsewhere, such as mountain terraces and spate irrigation. Each area has a special system and governance mechanisms, requiring any interventions or policies to be handled cautiously to serve the existing social context."[80]

Across the four studied governorates, the collapse of state services, the impact of war, and the unpredictability of the climate have not just created victims; they have forced a profound process of adaptation. Individuals, families, households, and local communities respond differently to crises, often taking sequential steps depending on the severity of the situation and their adaptive capacity. First, they may absorb the loss and damage caused by the hazard (absorptive coping), reducing the area of cultivated land or temporarily halting farming during droughts. Second, they may adapt their lives and livelihoods to reduce the risk of the hazard occurring or offset loss and damage after the hazard arises (adaptive), switching to short-season and drought-resistant crops; using solar-powered irrigation pumps, which are efficient but risk groundwater depletion; and engaging in community collaboration to maintain water systems. Third, some make bigger changes to their lives and livelihoods, again to reduce the risk of hazard occurrence or to mitigate effects of hazards (transformative), implementing modern irrigation technologies, using greenhouses and lined water tanks; and restoring traditional (e.g., rain-fed agriculture and spate irrigation) and watershed systems.

Last, sometimes the actions intended to absorb, adapt, or transform lead to the loss of assets, resources, and capabilities, such as the sale of land or livestock; expanding qat cultivation/expansion (profitable but highly water-intensive), drilling illegal deep wells, groundwater over-extraction via solar pumps; and migration or displacement. These can render the persons or groups even more susceptible to future hazards. The central inquiry revolves around how these interventions, ranging from traditional revivals to technological modernizations, contribute to the long-term viability of rural livelihoods.

5.1. Reviving and Sustaining Traditional Practices

Local efforts to restore and maintain indigenous agricultural practices were evident across all four study areas. In Hadramawt, local farmers have autonomously organized to clean spate irrigation channels and flood courses, a practice mirrored in Marib and Abyan.[81] In areas where expertise remains intact, such as Wadi Do'an in Hadramawt, there is a notable return to traditional rainwater harvesting practices. There, communities rely largely on traditional knowledge to manage spate flows as viable systems that preserve social structures. Customary water distribution for sharing rainfall and floodwater remains an effective practice in many areas, including Wadi Amd, with residents handling water distribution and system maintenance themselves.[82]

[80] Interview with a former deputy minister at MWE, Hadramawt, October 22, 2025.

[81] Male Farmers Focus Group, Hadramawt, September 27, 2025; interview with a farmer in Marib, June 25, 2025.

[82] Interview with a farmer and an official from the Agricultural Office, Valley and Desert Region, Hadramawt, July 3, 2025.

Such initiative extended beyond irrigation water management to include flood risk management. Given the nature of Yemen's intense rainfall, which has become increasingly severe in recent years due to climate change, local communities in Al-Hafah (Wadi Hadramawt) developed grassroots innovations and collective action mechanisms that evolved into a disaster management model. The community operates an effective volunteer disaster management system using locally maintained rescue equipment. This enables a rapid response even "faster than the official authorities".[83] This stands in contrast to the situation in other areas. In 2015, Cyclone Chapala devastated rural areas around Mukalla, causing an estimated 70 percent of the soil to erode and rendering large areas unsuitable for agriculture. With the absence of a local and official collective approach, at the time of the report, no rehabilitation measures or recovery interventions had yet been implemented.[84]

Across the governorates, farmers are adopting a variety of absorptive, adaptive, and transformative strategies to cope with climate shocks, water scarcity, and the impact of conflict. The examples below show some of these responses, some of which contribute to resilience, while others may, in the long term, increase vulnerability or contribute to resource depletion.

5.1.1 Crop Diversification and Collaboration with the Private Sector

Farmers in Hadramawt have pioneered partnerships with local investors to collectively purchase tractors and other expensive machinery. This mechanism allows individual smallholders access to modern equipment that boosts productivity and efficiency.[85] Onion farmers, via associations, have recently obtained international quality certificates. This has the potential to open external markets (e.g., Gulf countries), representing a shift from subsistence production to quality-oriented commercial farming.[86] Another notable example of local innovation is a farmer-led seed improvement program in Hadramawt. Local farmers, guided by local agricultural experts, have conducted their own strengths-and-weaknesses analysis of grain crops and developed climate-resistant wheat varieties that yield 4–5 tons per hectare,[87] significantly higher than the national average of approximately 1.67 tons per hectare.[88] This advancement resulted in a 60 percent increase in wheat production in Wadi Hadramawt in 2024. This initiative underscores a vital counterpoint to the decline of local seed families and the recent dominance of non-reproducible improved seeds from external donors.

[83] Interview with a senior official at the EPA, Wadi Hadramawt region, July 22, 2025.

[84] Interview with a general manager from the Rural Water Authority, Mukalla, Hadramawt, August 5, 2024.

[85] Male Farmers Focus Group Hadramawt, September 27, 2025.

[86] Interview with a farmer and officer from the agricultural office, Valley and Desert of Hadramawt, July 3, 2025.

[87] Interview with a local agriculture expert from Hadramawt, October, 12, 2025.

[88] 16,6667 hg/ha (hectograms per hectare) equals 1.67 tonnes per hectare. "Wheat yield in Yemen," Helgi Library, https://www.helgilibrary.com/indicators/wheat-yield/yemen/

5.1.2 Switching Crops

To cope with drought and changes in rainfall patterns, farmers are shifting toward short-season and drought-resistant crops that mature earlier and reduce exposure to drought. Farmers from the four study areas replaced water-demanding crops (e. g, maize, watermelon, zucchini) with less thirsty ones (e.g., legumes, okra, radishes, mint, fennel, and sofi grain).[89] This also includes switching to sesame in Al-Waziya and Sabr, and vegetables like onions and melons in coastal areas in Taiz.[90] This shift is driven by the need to match radically altered planting calendars.

5.1.3 Displacement and the War Economy

> "Today, migration has become one of the adaptation strategies.[90]

Although[91] most migration was driven by war, respondents also cited climate-induced migration, particularly due to irrigation water scarcity. Many smallholder farmers have been forced to abandon farming or sell their land to larger farm and instead seek employment opportunities in urban areas. "Due to the water crisis, my cousin abandoned his farmland and left the area entirely with his family to work in delivery services in the city."[92] Other farms, particularly large ones, have instead expanded the planting of cash crops at the cost of other cereal crops. The shift toward qat cultivation in Taiz and banana cultivation in Abyan has become widespread and profitable, but is ecologically devastating, as these rely mainly on deep groundwater, often extracted using solar energy pumps.[93] This divergence reflects uneven adaptive capacities within the agricultural sector, where ongoing water and financial pressures shape contrasting livelihood strategies.

5.1.4 Technological Adaptation Strategies

Solar Irrigation Pumps

Farmers are deepening existing groundwater wells, adding more pipes, and using solar pumps, despite the risks involved.[94] Across all four governorates, rising fuel prices have accelerated the adoption of solar energy systems for groundwater pumping, especially in Wadi Hadramawt. While solar energy reduces operational costs, because pumping occurs primarily during daylight hours, a substantial portion of the water is lost to evaporation under high temperatures.[95] In addition, recurrent failures of submersible pumps—linked to extended operating hours and insufficient quality control—have compelled many farmers to supplement with diesel-powered pumping systems.[96] To mitigate water loss due to evaporation, there is an increasing, albeit limited, initiative to shift toward drip irrigation, which improves efficiency and reduces the financial burden of pumping.[97]

[89] Interview with a local farmer, Wadi al-Dhabab, Taiz. June 30, 2025.

[90] Interview with a head of a local development and peace organization, August 3, 2025; Interview with a general manager at the Social Fund for Development in Taiz, August 4, 2025; Male Farmers Focus Group, Taiz, September, 28, 2025.

[91] Interview with an official at the MWE, October 14, 2025.

[92] Interview with a local farmer in Taiz, June 22, 2025.

[93] Interview with a director of a local foundation for people with disabilities, July 30, 2025; interview with a qat trader, Taiz, August 4, 2025; interview with a local farmer from Abyan, June 24, 2025.

[94] Male Farmers Focus Group Hadramawt, September 27, 2025.

[95] Interview with a farmer in Abyan, June 11, 2025.

[96] Interview with a farmer in Abyan, July 19, 2025.

[97] Ibid.

Food and water security are interconnected challenges in Yemen and efforts to address food insecurity should not come at the expense of water security. In this context, the Water–Energy–Food (WEF) Nexus is of critical importance. WEF Nexus is an integrated approach based on the understanding that these three sectors are inextricably linked, and actions in one area can have significant positive or negative impacts on the others. It seeks to optimize complementarities, minimize trade-offs, and improve resource security and sustainability. In Yemen solar energy irrigation is expanding, affecting deep aquifers, but for many it's a necessary option.[98] In a country facing extreme water scarcity, water is the ultimate limiting factor for all other forms of security and development.[99] Given the large number of rural Yemenis who depend on agriculture for their livelihoods, regulating the use of technology, developing and implementing the necessary policies, and promoting appropriate water-saving irrigation technologies is essential. Equally important is the revival of indigenous rainwater harvesting practices and development of rain-fed agriculture, particularly in areas where groundwater availability is insufficient to support supplementary irrigation.

Greenhouses

A local foundation successfully implemented a greenhouse project at the Al-Khayami Institute in Al-Ma'afer District, Taiz, as a graduation project for eight students, who were trained as both students and farmers. They then shared these skills with the local community. Farmers in Hadramawt are adopting greenhouses to protect crops from harsh conditions and pests and improve water efficiency through controlled environments.[100]

Low-Tech Adaptation Strategies

Local residents are implementing individual innovations and making changes to their livelihoods by using simple technologies to adapt to the current water crisis. For instance, a female farmer in Taiz who cannot afford large-scale irrigation systems has built her own small one. She uses two tanks and a gasoline-powered pump to spray water, which serves as a locally made sprinkler irrigation system. This setup allows her to store water when it is available and use it sparingly, maximizing the utility of each drop.[101] With diesel fuel scare or unaffordable, farmers in Abyan have resorted to an extreme homemade fuel: mixing burned oil, cooking oil, and paint thinner with a little diesel to run their water pumps.[102] This is a hazardous adaptation born of sheer necessity.

[98] Interview with farmer and an officer from the Agricultural Office, Valley and Desert of Hadramawt, July 3, 2025.

[99] World Bank. (2024). A water security diagnostic for Yemen. World Bank, https://documents1.worldbank.org/curated/en/099111924095042411/pdf/P180386156c0320eb1913217409bcab5d7a.pdf

[100] Male Farmers Focus Group Hadramawt, September 27, 2025.

[101] Interview with a local farmer, Taiz, June 10, 2025.

[102] Interview with a local farmer, Abyan, July 14, 2025.

5.1.5. Qat Expansion

In agricultural areas like Al-Dhabab in Taiz, significant desertification has occurred due to a lack of seasonal rainfall. As a result, many farmers have shifted to growing cash crops, particularly qat, which relies on groundwater. This transition to cash crops began before the war but has intensified in recent years. Factors contributing to this shift include the widespread consumption of qat, climatic pressures such as reduced rainfall affecting grain cultivation, the economic impacts of the war, and the greater profitability of cash crops compared to traditional grain farming. Additionally, the expansion of water-intensive crops such as bananas in Abyan has meant traditional methods are no longer adequate to meet the demand for water.[103]

Many farmers in the Al-Ma'afer[104] and Jabal Habshi districts in Taiz have turned to qat cultivation. The crop's cultivation remains profitable despite the high cost of groundwater pumping. People used to cultivate crops such as corn. Now, agriculture that relies on the rainy season is in continuous decline.[105]

5.2. External and Institutional Support

Local civil society organizations (CSOs) also play roles in crop commercialization, support local initiatives, and rehabilitate spate irrigation systems. Sesame cultivation has been encouraged in Al-Waziya and Sabr in Taiz, as an alternative to long-season and water-intensive crops, while private coffee growers' associations have formed in Al-Mawasit, Taiz, to cultivate and market a high-value crop that is generally less water-intensive than qat, less water-intensive crop.[106] Another story from Al-Kala'iba in Taiz tells of farmers who originally built simple arched barriers to capture rainwater. A local organization upscaled this local innovation by transforming the idea into gabion basins, providing a successful example of external support that upgrades community initiative.[107] In Wadi al-Dhahab, a project by another organization reopened closed water inlets and repaired facilities, rehabilitating 500 acres of land and, critically, significantly reducing community tensions over water.[108]

> "The SFD has supported us with irrigation networks, training in organic fertilizer production, and irrigation network management, empowering our community to reduce its reliance on expensive chemical inputs."[106]

Yemen's[109] Social Fund for Development (SFD), a key local public institution, has undertaken extensive efforts to rehabilitate dams and water barriers,[110] develop irrigation systems, and establish household rainwater-harvesting structures to support community adaptation to prolonged drought. In addition, the SFD has invested in capacity-building initiatives and in strengthening community

[103] Interview with a local farmer, Abyan, July 7, 2025

[104] Interview with a general manager in, Taiz, July 31, 2025.

[105] Interview with a staff member from theWomen and Child Support center in Taiz, August 6, 2025.

[106] Interview with a senior agriculture official in Taiz, July 30, 2025.

[107] Interview with a livelihoods program specialist, Taiz, September 28, 2025.

[108] Interview with a senior official at the EPA, Wadi Hadramawt, July 22, 2025.

[109] Interview with a local farmer, Taiz, July 21, 2025.

[110] Interview with an agricultural consultant, Taiz, August 13, 2025.

resilience to the impacts of climate variability.[111] Interventions by national or international governmental and non-governmental organizations (NGOs) have proven effective when they align with local needs. Farmers have reported benefits from these interventions, noting that, in some cases, they have alleviated the burden on local communities and played an essential role in maintaining social peace. The Food and Agriculture Organization's (FAO) intervention in Tarim, Hadramawt, for example, repaired traditional water infrastructure, restoring irrigation and resolving a 13-year-old community conflict. The project is credited with actively rebuilding social cohesion alongside physical assets.[112] Organizations have provided direct support through solar pumping systems, irrigation networks, and support for drip and sprinkler irrigation systems, directly boosting water productivity.[113]

Despite a backlash of distributing cash without conditions, which has in some cases led to dependency,[114] programs such as cash for work are among the interventions that benefit farmers the most by engaging locals as workers in the construction of local projects, including rehabilitation of irrigation channels,[115] and the establishment of markets for export marketing.[116] Respondents noted significant support for the introduction of modern irrigation techniques, the use of low-water-use seeds, and extensive awareness campaigns initiated by development organizations. "Something is better than nothing, and many have benefited from it," summarized one respondent.[117] The prerequisite of an environmental assessment before establishing a project was viewed as an important contribution by the international community. Authorities began to adopt this approach in their own initiatives, including sanitation projects that had previously disposed of waste at sea.[118]

However,[119] most of these relief interventions are short-term and not linked to long-term development programs that support sustainable recovery and genuinely enhance resilience.[120] Many development projects stalled at the start of the war; existing ones tended to be limited in scope. Consultations with respondents indicate poor coordination between international actors, national and local authorities, and people being overlooked or caught in between efforts.[121]

> "Sometimes marginalized groups or displaced people from outside the community are supported, while among the original residents, there are those in greater need. This causes tensions and conflicts."[116]

[111] Interview with a general manager at the Social Fund for Development, Taiz, August 4, 2025; Male Farmers Focus Group, Taiz, September, 28, 2025.

[112] Interview with the chairman of a local civil society organization, August 16, 2025.

[113] Interview with a local agriculture expert from Hadramawt, October, 12, 2025.

[114] Interview with a general manager at the Social Fund for Development, Taiz, August 4, 2025.

[115] Interview with an official at the rural water projects authority, Hadramawt Coast, July 24, 2025.

[116] Interview with a community activist in Hadramawt, August 18, 2025.

[117] Interview with senior official at the EPA, Wadi Hadramawt, July 22, 2025.

[118] Interview with a general manager at the EPA Al-Mukalla, Hadramawt, August 5, 2025.

[119] Ibid.

[120] Interview with a senior engineer working with the International Committee of the Red Cross (ICRC), October 14, 2025.

[121] Interview with senior official at the EPA, Wadi Hadramawt, July 22, 2025.

Although international support helps, respondents noted that it is guided by sponsors' or international non-governmental organizations (INGOs) visions, with little local input. Such initiatives promote resilience, but unfortunately, do not reflect reality or meet the needs of the local community. "Many farmers receive support twice, while others receive none. There is a lack of clear vision, monitoring, priorities, and evaluation," stated one respondent.[122]

Overall, respondents felt that INGOs & UN interventions helped but remain limited due to weak support and weak coordination, as well as the non-involvement or absence of official authorities in these interventions.[123]

5.3. Social Dynamics and Marginalization in Rural Areas

The protracted war, combined with climate-induced resource scarcity, has reshuffled the social architecture of rural life in Yemen, elevated new actors, marginalized others, and altered the rules that govern access to land, water, and labor. This segment dissects these dynamics to reveal how social hierarchies are tested, reinforced, or reinvented on the ground, with a focus on women and IDPs.

5.3.1 Gender roles and additional burdens on women

Since the war, one of the most significant evolutions has been the expanding role of women in irrigation and farm management. In Hadramawt, women actively collect and store water in ground tanks, operate and monitor drip irrigation systems, and help maintain channels. Beyond manual tasks, they lead community initiatives such as removing harmful weeds and directly improving water efficiency. The war's economic crisis has pushed women into agricultural wage labor on an unprecedented scale. The conflict led many households to lose their primary breadwinners, increasing women's involvement in agricultural labor. Even for civil servants and government employees, the collapse of the local currency, means a man's salary no longer suffices for a family, forcing women to seek any work available.[124]

Women's burdens increased significantly during the conflict, especially for those who are displaced. IDP women from Hudaydah are a major segment of the workforce in Abyan; they labor as daily wage harvesters, often alongside men, under harsh conditions for meager pay. Banana harvesting, the most common daily agricultural job available, is physically too demanding for many women to perform.[125]

The data confirms that women's participation is heavily concentrated in labor-intensive, low-value segments of the agricultural value chain (harvesting, processing, and livestock management), not only on family farms but also as hired laborers on other landowners' farms, with displaced women being particularly affected. This accounts for the largest share of their economic activity, reinforcing their role as laborers rather than owners (Figures 8 and 9).

[122] Interview with a senior official at the EPA, Wadi Hadramawt July 22, 2025.

[123] Interview with a senior director of a research center, Hadramawt, August 13, 2025.

[124] Interview with an environmental and social protection consultant, Taiz, July 20, 2025.

[125] Interview with a displaced farmer, Abyan, July 14, 2025.

Figure 8. Agricultural Roles of Women

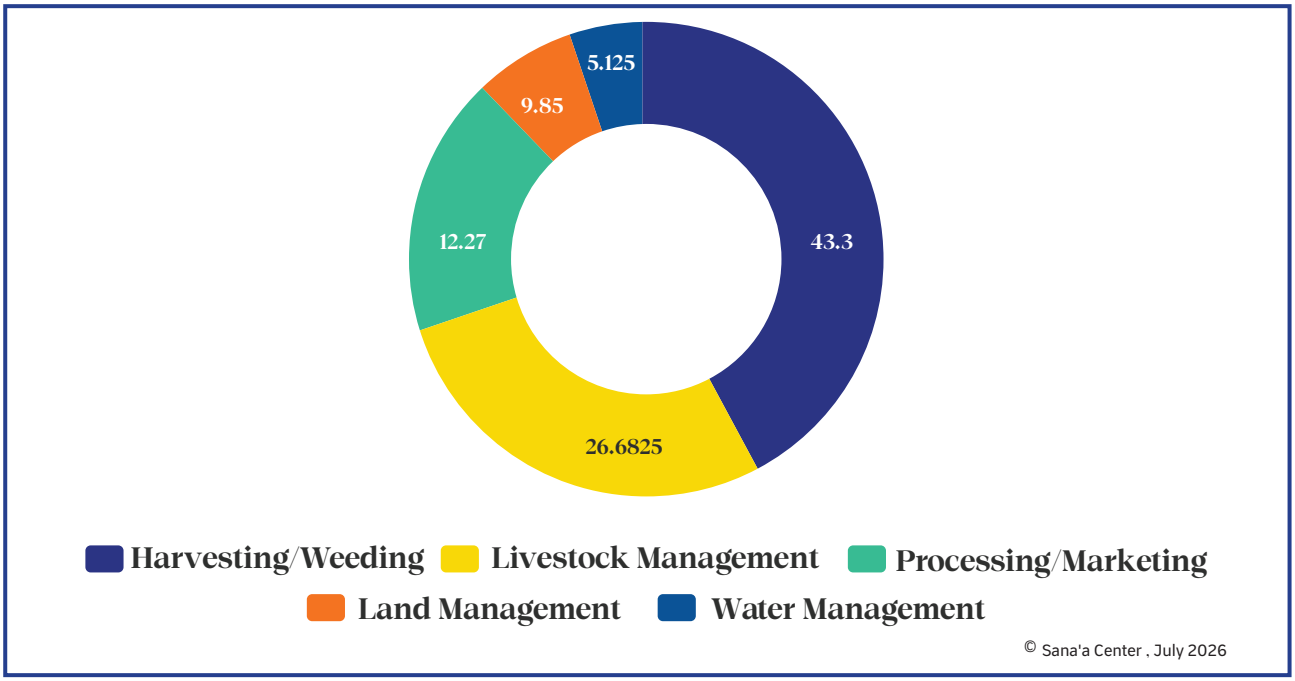
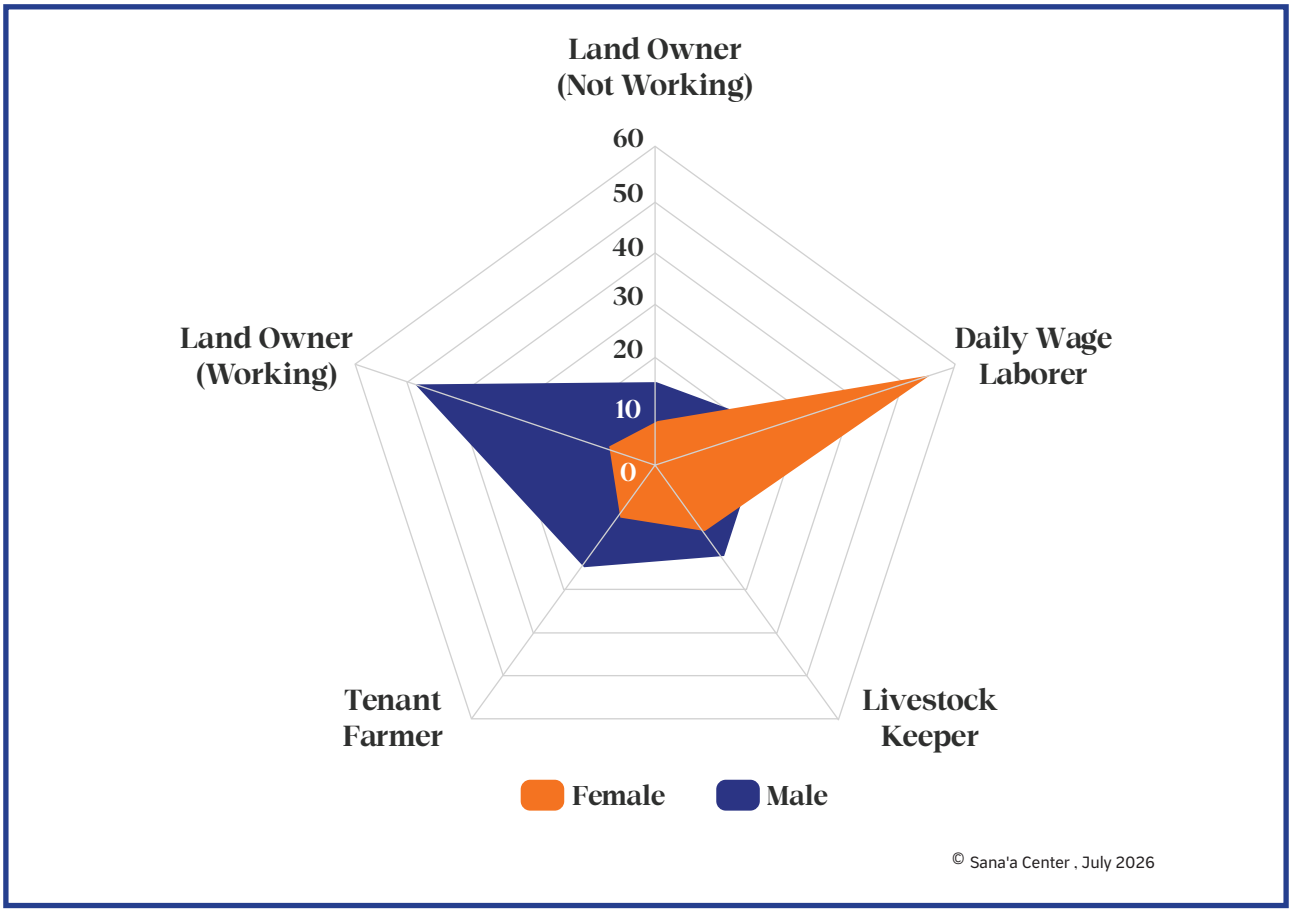


Figure 9. Agricultural Roles, Distribution by Gender



Despite their crucial role in sustaining households, women's agricultural contributions remain undervalued and constrained by unequal access to resources and cultural barriers. Many women prioritize household and childcare responsibilities over paid work, and face restrictions on movement, trade, and control over land, income, and assets (Figure 11). Some women mentioned facing exclusion or receiving less water because they were not from the same community or were tenants, and several survey answers highlighted that certain farmers exclude newcomers or less-experienced women from harvest work.

Among the challenges faced, respondents noted a lack of legal and institutional support (no contracts, unsafe working conditions, no clear grievance mechanisms to prevent abuse or enforce rights) and a lack of protection and physical safety while working (risk of harassment, violence, or exploitation in fields, water points, or markets). War and displacement, as reported especially in Abyan and Taiz, have led to loss of land and primary income sources, forcing women to seek farm work to support their families. Limited job opportunities and low wages were also frequently mentioned, along with high farming costs, competition from displaced laborers, and the physical demands of farm work, which are often incompatible with women's health, age, pregnancy, and household responsibilities.[126]

When a household experiences a loss of agricultural income, women enter the broader economy to secure other livelihoods. In Al-Dhabab, women have diversified into home-based food industries (cheese, yogurt), sewing, tailoring, electronic marketing, retail trade, and incense making.[127] The war and drought have forced a painful but real shift in gender roles.[128]

In some cases, the burden is crushing: one land-owning woman lost all her crops and livestock to drought and wept as she sold her gold and land to survive.[129] While diversification provides a vital coping mechanism and new sources of income, it simultaneously highlights the structural limitations for women in times of crisis.

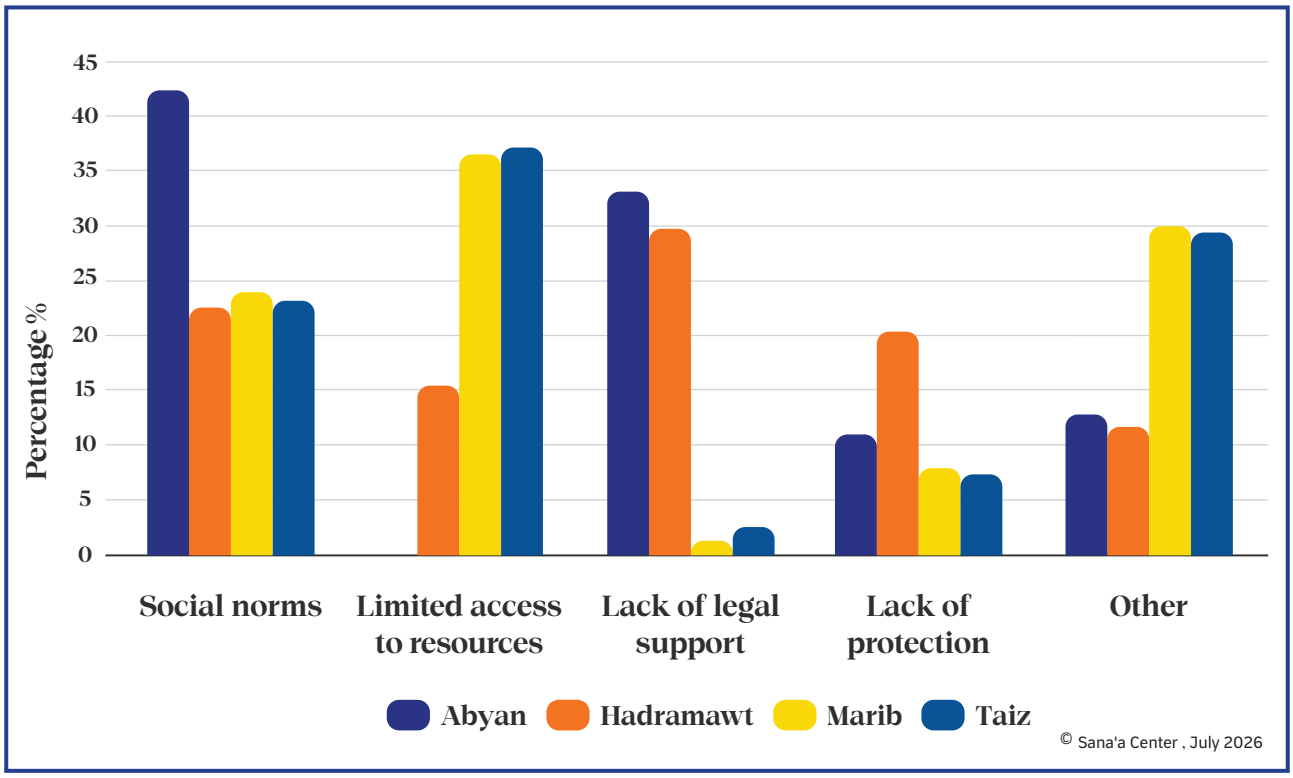
[126] Women FGDs in both Hadramawt and Taiz, September 28 and 29, 2025; interview with Iftihan Al-Mashhari, former General Manager of the Cleaning and Improvement Fund in Taiz, July 30, 2025; interview with a director of a local foundation for people with disabilities, July 30, 2025.

[127] Interview with the secretary-general of a local association, Al-Dhabab, Taiz August 4, 2025.

[128] Interview with Iftihan Al-Mashhari, former General Manager of the Cleaning and Improvement Fund in Taiz, July 30, 2025.

[129] Interview with a female land and well owner, Wadi al-Dhabab, Taiz, September 29, 2025.

Figure 10. Challenges Faced by Rural Yemeni Women



Women are increasingly involved in key decisions over land use, crop selection, and water management methods.[130] This is a shift, driven partly by war, climate impacts, the death of males and/or male outmigration, and the sheer necessity of adapting to scarcity. A woman in Taiz, whose husband died of cholera, was left with a newborn when the planting season arrived. She had no choice but to leave the baby at home while she plowed and planted alone to feed her family. In Taiz's Ash Shamayatayn district, women have significant decision-making roles at the family, sub-district, and even district levels.[131]

The Emergency Livelihoods Support project (Food for Assets),[132] implemented by the Small and Micro Enterprise Promotion Service (SMEPS), increased women's representation in community committees, even in highly conservative settings, demonstrating that targeted programming can alter deeply embedded gender barriers.[133]

Still, when it comes to land ownership and overall visible control, these remain the purview of men. "Women are not the actual controllers in agriculture because they do not own land; even if they acquire land, their husband and sons appear as the owners, and social customs hinder women's active participation."[134]

[130] Women Farmers Focus Group, Hadramawt, September 28, 2025.

[131] KII with an agriculture specialist at the Social Fund for Development, September 28, 2025

[132] Food for Assets: with Food for Assets, vulnerable households receive food assistance in exchange for their participation in labor-intensive activities that create or rehabilitate community assets.

[133] KIIs with an environment and climate protection consultant, Taiz, September 28, 2025.

[134] Interview with local farmer, Abyan, July 23, 2025.

The outcome is a labor market that is heavily influenced by gender, where women engage in essential but low-paying and physically demanding jobs. Although they contribute to decision-making processes, their involvement is often limited. In contrast, the authority to determine what crops to plant, how much water to use, and who reaps the profits remains firmly in the hands of men.

The study revealed that women, tend to focus on rearing small-scale livestock such as goats, sheep, and poultry, as these animals are better able to cope with the current scarcity of pasture and provide a quick source of income and food: "This was the case in the past, almost every household had at least a cow and some pasture, which served as an important source of sustenance for rural communities."[135]

5.3.2 Role of IDPs

Displaced people in rural communities have generated both positive and negative effects. Positive impacts include increased demand for agricultural products, exchange of expertise, integration into the community, and creation of new job opportunities. Negative impacts include the introduction of negative habits such as qat chewing, new fertilizer mixes (techniques that increase production and strain soil and water), taking job opportunities from host communities, renting agricultural land (which may displace local farmers), pressure on services, and increasing house rents.[136]

Local leaders (*sheikhs and aqils*) have stepped into regulatory roles in many areas, mediating water access and granting land to IDPs.

Despite the degradation of physical infrastructure, traditional social structures have demonstrated remarkable resilience among displaced and host communities. Local leaders (*sheikhs and aqils)* have stepped into regulatory roles in many areas, mediating water access and granting land to IDPs. In one village, the local sheikh gave all arriving displaced persons land to cultivate.[137] This integration of IDPs into the local economy and agricultural production represents a form of "social governance" and a traditional mechanism of absorption that functions even in wartime.[138] In Taiz and its neighboring areas of Aden and Lahj, such as Tur Al-Baha, and Al-Sabaiha—displaced persons move to places where they have acquaintances or to areas known for peace and social acceptance.

Displaced farmers have introduced new and intensive cultivation patterns, and have grown new crops. One displaced farmer, known as Al-Hajj Ahmed, transferred a successful technique from Al-Sharman (Mawiya district) to Al-Dhabab: digging a large pit and lining it with a special tarpaulin to retain water longer and prevent it from infiltrating the soil layers. Although this method does not meet all their water needs, it has been recognized as a "success story" in climate adaptation, and it is seen as worthy of replication.[139]

[135] Interview with a local farmer, Marib, June 23, 2025.

[136] Experts Focus Group, Hadramawt, September 30, 2025.

[137] Interview with a farmer and an official at the agricultural office in the Valley and Desert Region, Hadramawt, July 3, 2025.

[138] Ibid.

[139] Interview with a female IDP, Taiz, September 29, 2025.

Notably, such integration is not without its challenges. The study participants documented the contrasting experiences of IDPs from Hudaydah who moved to a fishing community in Aden. They were non-fishermen who lacked the required skills, and the transition from a sheikh-governed social order to a mixed-governance system posed significant adaptation challenges. In Abyan, IDPs from the governorate of Hudaydah have brought with them intensive cultivation techniques, introducing year-round watermelon and tomato production based on heavy fertilizer use.[140] This represents a transfer of knowledge that is reshaping local farming calendars and market supply. These two cases show the importance of livelihood compatibility and social-system familiarity.

IDPs participate in agricultural work, mostly in selling products and renting farmland.[141] Thus, while host communities have absorbed newcomers, the process has not always been frictionless, and the benefits are not necessarily equally distributed on both sides. The profit flows mainly to those who own the land, not the displaced laborers who work on it. This is a clear example of traditional authority exercising inclusive power, though it remains an isolated bright spot in an otherwise exclusionary landscape.

[140] KII with a director general in Al-Ma'afer district, Taiz, July 21, 2025.

[141] Experts Focus Group and Women Farmers Focus Group, Hadramawt, September 28 and 30, 2025.

6. Conclusion

Field surveys and discussions with agricultural communities revealed a stark reality of declining quality of livelihoods. However, they simultaneously highlighted a remarkable capacity for resilience and innovative adaptation practices amid ongoing conflict and increasing climate shocks, painting a clear picture of the challenges and responses at the field level. Despite the variety of sustainable adaptation strategies, traditional techniques remain the most essential and beneficial for achieving a resilient and sustainable future. This is particularly true when considering the emerging challenges of recent years, including shifts in rainfall patterns, increased flooding, and migration or displacement.

The results from the field study indicated a transition toward hybrid water governance. In this model, traditional social customs, such as local customs (al-'urf), have taken on roles to fill the gaps left by the state. Yemen's ability to adapt to water scarcity has depended more on traditional tribal governance mechanisms than on a centralized bureaucracy.

However, customary practices are cracking under the pressure of modern economic privatization, including the adoption of solar-powered irrigation systems and groundwater exstraction. While hybrid governance is a necessary survival strategy in conflict and water-scarce zones, it is not a magic bullet. The absence of state oversight often leads to a "might makes right" scenario, where new, more powerful actors co-opt traditional norms. The non-enforcement of the law, exacerbated by conflict, and citizens' non-compliance have only exacerbated problems, including unregulated drilling, building on flood paths, and encroachment on public property. Additionally, coordination between national and local official bodies in the water sector is weaker now due to the government's overall decline, significantly impacting water distribution and access.

The documented capture of water resources by different state or non-state actors provides a clear example of the "weaponization of water" in Yemen. Armed conflict, particularly in Taiz, has disrupted water provision by reshaping management power dynamics. As formal institutions weakened, access to water has become increasingly shaped by power relations rather than established governance arrangements. The emergence of Water User Associations (WUAs), as in many areas of Taiz, can thus be viewed as a form of "community-led counter-governance," a direct response to militarized capture that seeks to reclaim the public commons through collective agency.

The future of Yemen's water governance thus lies in the formalization of the informal. The practices that have proven effective must be integrated into a new, decentralized regulatory framework. The "rain of hope" for Yemen lies in community-led initiatives that bridge the gap between tradition and innovation.[142] Recovery strategies must therefore consider traditional norms and prioritize the empowerment of local associations and adopt a Water–Energy–Food (WEF) Nexus approach to regulate new technologies (such as solar-powered irrigation pumps) to ensure that today's resilience does not come at the cost of tomorrow's resources.

The most effective way to build agricultural resilience is therefore not to create large new projects from a distance, but rather to identify, protect, and enhance local practices that have already proven effective during crises. This must be supplemented with appropriate modern technologies and knowledge, such as advanced irrigation systems, greenhouse farming, and climate-smart agriculture, tailored to the specific ecological and socio-economic conditions of each region, ensuring the sustainable use and protection of non-renewable natural resources, particularly groundwater. To ensure these adaptations lead to long-term recovery, future interventions must prioritize institutionalizing local models into regional policy, regulating technological shifts to support productivity and prevent ecological collapse, and empowering women and IDPs who contribute to and lead adaptation on the ground.

In conclusion, resilience is not a given: it is a function of integrated governance and equity. Sustaining indigenous capacity requires a deliberate shift towards a hybrid, nexus-aware[143] governance model that integrates the legitimacy of traditional institutions with the technical and legal capacity to manage modern interdependencies and ensure equitable access, with the explicit goal of prioritizing and restoring water security. Without this integrated governance intervention, short-term coping strategies will consume the long-term resource base, transforming a crisis of conflict and climate into a permanent state of ecological and social collapse. The recommendations that follow provide a roadmap for stakeholders to intervene strategically, with a focus on governance, regulation, and equity. The resilience strategies documented in Hadramawt, Taiz, Marib, and Abyan can help lay the foundation for a sustainable post-conflict water governance framework.

[142] "Rain of Hope: Yemen's Fight for Water in a Time of War," IHE Delft, Water and Development Partnership Programme, December 9, 2024, https://www.un-ihe.org/news/rain-hope-yemens-fight-water-time-war

[143] Water–Energy–Food (WEF) Nexus

7. Recommendations

7.1 Stakeholder-Specific Recommendations

For Government Actors:

- Review and enforce water laws to reduce groundwater depletion, including enacting legislation on the use of solar-powered pumps.
- Support local water authorities with the mandate and capacity to enforce regulations on well drilling and pumping, particularly for solar systems.
- Link agricultural land use to water availability and sustainability, restricting the expansion of water-intensive crops (e.g. Qat and Banana) in critical basins.
- Dedicate local resources (e.g., from local taxes) to the maintenance of critical public water infrastructure, including traditional and spate irrigation systems, which are essential for community resilience.
- Formulate a disaster risk reduction strategy, secure funding, and support the implementation of flood management plans.
- Prohibit residential and commercial development in flood-prone and flash-flood areas, and protect agricultural lands from urban encroachment by enacting necessary legislation and regulations.

For Donors:

- Prioritize conflict-sensitive, multi-year resilience programs that integrate water, agriculture, and peacebuilding, recognizing water as an entry point for local cooperation and peace.
- Invest in hyper-governance regulation and policies, as well as in integrating Water-Energy-Food nexus in local and national strategies that account for accelerating climate change and extreme events.
- Support the establishment of functional local water governance structures, such as water user associations and water committees, with clear rules for resource allocation and conflict resolution.
- Support rainfed agriculture and traditional resilience practices such as terracing, spate irrigation, and crop diversification, while providing climate-resilient seeds and revitalizing local water-harvesting structures.
- Promote cooperation among national and local authorities, farmers' cooperatives, local communities, the private sector, and research institutions.
- Utilize a systems-based, bottom-up approach by starting with a comprehensive context analysis that includes mapping traditional governance structures.

For the United Nations (UN) and International Non-Governmental Organizations (INGOs):

- Partner with and build the capacity of both traditional (tribal leaders, indigenous councils/communities) and modern (Water User Associations, local authorities) water governance actors. Ensure project design reinforces, rather than bypasses, local legitimacy and norms.
- Conduct mandatory conflict analysis before any water or land project (e.g., well drilling, dam repair, etc.) to ensure the intervention does not exacerbate local tensions or lead to elite capture.[144] Prioritize projects that benefit marginalized groups such as IDPs and women.
- Ensure a minimum quota for women's participation in all water management committees and decision-making processes, recognizing their critical role in household water security and conservation.

For Local Civil Society Organizations (CSOs):

- Facilitate dialogue and cooperation between traditional leaders, local authorities, and international actors. Use local water knowledge to translate formal regulations into culturally appropriate and enforceable community rules.
- Monitor and report on instances of injustice in water resource capture and inequitable distribution, particularly regarding IDPs and smallholder farmers. Advocate for their inclusion in local water governance structures.
- Support women's economic collectives by providing access to market linkages and safe production spaces, transforming crisis-driven adaptation into recognized, protected employment. Emergency cash transfers and psychosocial support should specifically target female-headed farming households.
- Systematically document and share successful indigenous water and agricultural practices as a foundation for climate change adaptation strategies.
- Ensure that water management committees are transparent in their decision-making and financial management. Actively encourage the participation of women in decision-making roles, given their critical role in household water and food security and emerging economic activities.

For the Private Sector:

- Solar pump and irrigation equipment suppliers should promote and offer certified, high-efficiency pumps and modern irrigation systems. In consultation with relevant authorities, explore "smart" technologies to monitor and limit extraction rates.
- Invest in processing, storage, and market access for drought-tolerant, high-value crops (e.g., specific grains, herbs) to provide economic alternatives to water-intensive "qat" cultivation.
- Contribute to enhancing climate finance for Yemen through the private sector or climate funds to support climate adaptation activities in the water, agriculture, and livestock sectors, especially in rural, marginalized areas.

[144] For instance, local leaders, wealthy families, or armed actors influencing projects or interventions so that they benefit disproportionately, while poorer or marginalized groups are excluded, undermining equity.

For Research Institutions:

- Conduct in-depth research on the political economy of water in conflict zones, analyzing how power dynamics, informal markets, and aid interventions shape water access and depletion.
- Develop high-resolution models to project the long-term impacts of solar pumping on key aquifers, and use the resulting data to provide evidence-based policy recommendations for regulation.
- Systematically document traditional water practices and customary law related to water management across regions to provide a legal and social foundation for the hybrid/WEF nexus governance model.

7.2 Study Areas Specific Recommendations

For Hadramawt:

- Establish and strengthen local legal aid and arbitration mechanisms to protect small-scale farmers and marginalized landowners. This involves providing legal aid and formalizing land tenure to prevent the privatization of communal lands. Such action will also address illegal threats, including intimidation and imprisonment, from influential figures encroaching on these lands.
- Support the self-organized disaster response system in Al-Hafa and other valleys. This includes training local volunteers and providing them with basic rescue equipment and maintenance tools to manage climate shocks independently of the central government.
- Incorporate women into the governance of water user associations and the scheduling of irrigation. Women in Hadramawt are already actively involved in collecting water, managing drip irrigation systems, maintaining channels, and increasingly participating in decisions regarding land use and crop selection. To transform this operational presence into institutional power, all water user associations and their committees should implement a mandatory minimum quota for female members.
- Leverage the success of quality certification to access export markets. Onion growers in Hadramawt have recently obtained international quality certificates, which allow them to enter external markets. Public investment in quality-assurance laboratories and certification can transform this emerging success into a scalable model for producing water-efficient, high-value cash crops.
- Regulate and establish local committees to oversee the installation of solar-powered pumps. This prevents the anarchic depletion of deep aquifers by ensuring that technological adoption is balanced against the basin's recharge capacity.

For Taiz:

- Prioritize the demilitarization of water resources through:
  - Negotiating the withdrawal of influential figures, political actors, and state and non-state armed groups from water infrastructure and enforcing a "water sanctuary" policy under the auspices of a UN-led truce and local ceasefires.
  - Advocating for a "Neutral Water Zone" policy where state and non-state actors are prohibited from drilling or controlling wells. Seized public assets must be returned to the Local Water and Sanitation Corporation, with oversight from community monitoring.
- Formalize and support Water User Associations (including in Al-Silw and Al-Mawasit districts), granting them clear legal rights to support local wells and distribution management, and expand community-based, participatory governance to other districts. This includes incorporating lessons from Ash Shamayatayn, where women have reached decision-making roles, and from the SMEPS project, which significantly increased women's representation on committees through awareness programs.
- Break the monopoly of well owners over water sales to tankers, and regulate the water-trucking market to ensure affordable access for female-headed and poor households, who are currently priced out. Pair this with support for household rooftop harvesting and storage, as already practiced by some women using jerrycans and small tanks.
- Counter the expansion of qat-driven groundwater depletion by offering viable, high-value alternatives. The solution is not prohibition, but the simultaneous scaling of sesame, already encouraged in Al-Waziya and Sabr, and coffee value chains, building on the private coffee growers' associations already established in Sabir and Al-Mawasit. These crops are less water-hungry, provide stable income, and have proven market traction that can outcompete qat if supported by consistent extension and post-harvest processing.

For Marib:

- Rehabilitate the Marib Dam, including repairing damaged irrigation canals and clearing landmines from well fields to restore the backbone of agriculture. This requires coordinated funding and technical cooperation between the local authority, international agencies, and demining organizations. A water council, including elected farmer representatives, tribal authorities, and technical agencies, should oversee the rehabilitation and set transparent distribution rules that are resilient to future closures.
- Develop drought contingency plans for the Marib Dam that integrate early warnings of low rainfall and reduced water flow, enabling collective decisions on water rationing before a crisis occurs.
- Invest in drip irrigation as a complement to canal supplies to enable more efficient groundwater use during periods of canal closure. This aligns with farmers' expressed need for modern technologies that save water and increase productivity.
- Formalize IDP water-sharing agreements through transition from informal tribal hospitality to formal social contracts that define the rights and responsibilities of displaced populations regarding water and land use to prevent future resource-based conflicts.

For Abyan:

- Reestablish the Delta-wide Flood Distribution Committee under the Agriculture Office to ensure that every farm in the delta receives spate water. This committee should have the statutory authority to allocate spate water based on historical cropping rights. This includes reviving the spate irrigation committees responsible for overseeing water distribution in the delta. These committees should have the authority to eliminate illegal barriers and enforce quotas that protect downstream farmers.
- Invest in the communal rehabilitation of the main canal from the Ba Tays diversion dam by fostering coalitions of farmers from both upstream and downstream areas. Build on the existing practice of farmers collectively cleaning their shared canals, with support from local authorities for equipment and materials to scale up these efforts.
- Manage the banana boom using water-saving technologies and economic alternatives. The expansion of banana cultivation that relies on groundwater poses a nearly irreversible threat, and halting it is challenging due to compensation issues. A phased approach should include:
  - Mandate drip irrigation for all new banana plots, with subsidized equipment provided.
  - Concurrently, promote high-value, low-water crops—such as sesame, greenhouse-grown vegetables (following the pilot at the Al-Kod research station), and pomegranates—so that farmers have viable options to transition away from banana cultivation.
- Integrate displaced farmers' knowledge and regulate labor conditions while managing environmental externalities. Displaced people from the North of Yemen have introduced intensive year-round cultivation of watermelon and tomato, using heavy fertilizer mixes, a technique that increases yields but threatens soil and water quality. Local authorities and should work with these IDP farmers to integrate their techniques with soil conservation and integrated pest management, turning a potentially extractive practice into sustainable intensification that benefits both hosts and the displaced.
- Establish a minimum agricultural wage, and enforce it through farm registration tied to water permits. Displaced women from Al-Hudaydah and local landless women now work as daily wage harvesters, often alongside men, in arduous tasks. Banana harvesting is explicitly noted as too physically demanding for most women, for miserly pay.

About the Authors:

Musaed Aklan is a Senior Researcher at the Sana'a Center for Strategic Studies focused on water, the environment, and climate change. He holds a Master's in Integrated Water Resources Management from Cologne University in Germany, and a double PhD in Water Resources Management from IHE-Delft and Wageningen University in the Netherlands. He has worked with INGOs and international institutions as a lead researcher and consultant in the field of water and the environment.

Raidan Bassah is a hydroinformatics researcher specializing in artificial intelligence, deep learning, remote sensing, and GIS for water and environmental challenges. He holds an MSc in Hydroinformatics from IHE Delft, the Netherlands, and a BSc in Civil Engineering from Sana'a University, Yemen. His work focuses on environmental forecasting, climate adaptation, and sustainable development.

Maryam Abdulrahman is Research Assistant specializing in stakeholder engagement, field survey, organization of stakeholder meetings, and the collection, management, and verification of primary data from fieldwork activities.

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