CLIMATE CHANGE, AGRICULTURE AND GENDER IN GAZA

Assessing the implications of the climate crisis for smallholder farming and gender within olive and grape value chains in Gaza

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Women and men working in smallholder olive and grape sectors in Gaza face many difficulties in eking out a living, many as a result of a long blockade that restricts free movement of people and goods and access to land needed for agriculture, severely hampering any economic prospects. Climate change exacerbates the crisis, with rising temperatures and sea levels causing further shocks, stresses and uncertainty. This research assesses smallholder farmers' capacity to absorb, adapt and transform their livelihoods in the face of these challenges – with a particular focus on women, who bear the brunt of climate change and inequality – and suggests a range of actions that should be taken to address the crisis.

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Cover photo: Ammar is an olive farmer and a member of an agricultural cooperative in Gaza City. Oxfam and the Agricultural Development Association have supported olive farmers like Ammar with training on modern practices and innovative tools. Photo: Kieran Doherty/Oxfam (2019)

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LIST OF ACRONYMS

NAP	National Adaptation Plan
CSOs	Civil society organizations
FAO	Food and Agriculture Organization of the United Nations
IPCC AR5	Intergovernmental Panel on Climate Change: Fifth Assessment Report
GDP	Gross Domestic Product
MoA	Ministry of Agriculture
NGOs	Non-government organizations
OPT	Occupied Palestinian Territory
PADRRIF	Palestinian Disaster Risk Reduction and Insurance Fund
RCP	Representative Concentration Pathways
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

SUMMARY

The Gaza Strip is a small area of land on the eastern coast of the Mediterranean Sea. It forms part of the Occupied Palestinian Territory (OPT) along with the West Bank, including East Jerusalem. Israel and Egypt maintain a blockade of Gaza, restricting the free movement of people and goods as well as access to land needed for agriculture, and severely hampering the economic prospects of women and men. As a result, the people of Gaza face daily difficulties, chronic need, and dependency on donor support, most of which is in the form of stop-gap measures. It is estimated that 70% of the population live below the poverty line.[1]

Climate change exacerbates the crisis faced by most Palestinians in Gaza, with rising temperatures and sea levels, causing further shocks, stresses and uncertainty for those trying to survive in extremely difficult circumstances. Women face a multitude of additional risks due to discriminatory social norms and practices that prevent them from participating fully in society and the economy.

Smallholder agriculture, on which many people depend, is the sector which is most vulnerable to the effects of climate change. Temperature rise and humidity, increasingly irregular and unstable rainfall patterns, and sea-level rise paint a bleak picture for grape and olive smallholder farmers in Gaza. Negative impacts on olive and grapevine sectors which are already evident include reduced flowering and growth, attack from pests and diseases, direct tree stress, and reduced quality and quantity of fruit. Scarcer water resources and increased water and soil salinity add to crop vulnerabilities. Violent winds cause loss of leaves and flowers, and directly damage and destroy fruit, while drought dries out seedlings and plants, putting them under further stress.

Ultimately, all these effects lead to production losses, reduced income and livelihood insecurity for farmers. Smallholder farmers are also highly vulnerable to the impacts of the Israeli occupation on their basic needs manifested in market closures, lack of access to inputs, and even lack of access to and control over the very resources they need for production. Years of violent conflict and occupation have already deprived smallholder farmers of the knowledge and skills they need to adapt and transform their livelihoods to the various risks.

At the supply chain level, climate change and other factors are causing reduced selling capacity for smallholder farmers due to production losses, reduced purchasing power and inability to compete with larger producers, ultimately diminishing their market opportunities. Of particular importance, and highly affected by climate change, is storage and processing in olive and grapevine value chains, where rising temperatures and humidity during storage have detrimental effects on product quality. This is compounded by the lack of access to storage infrastructure needed to mitigate these effects; without this, the quantity, quality and ultimately the price of olive and grape products is reduced.

For women, climate change exacerbates existing vulnerabilities; it intersects with a range of social, economic and political inequalities that affect their access to natural and physical assets and supporting services, as well as their ability to make decisions affecting their everyday lives. While women cannot be treated as a homogenous group, their key role in agriculture is usually as the family support system; women help their husbands or other male family members in farm production, providing substantial unpaid labour (particularly in harvesting and post-harvesting) and thus reducing overheads and costs. Lack of recognition of the many hours women spend in productive work perpetuates the invisibility of women's role in the agriculture sector and undermines their status overall.

Given women's particular roles within the agricultural production cycle, the climate crisis is felt acutely by them, especially by those working in smallholder farming, as it jeopardizes their roles in the production cycle. For women involved in processing, extreme weather events such as

flooding affect their supply of produce, while they also face an increase in the social tensions and gender-based violence caused by the economic consequences of the climate crisis and the blockade. Women also have the added mental burden of taking care of their household with limited financial resources; thus increasing their unpaid care and domestic workload. Government policies do not alleviate gender inequality, and agricultural policies are, for the most part, gender-blind. Women therefore bear the brunt of the climate crisis. Without significant interventions by government, donors, agricultural departments and a range of other stakeholders, future climate change scenarios are set to worsen these effects and impacts on women.

Ultimately, for both women and men in smallholder farming, climate resilience capacities (as defined by Oxfam's Framework for Resilient Development[2]) are low. 'Absorptive capacity' is the capacity to take intentional protective action to cope with known shocks and stresses. While olive and grape smallholder farmers have generations of knowledge and experience and have taken action to cope with climate change and other risks, including the occupation, many famers, especially women, are barely coping. Even small changes in the climate have affected crop production; coupled with the crippling effects of the occupation, it means that their absorptive capacity is low and evidently decreasing.

'Adaptive capacity' is the capacity to make intentional incremental adjustments in anticipation of or in response to change, in ways that create more flexibility in the future. While olive and grape smallholder farmers are learning every day about how to adapt to climate change and become more resilient to the ongoing uncertainty caused by external forces, in particular the occupation, it remains very difficult for farmers, particularly women, to plan for their future. Farmers survive season to season and even when they want to plan more intentionally for change, their circumstances prevent this. All these factors mean that their adaptive capacity is low.

'Transformative capacity' is the capacity to make intentional changes to stop or reduce the drivers of risk, vulnerability and inequality, and ensure the more equitable sharing of risk so that it is not unfairly borne by poor and vulnerable people. This lies at the heart of the issues facing not only smallholder farmers, but the population of Gaza in general. Factors other than climate change are currently their biggest obstacle to building transformative capacity. The Palestinian government is struggling to maintain its operations and is unable to provide the policy and practical support its citizens need. For smallholder farmers to build their transformative capacity – which is very low – the enabling environment of the OPT needs to significantly change.

SUMMARY RECOMMENDATIONS

To address the multiple challenges faced by women and men smallholder farmers, the research makes the following recommendations: (1) to increase climate-resilient olive and grape production; (2) to strengthen the resilience capacities of farmers; (3) to foster more resilient and inclusive olive and grape value chains; and (4) to create an inclusive and resilient enabling environment.

1 Increase climate-resilient olive and grape production

- Farmers should choose from and use olive and grapevine varieties that are able to cope with the combination of stresses and extreme events, where available, as these are better able to deal with the effects of climate change. This includes varieties where flowering occurs before the beginning of the dry period, and those whose life cycle allows them to avoid or significantly reduce damage caused by temperature extremes.
    - Relevant actors for this recommendation include the private sector, nurseries and input suppliers, particularly with regard to balancing customer preferences for traditional varieties with the need to adopt new resilient varieties.

- Farmers should adopt or be supported to adopt improved management techniques, such as modification of canopy temperature (e.g. pruning and adapted shading techniques in order to limit heat stress impacts) or supplementary irrigation (i.e. a single irrigation event to protect flowering of current varieties, or in extreme conditions in future years), that will support adaptation in addition to adapting crop cultivars.

    - Relevant actors for this recommendation are: farmers, extension service providers, the private sector.

- Farmers should apply or be supported to apply soil and water management techniques in order to mitigate the effects of increased evapotranspiration and heavy rainfall (with associated soil erosion and flooding risks). This includes mechanical measures (bunding, terracing, ridging, pitting), mulching, intercropping, fertilizing with compost and manure, cover crops (green manure) and conservation agriculture, among others.

    - Relevant actors for this recommendation are: farmers, extension service providers, the private sector, Ministry of Agriculture.

- Farmers should apply or be supported to apply integrated pest management techniques. These should focus on ecological pesticides and biological control methods, especially given the current excessive dependence on chemical pesticides and environmental issues stemming from this. Complementary approaches could include adopting physical control methods, such as installing insect traps to stop the vectors that cause olive and grape diseases.

    - Relevant actors for this recommendation are: farmers, extension service providers, the private sector (particularly input suppliers), Ministry of Agriculture and NGOs.

- Farmers should plant or be supported to plant windbreaks around plot boundaries, as a strategy to protect trees and crops from *Khamaseen* winds.

    - Relevant actors for this recommendation are: famers, Ministry of Agriculture and NGOs.

2 Strengthen the resilience capacities of farmers

- Farmers' resilience capacities should be strengthened in agricultural and olive/grapevine orchard management through the adoption of climate-resilient practices such as the ones mentioned above, and through better climate risk management. This can be achieved by strengthening the capacities of female smallholder farmers and processors in the adoption of improved and climate-resilient techniques and promoting their role in the development of innovative approaches. A strong 'gender lens' should be applied to review existing outreach mechanisms, women's learning needs, and delivery methods.

    - Relevant actors for this recommendation are: cooperatives, community-based organizations, INGOs, local NGOs, Ministry of Agriculture and the private sector.

- Local breeding capacities for improved and adapted olive and grape varieties should be developed, including new varieties that have shorter production cycles (particularly to avoid the expected higher frequency of heat events during flowering times, as well as to cope with shorter production seasons), are more tolerant of high temperatures and drought, and have greater disease immunity. Investment in research and development is required to develop local genetic engineering capacities and new breeding programmes that are capable of testing new varieties, adapted to the local context (i.e. adapted to local consumer preferences and local culture).

    - Relevant actors for these recommendations are: Ministry of Agriculture experts, nurseries, external experts, and research and development institutions.

- Oxfam and other stakeholders should work alongside farmers to improve community disaster risk management mechanisms, including early warning systems. This includes identifying key seasonal climate risks, providing relevant agro-climatic support, and developing appropriate contingency measures and adaptation practices. Efforts to strengthen or develop disaster risk management mechanisms should place women at the centre of planning and decision-making structures, ensuring that their differentiated vulnerabilities and needs are prioritized and integrated in all processes, including analysis of risks and the development of contingency and response measures. Gendered consideration is necessary when developing the content of disaster risk management and preparedness trainings.

  Under this recommendation it is critical to pay close attention to access to information, in relation to climate information, weather forecasts and early warning systems. Access to information interventions should consider how different farmers, particularly female farmers, receive and are able to understand and interpret such information. Multiple channels should be used to deliver climate information, consider the best mechanisms to reach both small- and large-scale, male and female farmers and taking into account literacy levels and mobility across different geographical locations.

    - Relevant actors for these recommendations are: national meteorological units, Ministry of Agriculture, Palestinian Disaster Risk Reduction and Insurance Fund (PADRRIF), municipalities, women's rights organizations working on the environment and climate, community-based organizations, NGOs and research institutions.

- Technological innovation capacity in grape orchard practices, including promotion of specialization in arboured grape production systems, should be increased, provided that these have better profitability margins. This should be linked with appropriate investments in developing locally adapted varieties, including research and development, and in extension services that facilitate farmers' adoption of new technologies.

- Climate-resilient community-based funds that are gender- and vulnerable-community responsive, should be created and supported in order to compensate communities whose livelihoods are suffering as a result of the climate crisis. This includes raising awareness about the PADRRIF in the Gaza Strip and its operationalization.

    - Relevant actors for this recommendation are: Ministry of Agriculture, PADRRIF and INGOs.

3 Foster more resilient and inclusive olive and grape value chains

- Oxfam and other stakeholders should support research that analyses how women within different value chains are being impacted by the climate crisis. These value chain analyses should include specific gender and climate change analyses as well as considering intersectionality; looking at aspects such as differentiated vulnerabilities to climate risks and impacts, and inequality in opportunities to strengthen climate resilience (considering access to assets, information, capacity building, etc.). Oxfam's Vulnerability and Risk Analysis (VRA) provides a useful tool for this.

    - Relevant actors for these recommendations are: INGOs, Food and Agricultural Organization of the UN (FAO), women's rights organizations, and farmers and processors, particularly women.

- Access to post-harvesting infrastructure should be improved, particularly for processing, where women are highly concentrated. This could include putting in place storage facilities, or solar energy infrastructure (to allow cold storage) as a complementary strategy, to enable women to access a continual supply of raw materials for food processing businesses led by them, thereby reducing vulnerability to price instability and risk of fresh fruit loss. This is likely

to create economic opportunities for women and strengthen their empowerment in the olive and grape value chains.

    - Relevant actors for this recommendation are: INGOs, cooperatives, the private sector, investment companies, financing institutions, and female farmers and processors.

- Support should be given for the organization of farmers in producers' groups or cooperatives, particularly women's groups, to improve their market opportunities and bargaining capacity over access to key inputs and product sales, as well as to strengthen their negotiating position with other value chain actors. Such groups, once they are exercising collective bargaining power, can also influence agricultural and climate-related policies. Organized farmers can also collectively tackle and reduce risks by developing savings and loans associations or informal mutual insurance mechanisms. Creating platforms to regroup different supply chain actors (producers, processing units, retailers, etc.) could also represent an important step towards seeking joint action and maximizing synergies among actors intervening in the olive and grape value chains.

    - Relevant actors for this recommendation are: INGOs, cooperatives, the private sector, women's rights organizations, investment companies, and farmers and processors.

4 Create an inclusive and resilient enabling environment

- Oxfam and others should support advocacy for the integration of gender issues through needs and capacity assessments during the development of climate change policies/strategies, including through women's involvement in policy decision-making spaces. This can be enabled by investing in the research capacities of women's rights organizations to uncover linkages between the climate crisis and gender inequalities, and by supporting women-led influencing and mobilization to promote gender justice in climate policy making (local to national development plans, adaptation plans).

  There should be a specific focus on the integration of gender and vulnerability analysis in future projects of the government and implementing organizations.

    - Relevant actors for this recommendation are: INGOs, FAO, Palestinian Environment Quality Authority, women's rights organizations, research institutions and Ministry of Agriculture.

- Oxfam and others should advocate to facilitate women's access to and control over land, including development of strong regulations to protect women's rights in land cultivation and economic agricultural activities. Addressing these gender inequalities increases women's access to assets, finance, extension support, climate information and their participation in decision and climate policy making, and reduces women's compounded vulnerabilities.

    - Relevant actors for this recommendation are: women's rights organizations, INGOs, Ministry of Women's Affairs and community-based organizations.

- Oxfam and others should advocate to increase government support for climate-sensitive polices, as these will provide the enabling environment needed for farmers to absorb risk, adapt their livelihoods and transform women's involvement. With aquifer depletion and related soil and water salinity being among the most important problems for Gaza's agricultural production and livelihood wellbeing, state efforts to improve water reuse (wastewater treatment), provide rainwater-harvesting equipment/infrastructure or install water desalinization plants should continue to be pursued. However, as a result of the blockade, there are significant limitations in access to the necessary infrastructure.

    - Relevant actors for this recommendation are: INGOs, Palestinian Water Authority, Ministry of Agriculture, Palestinian Environment Quality Authority and community-based organizations.

- Oxfam and others should support advocacy to increase government provision of funds, incentives, risk-sharing schemes and subsidies for smallholder farmers to invest in climate adaptation techniques and mechanisms (e.g. shading, soil and water management, integrated pest management), as well as to cover farmers' losses and damages due to climate change.

    - Relevant actors for this recommendation are: PADRRIF, Ministry of Agriculture, donors and INGOs, local groups and community-based organizations.

- Whenever possible, the government should provide support funds, incentives or subsidies to enable smallholder farmers to invest in climate adaptation techniques and mechanisms (e.g. shading, soil and water management, integrated pest management), as well as to cover farmers' losses and damages due to climate change.

    - Relevant actors for this recommendation are: PADRRIF, Ministry of Agriculture, donors and INGOs, local groups and community-based organizations.

- Oxfam and others should support the government's efforts to strengthen national agricultural risk management structures. There is a strong need to reinforce the operationalization of existing national meteorological units and to develop national early warning systems and agro-climatic advice (including extension services). These have to be capable of translating climate risks into timely, relevant and user-friendly information for farmers, and particularly for women, on how to prepare for and manage extreme weather events and adopt adequate management techniques according to seasonal meteorological variability.

    - Relevant actors for this recommendation are: Ministry of Agriculture, Palestinian Environment Quality Authority, donors and INGOs, and national meteorological units.

- Oxfam and others should advocate for the Ministry of Agriculture to operationalize and strengthen the national agricultural insurance mechanism PADRRIF in West Bank and Gaza. However, such a risk management mechanism may only prove viable for smallholder farmers if highly subsidized, a lesson learned from other micro-insurance initiatives piloted by Oxfam.

    - Relevant actors for this recommendation are: PADRRIF, Ministry of Agriculture, donors and INGOs.

- Oxfam and others should advocate for government and private sector extension services that provide capacity building in climate-resilient techniques and appropriate management practices. This would include developing capacities to provide relevant and timely agro-climatic advice based on climate forecasts (e.g. pruning management), as well as support to enable producers to adopt improved and climate-resilient varieties. As existing extension capacities are limited due to lack of financial resources for farm visits, efforts to broadcast extension advice through other communication channels (radio, SMS, information-sharing structures at community level, etc.) should be promoted whenever possible.

    - Relevant actors for this recommendation are: Ministry of Agriculture, private sector, cooperatives, donors, INGOs and farmer communities.

- Oxfam and others should advocate for the government to reinforce phytosanitary regulations to avoid the excessive use of harmful and internationally prohibited pesticides. This should include improved supervision of the quality of imported products, and promotion of the development and adoption of eco-friendly phytosanitary products.

    - Relevant actors for this recommendation are: Ministry of Agriculture, the private sector, cooperatives and farmer communities.

- A mass cropping plan/map should be developed through an agricultural survey, analysing soil and temperature characteristics across the different geographical locations of the Gaza Strip. This can support Ministry of Agriculture planning of crop plantation based on climate variables.

    - Relevant actors for this recommendation are: Ministry of Agriculture, INGOs and donors.

1 INTRODUCTION

The Palestinian agriculture sector is characterized by its diversity in terms of agricultural production. It benefits from climatic variations, opportunities for expanding irrigated and export cash crops, and its ability to keep abreast of agricultural technological development as a result of favourable agricultural patterns and the presence of many entrepreneurs.[3] Despite this, Palestinian agriculture is currently estimated to be operating at just one-quarter of its potential.[4] This is due in part to Government of Israel restrictions stifling agricultural growth, but also because of bottlenecks – including underutilized agro-processing capacity, information asymmetries, weak supporting services and low private investment – combined with weak Palestinian legal and institutional frameworks that undermine agricultural market systems. Climate change adds to these challenges, with rising temperatures and rainfall variability making agricultural livelihoods more difficult.

From November 2019 to January 2020, Oxfam conducted research under its Economic Justice Programme into the impacts of the climate crisis on Gaza's agricultural sector. This focused on grape and olive value chains, including the particular impacts and implications for women smallholder farmers. To gather the necessary data, the research team used desk-based documentation, climate change modelling, stakeholder interviews and focus groups, as well as primary data from the participants of two key projects.[5]

Within these two projects, Oxfam works closely with farmers in different value chains to address the systematic bottlenecks hindering value chain growth and contribution to the economy. One of those systematic bottlenecks is related to the impacts of the climate crisis. Oxfam's experience shows that the agricultural sector is a high-risk business for smallholder farmers, whose livelihoods are vulnerable to both climate-related disasters (e.g. floods and drought) and the longer-term impacts of the climate crisis (e.g. temperature increase and seasonal shifts). Small-scale producers' exposure to the climate crisis perpetuates and deepens poverty and suffering; it also exacerbates structural inequalities, including gender inequalities. While the challenges facing the agriculture sector in Gaza are the consequence of interlocking factors, climatic shocks made worse by global warming have added a potent new threat multiplier, and serve to widen existing inequalities. This justified the need to assess the impact of the climate crisis on the different value chains and marginalized collectives in the Gaza Strip.

This research is primarily intended to inform Oxfam's understanding of the climate crisis, its gendered impacts, and how to adapt programming to make it more resilient to a range of risks and stresses. This will help inform the ongoing development of programming in Gaza and the wider region.

All quotes included in this report are approximate representations based on notes taken by the data collectors.

2 METHODOLOGY

2.1 OVERVIEW

This research was commissioned by Oxfam in the Occupied Palestinian Territory (OPT) to assess the vulnerability, risks and impacts of the climate crisis on the agriculture sector and their implications for gender inequalities in the Gaza Strip, with a particular focus on the olive and grape production sectors. The research had three key objectives:

1. To assess the risks and socio-economic impacts of climate change for smallholder crop production in the olive and grape value chains targeted by Oxfam.
2. To scope the differentiated vulnerabilities and gendered impacts of the climate crisis, including within these value chains.
3. To provide a well-illustrated framework of recommendations to support the integration of climate change adaptation in Oxfam's Economic Justice programme, including grape and olive values chains and gender justice considerations.

The research used a combination of desk-based review and field-based data collection and analysis. The approach was designed to be gender-sensitive and participatory in nature, and to ensure the inclusion of vulnerable groups throughout the data collection process. This included disaggregating the views of women and men both in consultation and in data analysis and having a gender-balanced research team. The research employed a mixed-methods approach to data collection, triangulating primarily qualitative data from key stakeholders with secondary data sources and quantitative modelling.

In total 48 people (13 female, 35 male) participated in the research, from seven stakeholder groups (smallholder farmers, government ministries and departments, universities, agricultural organizations, meteorological organizations, Oxfam staff, and partners). Of these, 20 people (1 female, 19 male) took part in individual semi-structured interviews, while 27 small-scale olive and grape producers (11 female, 16 male) took part in four community workshops (two female and two male focus group discussions, seasonal calendar exercises and spidergram surveys).

A range of data collection tools were used to collect quantitative and qualitative data for the research. These included: a desk review of bibliographic sources, grey literature and climate models;[6] climate modelling of olive and grape sectors to assess historical and future climate and agricultural trends;[7] focus group discussions on key aspects of the research; a seasonal calendar exercise to enable participants to provide detailed information on agricultural management and its variations with relation to climate change; spidergram surveys to measure community perceptions of changes in their lives in terms of resilience building; and more in-depth semi-structured interviews with all stakeholder groups.[8]

2.2 ANALYTICAL RESEARCH FRAMEWORK

An analytical research framework with three main components (and associated questions, as outlined below) was designed to support the analysis of data findings.

Figure 1: Research analytical framework

Risks, differentiated vulnerabilities and impacts

- **Risks:** What are the main climate risks in the intervention context? What are the (past and future) trends in the evolution of such climate risks? What are the other main risks (security, socio-economic, political, inequality, environmental, etc.,) intersecting with climate risks?
- **Differentiated vulnerabilities:** How are smallholder farmers particularly vulnerable to climate risks and other contextual risks? How is vulnerability differently shaped for women and men? What underlying factors shape these vulnerabilities (access to production assets, supporting services and networks for production and market access, inequalities in decision making over investments, economic distribution and benefits at household/community/policy level)?
- **Differentiated impacts:** What are the observed impacts of climate on smallholder production in the grape/olive sectors? How have climate change and climate-related disasters impacted differently on female and male farmers? To what extent have climate-related impacts on female and male farmers been amplified by other contextual risks?

Climate resilience building processes

- **Access to natural and physical assets:** What affects smallholder farmers' access to land (entitlement and quality), water, infrastructure (irrigation, storage infrastructure, etc.), inputs (fertilizers, machinery), workforce, financial resources for investment (i.e. access to and control over credits and savings)?
- **Access to supporting services:** What affects smallholder farmers' access to relevant agro-climatic or market information and advice, capacity-building opportunities, social protection schemes, government subsidies, credit/insurance schemes, and more?
- **Governance, policies and rules:** What climate change adaptation and disaster risk management strategies, policies and plans, agricultural and other sectorial policies exist that are relevant to building climate resilience and ensuring inclusion of women smallholder farmers in policy decision making, accountability, and consideration of the traditional/cultural norms and rules regulating access to assets and services?
- **Actors and multi-stakeholder action:** What networks exist, and what are the common actions between actors involved in the grapevine and olive sectors, including supply chain actors, CSOs, authorities, international actors, private sector, etc.?

Climate resilience capacities

Smallholder farmers' climate resilience capacities were also assessed according to the three capacities outlined in Oxfam's Framework for Resilient Development:[9] absorptive capacity, adaptive capacity and transformative capacity.

2.3 RESEARCH LIMITATIONS

The research was constrained by several factors, which need to be considered alongside the findings and analysis presented in this paper. These include:

- **Gender imbalance in research participants.** Despite efforts to ensure an equal number of female and male participants, this was not achieved. While the community workshops were generally evenly split between females/males (with two single-sex focus groups for each), the semi-structured interviews were not, with only one female out of 20 participants. This affects not only the gender components of the report, but its overall quality.
- **Issues with data collection.** Ongoing disputes between Israel and the OPT delayed the collection of primary data, which impacted on the time allocated to analysis and drafting of research findings. Furthermore, the limited timeframe for undertaking the research allowed for only a preliminary modelling analysis. This has affected the overall quality of the report. Nevertheless, this is the first piece of research of its kind to be conducted in the region, so it still has merit and can be considered as preliminary research upon which further research can be built.
- **Financial and time constraints.** While the topic is significant, financial and time constraints prevented the full consideration required to do it justice. As such, this research should be seen as a first step on this topic and a preliminary research piece.

3 FINDINGS

3.1 CLIMATE CHANGE IN GAZA

Observed changes

Variations in the climate of Gaza and the Occupied Palestinian Territory (OPT) have been recorded for more than 50 years. Meteorological observations for the Gaza Strip (available since 1976) are, however, scattered and incomplete, due to the partial destruction of meteorological stations by Israeli military air raids (Rafah station was destroyed during a bombardment of Gaza airport) and the Palestinian political division after 2006.[10] The observations described below are sourced from a combination of: (1) information reported to Oxfam by the Palestinian Meteorological Department; (2) smallholder farmer and stakeholder observations from semi-structured interviews; (3) smallholder farmer observations from the seasonal calendar exercise; and (4) reported observations from referenced documents.

Increasing temperature and humidity

> ***'Compared to approximately 10 years ago, when seasons were stable, seasons are shifting, and we experience hot or cold events at unusual times.'***
>
> Smallholder olive farmer, Gaza

According to the State of Palestine's National Adaptation Plan, average temperatures increased for the whole state during the nineteenth century, with high statistical confidence. Estimations point to an increase in average temperatures of 1ºC during this period, although there is medium confidence about this rate of temperature rise, due to the availability and quality of data. According to these estimations, the rate of temperature increase has been higher for the last 20 years (medium confidence). There has also been an increase in maximum and minimum temperatures since 1950 (very high confidence). The frequency of warm days and nights has increased, while the frequency of cold days and nights has decreased (high confidence). There is more limited evidence indicating the occurrence of longer warm spells and shorter cold spells.[11]

For the Gaza Strip, confidence about the available data is lower, owing to the scarcity of data and the destruction of meteorological facilities during the recurrent escalations of conflict after 2006. The available evidence points to a temperature increase of 0.4ºC from 1976 to 1995, which is consistent with estimations from other sources, indicating a higher temperature increase rate during recent years.[12] Other available sources have even estimated an average temperature rise of up to 2.5ºC since 1800.[13] Reported observations from smallholder farmers and other stakeholders are in line with the scientific estimations and observations. A rise in average temperatures was highly reported, mostly by smallholder farmers. This includes an increase in the frequency of hot days, including a higher occurrence of heat waves. Extreme high temperatures that impede agricultural labour and optimal crop production are most likely to occur in June and July, as indicated by smallholder farmers during the seasonal calendar exercise.

Another important temperature indicator for smallholder farmers involved in grape and olive production is the 'chilling accumulation' during the winter season. This is the number of hours of cold temperatures (e.g. below 18ºC for the local olive varieties[14]) needed by grapevines and olive trees to break the winter dormancy period and start vegetative development. A reduction of chilling accumulation during the normal production calendar was reported by some respondents. One reason many farmers gave for this is the delay and shortening of the winter season in

recent years, a changing pattern in the climate calendar with important consequences for local production.

Increasing temperatures are also often accompanied by high humidity levels (owing to the proximity of the sea), which is an added crop stress factor. Indeed, rising humidity levels was one of the two most prominent climate trends indicated by the survey interviewees (see Table 1). These observations are consistent with the Palestinian National Adaptation Plan, which indicates that specific humidity has significantly increased since the 1970s, with high confidence.[15]

A few interview respondents also indicated a higher frequency of cold/freezing events and 'cold waves' in recent years, while smallholder farmers indicated that the highest occurrence of these events is between December and February. The occurrence of both cold and heat waves is perceived by some farmers as more uncertain within the changed climate patterns.

Less predictable rainfall

'Before 10 years ago, the seasons were stable with a normal climate, regular periods of rainfall and moderate temperatures. There are notable changes in rainfall currently compared to 20 years ago. Today, olive production doesn't benefit from current precipitation patterns.'

Smallholder olive farmer, Gaza

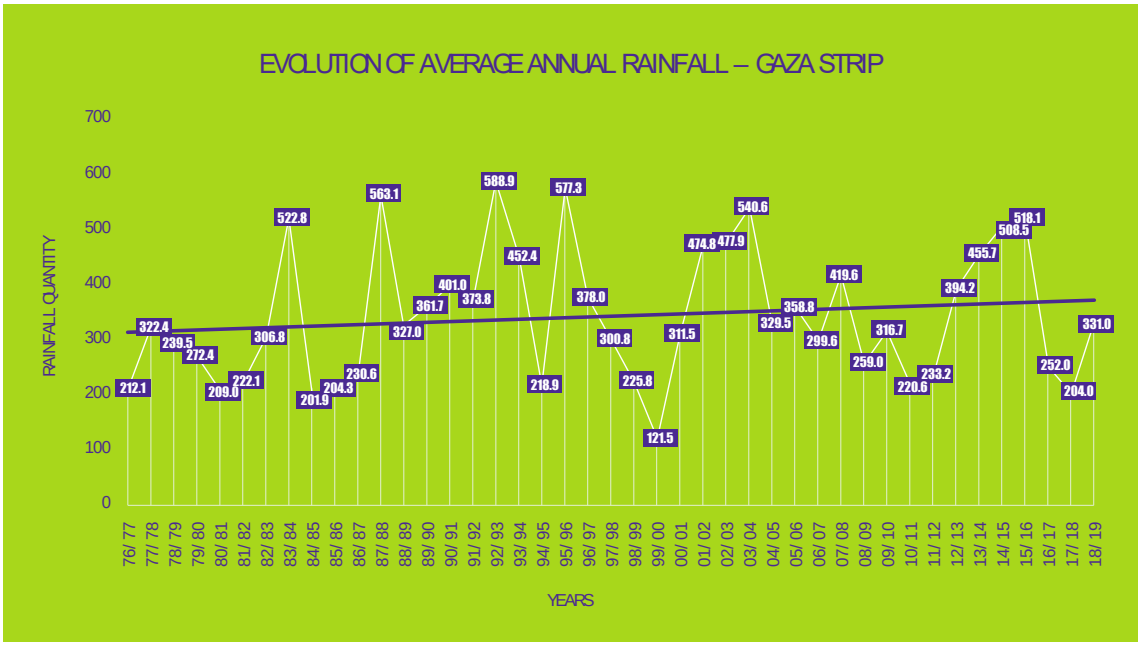
'The cold and rainy winter days come about two months later than they should. Previously, winter used to start in early October, but nowadays we only see rain in late November.'

Smallholder olive farmer, Gaza

The most important rainfall trend stated by smallholder farmer interviewees is the shifting of rainfall patterns. There is a common belief among them that production seasons have in general become more irregular and unstable compared with 10 to 20 years earlier. More specifically, the delaying of the seasonal winter rainfall was noted by smallholder farmers as a very important climate trend. During the creation of seasonal calendars with smallholder grape and olive farmers, olive farmers from the Al-Zaytoon region in Eastern Gaza marked the current rainfall period as lasting between November and January/February, while grape farmers from Rafah region indicated an even later and shorter season, only lasting from December to January. This represents a significant delay in the rainy season, which in the past used to start in October, according to the farmer testimonies

Another important trend reported by interviewed experts and smallholder farmers is the reduction of average rainfall and the number of rainfall days, in some cases referring specifically to the seasonal (October to January) rainfall. Such observations were mostly made by experts (ten times) compared with smallholder farmers (four times), while some experts also pointed to the occurrence of longer and more frequent droughts. Farmers' observations of reduced average rainfall levels based on recent years are not fully consistent with the evolution of the average annual rainfall in Gaza for the last 45 years, according to information provided by the Gaza Strip meteorological services. This data shows an increasing trend of annual rainfall levels from 1976/77 to 2018/19, as seen in Figure 2 below.

Figure 2: Evolution of precipitation patterns in Gaza Strip from 1976 to 2019



Source: Developed by authors from consulted Palestinian meteorological data provided by Gaza climate expert.

However, it should again be noted that the limited climate data available for Gaza Strip does not allow a fully accurate estimation of rainfall trends. For example, previous research about climatic variability conducted by M. Richard and J. Issac analysing rainfall from 2002 to 2011 reported a decreasing rainfall trend.[16] The rainfall values reported in that study and this research for the same time period are almost identical. However, the most complete data for Gaza Strip is found from 2000 onwards,[17] and an estimation from this year onwards as well as data from Figure 2 show a more stable and slightly increasing rainfall trend. The contradiction in reported trends is attributed to the time range covered in the analysis; where Richard and Issac analysed a small set of data covering 10 years, while the current research is covering a wider historical time range of 40 years, which allows for better conclusions on long-term rainfall trends.

Farmers' perceptions of reduced rainfall could also be attributed to the possibility that seasonal rainfall is becoming more widely distributed through the year, with reduced rainfall during the production season (October-January). This could explain why the shifting of rainfall patterns was the most reported climate trend by smallholder farmers. Although Figure 2 shows an increase in average annual rainfall, an interviewed meteorological expert stated that the number of rainfall days decreased from 44 to 33 days from the 1970s to the 2010s, while the amount of rain per rainfall day increased. In these circumstances, an increase in average annual rainfall would only be justified by a much more considerable increase in rainfall amount per day.

Several experts also mentioned an increase in the frequency of heavy rainfall events, with an increase in rainfall intensity. Farmers did not refer to these phenomena as an observed climate trend during the interviews, although during the seasonal calendar exercise they indicated that the heavy rainfall events mostly occur in December and January.

Finally, one of the two most reported trends by all interviewees, and the second most reported by smallholder farmers, is the occurrence of stronger winds, especially the very hot winds known locally as *Khamaseen* winds (see Table 1).

Table 1: Climate trends most frequently mentioned by interview respondents

Response type	Total responses	Farmers only
Rise in humidity	7	4
Stronger *Khamaseen* winds	7	5
Reduction in annual average rainfall	6	3
Rainfall patterns	6	6
Rise in temperature/more frequent hot days	5	5
Delay in seasons/shortened winter	4	3
Increased heavy rainfall frequency	4	0
Irregular/unstable seasons	4	4
Reduction in seasonal (Oct-Jan) rainfall average	3	1
More frequent heatwaves	3	3
Longer drought	2	0
Decreased annual rainfall days	2	0
Greater frequency of cold/freezing events	2	1
Reduction of cold 'accumulated chilling' hours	2	1
Extreme weather events (no detail)	1	0
More frequent drought	1	0
Increase in rainfall intensity	1	0
More frequent cold periods	1	1

Projected changes

Concerning future projected changes in climatic patterns for the State of Palestine, the National Adaptation Plan considers three scenarios which are representative of the IPCC Fifth Assessment Report (AR5) projections, see Table 2.[18]

Table 2: Future projected changes in climatic patterns in OPT

Scenario	Average temperature increase	Average rainfall	Extreme events
1. Optimistic (reduction of emissions in line with Paris agreement)	1.5ºC by 2055 and 2ºC by 2090	Stable or slightly increasing	Slight possibility of more droughts and floods
2. Moderate (limited reduction of emissions)	2ºC by 2055 and 3ºC by 2090	20% decrease by 2090	Little or no probability of increased floods More frequent droughts
3. Worst case (no action)	2.5ºC by 2055 and 4.5ºC by 2090	20% decrease by 2055 and 30% decrease by 2090	Extended dry periods, reduced wet periods and higher drought risks

All three scenarios are based on either more moderate or more exacerbated increases in global average temperatures. Temperatures will increase more rapidly under scenario 2 and 3, although it is likely that Gaza Strip temperatures may be more stable due to its proximity to the sea. The number of warm days is likely to increase, while the number of cold days will

decrease. More frequent heat waves and longer warm spells are also expected, especially during summer. Heat waves and severe droughts in summer are expected to increase in the Mediterranean climate areas.[19]

Average rainfall is likely to significantly decrease if no climate action is taken to comply with the Paris Agreement's 2ºC target. However, under the optimistic scenario rainfall might decrease or even increase, as also shown by the latest 50-year rainfall trend (see Figure 2); even in the 3ºC scenario, rainfall levels in the OPT region might still increase.

For all scenarios, there is more uncertainty and variability in rainfall seasons throughout the twenty-first century. Moderate and worst-case scenarios show a significant increase in the frequency of droughts, with a higher likelihood in the no-action scenario. There is more uncertainty concerning the occurrence of intense rainfall events, which are also more likely in the no-action scenario.

Projections point to an increase in sea level by between 0.1m and 0.4m along the Gaza coastline by 2100.[20] Major risks related to this are the consequent saltwater intrusion into the groundwater aquifers (exacerbated by intensive groundwater discharge), the reduction of available water for consumption, and the degradation of coastal agricultural land. Communities living near the coastline may also become displaced due to the higher frequency of storm surges and coastal flooding.

Overall, there is general consensus among scientists that 'impacts will be minimized if global emissions can be controlled'.[21] This is reinforced by the latest IPCC Special Report on the global impacts beyond 1.5ºC, which is already considered to be a very dangerous threshold for the future sustainability of natural and human systems.[22]

3.2 VULNERABILITY OF SMALLHOLDER AGRICULTURE

Background

Importance of the agricultural sector in OPT

Palestinians' affinity with the land is manifested in how the agriculture sector is intertwined with economic and social life, particularly in rural areas. In fact, to a great extent the agriculture sector is viewed as an important 'pillar of Palestinian resilience in the face of Israeli occupation' and as a main source of food security and livelihoods, as described by the Ministry of Agriculture (MoA) in its national Agricultural Sector Strategy (2017-2022).[23] Yet despite its importance, the sector contributed only 3.7% of Gross Domestic Product (GDP) in 2016.[24] The Palestinian agriculture sector, including fishing and forestry, witnessed a decline in the number of workers from 14.1% (2000) to 10.4% (2014)[25] to 6.8% in 2018; of the 2018 figure, 5.7% were workers engaged in the agriculture sector in Gaza.[26] Only 10% of Palestinian agricultural land is located in the Gaza Strip, and of this 40% is located in the Access Restricted Area, where the Israeli authorities heavily restrict or prevent access, making it difficult and dangerous for farmers to use the land.[27]

Olive production in the Gaza Strip[28]

The olive sector is the most important agricultural sub-sector for the Palestinian economy.[29] Based on Oxfam's olive value chain analysis, more than half of the cultivated agricultural land across the OPT (54% of arable land) is used for cultivating olives, with olives comprising 85% of the total area of fruit trees in OPT (of which 95.4% is in the West Bank and 4.6% in Gaza). The number of olive trees is estimated to be around 8,895,000, of which 7,798,000 (88%)[30] are fruit-bearing. Olive production is characterized by rain-fed smallholder agriculture, with individual

land holdings averaging eight dunums per farming household (one dunum = 1,000 square metres). Labour-intensive tasks in orchard upkeep and harvesting provide important seasonal employment opportunities for farming household members, particularly youth and women, and seasonal income-earning opportunities for a large number of share croppers and agricultural labourers, again a large proportion of them youth and women. For most land holders and share croppers, olive production augments their income from other economic activities.

Olive trees are grown across the Gaza Strip, with a heavy concentration in Al-Zaytoun in the southeast of Gaza City. This area has about 400 small- to medium-scale producers (1-23 dunums) and 50 large-scale producers (13+ dunums). The main olive varieties used are Souri (90%, used for both fruit and oil), K18 and Shemlali (the remaining 10%, only used for oil). Olive trees are well suited to the environment of Gaza, being tolerant of both saline water and drought. They can also be cultivated in poor soil (although yields and quality of fruits and oil will be affected).

A large proportion of workers in the olive sector are family workers, and the sector is characterized by unpaid and underpaid labour. Olive processing is a flourishing business; the number of olive pressers and pickers has increased over the past two years, due to donors' and INGOs' work in the sector. In addition, at the household level, women process olive fruit into unbranded pickled olives and olive oil in small processing units, and sell their produce to neighbours. They can only sell small volumes through informal networks within their communities, with only small profits. They are not engaged in marketing to retailers or supermarkets.

Grape production in the Gaza Strip[31]

Grapes represent the second most important fruit crop in terms of cultivated area and contribution to agricultural GDP in Gaza.[32] Production is exclusively of the traditional varieties (Dabougi and Kareeshi) and is mainly concentrated in Gaza Governorate, which accounts for nearly 65% of the region's grape production.[33] The area of agricultural land cultivated with grape in Gaza is 6,548 dunums, of which 5,559 dunums are seeded grape and 989 dunums are seedless grape. Table 3 below shows the distribution of seeded/seedless grapes across the Gaza Strip, based on a 2019 feasibility study by the Ministry of Agriculture.

Table 3: Distribution of seeded/seedless grapes across Gaza Strip governorates[34]

Grape variety	Northern Gaza	Gaza City	Dier Al Balah Governorate	Khanyounis Governorate	Rafah Governorate	Total land (dunums)
Seeded	310	4,600	550	79	20	5,559
Seedless	188	21	45	450	285	989
Total	498	4,621	595	529	305	6,548

More than two-thirds of the grapes cultivated in the Gaza Strip are non-arboured (ground grapes), which are of a lower production quality than arboured grapes. This is due to the high investment cost of the arboured system. However, arboured systems have higher productivity (1.1–1.2 tons per dunum in arboured vs. 700kg per dunum in non-arboured) and gross margin (net revenue 2.5 times higher in arboured vs. non-arboured). Therefore, the current cultivation system in Gaza (ground grapes) is less productive and less profitable than it could be. The sector has strong potential, as Gaza's demand for fresh grapes and grape products is greater than its supply, and there is continuous demand for grapes beyond the season. The limited production is attributed to the limited ability of input suppliers and nurseries to import more modified varieties to improve grape quality. Cultivation and production of grapes has increased in the last six years, with an important influence from the cultivation of new seedless varieties with a comparative market advantage.

Grapevine sub-products: Very limited processing activities are performed in the Gaza Strip. Limited production periods to fulfil the demand for fresh fruit leaves almost no opportunity for processing. Raisin production is performed at household level for home use only. The processing sector has only minor potential in the Gaza Strip, as the fresh product price leaves no economic incentive to produce raisins.

Main risks for smallholder agricultural production in the Gaza Strip

Climate risks for smallholder agricultural production

'In the Gaza Strip, more than 70% of farmers are smallholders. Smallholder agricultural producers are more vulnerable, as their capacity to recover from climate impacts is very low. Loss of all or part of their seasonal crops puts them in danger of losing their only income, increasing their chances of falling below the poverty line.'

Luay Alwuhaidi, Economic Justice Lead – Gaza, Oxfam in the Occupied Palestinian Territory and Israel

Accounting for 5% of national GDP, agriculture is the sector which is most vulnerable to climate risks in OPT and more particularly in the Gaza Strip.[35] One of the most frequently mentioned climate risks to agricultural production, and the most important risk for smallholder farmers, is temperature increase. This is firstly due to the high vulnerability of crops to high temperatures. This is particularly the case during the flowering phase, when high temperatures result in increased loss of flowers and lack of effective pollination, with a consequent impact on fruit production. Secondly, the increased presence of diseases and pests resulting from higher temperatures, was another risk mentioned by smallholder farmers. According to one interviewed expert: '*One of the most serious issues resulting from hot temperatures is the intensive spread of insects and their reproduction, causing many diseases and affecting the growth of plants.'*

The incidence of disease is further aggravated by high humidity levels, which was also mentioned as one of the most important climate risks for agricultural production. This in turn creates an additional environmental issue due to excessive use of pesticides, as mentioned by several farmers.

Precipitation declines are another important climate risk for experts and farmers. Farmers more often related this to the reduction of seasonal (October to January) accumulated rainfall, although the highest perceived risk by farmers in Gaza was the shifting and shortening of production seasons and the increasing instability of annual/seasonal rainfall patterns, which severely affect the crop production calendar and limit optimal conditions for seasonal fruit production. Other respondents (mostly experts) also pointed to the high risk of more frequent and longer droughts (according to participants of the seasonal calendar exercise, the period with highest occurrence of drought is May to July).

All of these factors have important effects on the already scarce water resources. The lack of seasonal rainfall aggravates the problem of groundwater overexploitation. According to an interviewed agricultural expert: *'The variation in precipitation levels across the year has led to changing or shifting seasons, which has directly affected the seasonal calendar of the plants. This has led to the overexploitation of water resources to cover the shortage*.*'* The depletion of the water aquifer creates an additional and more serious problem for smallholder farmers: the increase in water and soil salinity due to seawater intrusion into the aquifer, which creates many risks for crop production and human freshwater consumption. As expressed by a female olive farmer during a focus group discussion: *'Because of climate change and the decline in precipitation, agriculture land and soil become very dry. One of the most serious ramifications of reduced rainfall is associated with water salinity, which mainly affects the completion of plant growth*.' Another related consequence of declining freshwater availability is increased water contamination, especially from heavy metals resulting from the intensive use of agrochemicals.

Table 4: Climate risks and consequences for agriculture in the Gaza Strip

CLIMATE RISK AND CONSEQUENCES FOR AGRICULTURE			
FACTORS	**CONSEQUENCES (1)**	**CONSEQUENCES (2)**	**CONSEQUENCES (3)**
Increased heavy rainfall frequency	Flooding		Production losses
	Water runoff and less infiltration into the aquifer	Intrusion of saltwater in aquifer and soil	
	Soil erosion and degradation		
	Increased crop disease occurrence: Peacock eye disease	Impact on fruit and tree	Production losses
Decreased precipitation	Weakening of trees	Increase in diseases	
	Aquifer depletion Increased use of low quality (salty) groundwater	Intrusion of saltwater in aquifer and increased soil salinity (Women olive farmers, Women grape farmers)	
		Increase in heavy metal elements (Women olive farmers)	
	Decreased appearance of flowers	Lower fruit development	
Drought	Drying of agricultural land and soil (Women olive farmers, Women grape farmers)	Degradation of soil texture and biosphere needed for plant growth	
Decreased winter season precipitation	Aquifer depletion	Intrusion of saltwater in aquifer and soil	Production losses
	Cease of rainfall from mid-February affecting vegetative growth and fruit development in olive production		Decreased fruit quality Reduction of olive oil percentage
Reduction in cold hours	Impaired bud and fruit development		Production losses
Strong winds (khamaseen winds)	Loss of flowers (Male olive farmers) Drying of flowers and buds of plants (Male grape farmers)	Lower fruit development (Women olive farmers) (Male olive farmers, Male grape farmers)	
	Weakening of plants and trees	Higher susceptibility to diseases	
	Loss of grapevine leaves in early stages	Grapevines do not bear fruit	
Increased temperatures	Lower olive flowering (Male olive farmers)	Lower fruit development (Male olive farmers)	
	Increased presence of insects (incl. vectors) and diseases (Women olive farmers, Women grape farmers) (Male grape farmers) Higher spread of downy mildew and powdery mildew in grapevine (Male grape farmers) *'Spreading of pathogens, rodents, fungi, bacteria and pest insects'*	Increased use of pesticides harmfully impacting the environment and contaminating groundwater	
		'Increased use of pesticides which in turn is a cause of fruit drop' (Women olive farmers)	
	Increased plant stress		
	Increased soil water evaporation	Increased water pumping and reduced water availability	
	Decreased olive fruit quality		Decreased olive oil production
			Decreased fresh fruit quality - Grapevines
Heatwaves	Olive: Decreased appearance of flowers during heat waves (Male olive farmers)		Production losses
	Seedling and plant dryness and death (Women grape farmers) *'Burning and damaging grape trees'*		
Cold periods	Impact on leaves and fruit - Grapevines		
	Direct plant stress in olive trees (Women olive farmers)		
Shifted / shortened production seasons	Over exploitation of water resources to cover water shortage	Intrusion of saltwater in aquifer and soil	
	Reduced soil moisture duding production season		
Unpredictable rainfall patterns			
Increase of humidity	Increased spreading of diseases (Male olive farmers) Increased spreading of insects and downy mildew (Male grape farmers)		
	Increase spreading of insects and diseases (Women grape farmers)		
Floods	Increased soil erosion		

KEY
Impacts stated by smallholder farmers (semi-structured interviews, focus groups)
Red (female smallholder olive/grape farmers) and Purple (male smallholder olive/grape farmers) refer to responses from female and male focus group discussions

Other risks mentioned are directly related to extreme events. Violent winds, and especially the *Khamaseen* (hot and dry winds), was commonly mentioned by farmers as one of the most important climate risks for agriculture. Strong winds have a direct impact on vegetative and fruit development through the loss of leaves, flowers and direct fruit damage/loss. Heat waves also carry similar and significant risks related to lower apparition of flowers and dryness or dying of seedlings and plants. Increased heavy rainfall frequency and related flooding were other commonly mentioned climate risks, although such observations were made almost exclusively by government, research and civil society interviewees rather than by farmers. Related impacts are water runoff, soil erosion and degradation, and higher crop disease occurrence resulting from higher humidity levels. Respondents also referred to very low temperatures and 'cold waves' as important risks, causing direct plant stress and loss of leaves/fruits. Table 4 above shows an overview of the main climate risks and their related consequences for agricultural production, according to responses provided by smallholder farmers and interviewed experts.

Climate risks for agricultural production in the Gaza strip

In summary, climate change risks, particularly increases in temperature and humidity levels, declining precipitation levels, more unstable production seasons and the higher occurrence of climate extremes (heat and cold waves, strong winds, heavy rainfall and flooding) are key risks that are already negatively affecting agricultural production in the Gaza Strip. Some of the most important impacts, exacerbated by climate change, include: declining water availability and quality, production losses as a result of direct crop stress (temperature, humidity, water stress and extreme events), increased pest and disease incidence, and land degradation.

Other (non-climate) risks for smallholder agricultural production in the Gaza Strip

'Because of close proximity to the eastern fence perimeter, Palestinian homes and agricultural lands are highly vulnerable to bombing and levelling operations. Olive and citrus trees can be uprooted. This, in turn, considerably affects the whole agriculture production.'

Female smallholder farmer, Gaza

When looking at other risks affecting and limiting agricultural production in the Gaza Strip, the most important factor relates to the Israeli occupation, including the blockade. The current situation and possible perpetuation of the conflict and occupation brings a wide range of risks and problems for smallholder production, including:

- Severe Israeli-imposed restrictions on exports of agricultural products produced in Gaza towards external markets and restriction on agricultural inputs importation from abroad to enter the Gaza Strip. Importation of most agricultural inputs, which are vital for production, is heavily restricted or prevented as part of the blockade imposed by the Government of Israel. This results in high levels of instability in the sourcing of essential inputs such as equipment, tools and chemicals (pesticides and fertilizers). Furthermore, these restrictions result in lack of access to climate-resilient seedlings and varieties due to Israeli-imposed restrictions as part of the blockade.
- Lack of freedom of movement beyond the Gaza Strip (due to the Israeli-imposed closure), but also restricted access to land *within* Gaza close to the perimeter, especially during escalations in violence. Israel restricts Palestinian access to land located along the northern and eastern side of the perimeter fence in Gaza – this Access Restricted Area has affected up to 40% of Gaza's fertile agricultural land and up to 85% of its fishing waters at different times.[36]
- Lack of access to and control over key natural resources for production, particularly land and water, due to the physical occupation and continuous access restrictions.[37] Palestinians'

access to water resources is mostly controlled by Israel, which controls 80% of the mountain aquifer in West Bank water.[38]

- Electricity cuts and shortages, limiting farmers' ability to pump water for irrigation and meet their basic livelihood needs. A smallholder olive farmer stated that: '*It is an extremely important problem, as I can't irrigate my olive plants during very hot days when the electricity is off*.'
- Direct threats from war and conflict: these include the destruction of assets and infrastructure for agricultural production and processing by acts of bombing and shelling, as well as damage to and destruction of water, sanitation and hygiene infrastructure.
- Targeting of agricultural land by Israeli forces, including the destruction of olive trees and grapevines.

Other risks for agricultural production are quite frequently linked with the effects of the blockade and also relate to access to inputs for agricultural production. Water scarcity is the most important of these risks: the current annual amount of freshwater per capita is less than 200 cubic metres, which is far below the 500 cubic metre water scarcity limit set by the World Health Organization.[39] This was the second most-mentioned risk to agriculture (other than climate risks) by all smallholder farmers consulted in this study. Smallholder farmers lack appropriate infrastructure and quite often have no alternative other than to water their crops with saline and/or contaminated water, which risks their agricultural production.

This problem is likely to be exacerbated by climate change, continuing pressure from Israel, population growth and the current unsustainable extraction of water resources (Gaza is currently drawing water three times faster than the sustainable rate allowing groundwater aquifer recharge).[40] The depletion of Gaza aquifers exacerbates the problem of seawater intrusion and resulting water and soil salinity. Another associated risk to aquifer depletion is water contamination from sources such as agrochemicals (heavy metals) or sewage pools (nitrates). Some smallholder farmers mentioned lack of access to pesticides as their primary risk for agricultural production, due to their high cost and existing market restrictions. In addition, farmers often mentioned that most pesticides are of very low quality or are even contaminated. This is due to the lack of proper inspection by the MoA of the quality of imported pesticides. According to interviewees, high prices also limit access to other agricultural inputs, such as fertilizers.

Another frequently stated problem for agricultural production is lack of farmer knowledge, capacities and information on agricultural management, on the adoption of new or improved agricultural practices/technologies, on strategies to adapt to climate change, and on disaster preparedness/risk management. Respondents also often referred to poor agricultural management practices as an added risk for production, including excessive use of pesticides and their harmful effects on crop production and human health, and the overexploitation and inappropriate use of water resources. According to one female focus group discussion respondent: *'Excessive use of chemical pesticides has serious consequences for the beginning of plant growth, reducing its flowers and fruit, and adversely affecting the rest of the plant life cycle.'* These problems are also a consequence of the lack of technical (as well as financial) support from the MoA for smallholder farmers, including the lack of skills of support staff (MoA and NGO staff).

Market risks are another important risk factor for agricultural production. Owing again to the Israeli restrictions, weaknesses in Palestinian agricultural markets do not create favourable conditions for small-scale farmers to access markets, sell their products at profitable margins and access inputs at affordable prices. Poor market access is aggravated by: (1) crop price volatility and low selling prices; (2) low purchasing capacity of consumers, due to the weak economic situation in Gaza; and (3) poor market and economic policies in Gaza, including the liberalization of imports of essential crops such as grapes during peak production periods. Agricultural market systems are also underdeveloped due to the weak legal and institutional

frameworks, weak supporting structures, low private investment, and the lack of specialization in agro-processing within agricultural value chains.[41]

Other mentioned risks include: weak research and development capacities for agricultural development and resilience to climate change; plant diseases and vectors; the internal political division (Gaza/West Bank); incorrect land usage and its effects on agricultural land (industrial factories, landfill sites); urban expansion at the expense of agricultural land; the social and gender impacts of poverty; and the lack of influencing capacity of smallholder farmers (lack of syndicates).

Main risks and vulnerabilities for smallholder grape and olive farmers

For smallholder farmers working in these two sectors, olive and grape production is an essential income source and very often the main income source for the whole family, defining the high vulnerability of these production systems. Vulnerability assessments carried out for the Palestinian Authority National Adaptation Plan categorized olive and grape production as among the most vulnerable sectors ('highly vulnerable') to climate change.[42]

According to the consultations (interviews and focus groups) with stakeholders, smallholder grapevine and olive production systems share many of the above-mentioned risks that affect smallholder agriculture in general. However, when asked about the main issues threatening their farm production, women and men farmers more frequently pointed to risks other than climate risks; this was in contrast to technical stakeholders, who mentioned climate risks more frequently. This does not necessarily mean that climate risks are not important for farmers; rather it suggests that in their day-to-day lives, they feel more intensely the impact of other socio-economic, political and common production risks, many of which can also be adversely affected by climate change. For instance, one of the most-mentioned problems by olive and grape producers is the spread of insects and diseases, which is fuelled by rising temperatures and humidity. Water shortages and water and soil salinity are also a consequence of changing rainfall patterns.

When asked about the main climate risks for their production systems, smallholder olive and grape farmers stated the following (in order of importance): (1) water and soil salinity; (2) rising temperatures; (3) heat waves; (4) declining rainfall and drought; and (5) violent winds. Other important risks include the shifting of seasons and precipitation patterns (including delayed winter); extreme weather events; and weather variability or rising humidity.

In terms of the most important overall risks (climate and other) mentioned and ranked by smallholder olive and grape farmers, these are (in order of importance): (1) the high cost of agricultural inputs, especially pesticides; (2) olive plant diseases; (3) lack of water supply; and (4) excessive use of pesticides and the effect of this on human health and plant growth. Women farmers in particular saw excessive use of pesticides as a poor management practice that causes serious environmental problems in their farming systems. Other issues mentioned include lack of access to climate-resilient olive and grape varieties, and the lack of electricity. All of these are influenced by restrictions on access to inputs and technology due to the Israeli blockade, as previously mentioned.

Other frequently mentioned problems relate to the lack of skills for grape and olive production, and the lack of farmer adoption of new practices and technologies to adapt to climate change. Some interviewed experts also referred to poor orchard management practices, including irrigation, trimming, lack of tree fertilizing, incorrect harvesting/fruit storage/processing practices – issues that also contribute to low productivity and yearly yield fluctuations in the olive sector.[43]

The same market challenges identified in the agriculture sector overall also apply to smallholder grape and olive farming: lack of market opportunities, crop price volatility and low consumer purchasing capacity. Grape farmers complained about the liberalization of grape imports during

the production season, a recent measure implemented by the Gaza government as a response to the local imbalance in demand/supply.

The low capacity of farmers to manage agricultural-related risks is an added vulnerability factor. According to interviewees, support for farmers in risk management is mostly absent; farmers also lack access to finance (beyond borrowing from family and friends) to support farm investments, savings or agricultural insurance, adding to the poor risk-management mechanisms at community and institutional levels.

Specific risks and vulnerability factors within each sector are described below.

Main risks and vulnerabilities in olive farming

'Previously, 27 September was considered the first rainfall event which indicates the olive ripening; however, nowadays we face a shifting winter season and delays in the early rainy days, to late November. There are seasonal variations, such as high temperature levels, delaying the winter season. We don't see rain till late November.'

Agricultural expert, Gaza

Disease and pests were the most-mentioned risk for olive farming. Common diseases that can be aggravated by high temperatures and moisture include Peacock Eye disease or 'olive leaf spot' (*Spilocaea oleaginea*, causing leaf damage or defoliation) and the olive knot disease (affecting fruit development). Pests include the olive fruit fly (*Dacus oleae*), the olive psyllid (*Euphyllura olivine*) and several beetles (*Phloeotribus scarabaeoides*; *Rhynchites cribipennis*).[44]

Olive orchards are in general more resilient than others to harsh environmental conditions, including resistance to poor soil and saline water.[45] However, one of the main perceived climate risks for smallholder olive farming is the changing winter production season, as expressed by several interviewees. Other climate risks for the sector include frost, heat waves, drought, violent winds and hail.[46]

Access to assets is also constrained for the olive production sector. Farmers frequently mentioned the high cost of agricultural inputs, especially pesticides, as a limitation to their production. However, an Oxfam report on the olive value chain refers to the positive side of this, stating: *'The low use of chemicals is due to the high costs of these inputs, not affordable to many farmers, but at the same time represents an opportunity to steer toward a more organic type of farming.'*[47] Lack of water supply is another important issue, due to farmers' poor access to water infrastructure for irrigation.

Compounding these factors is a lack of access to finance; this is especially the case for women, who are mostly involved in olive processing (into pickled olives or olive oil), but generally only at household level, and who lack the ability to purchase processing equipment as well as the necessary equipment and materials for storage and packaging.[48]

Despite all of these limitations, the olive production sector and value chain is considered one of the least vulnerable agricultural sectors to socio-economic, political and institutional risks in the Gaza Strip, including the Israeli blockade. One of the reasons given for this is its relative lack of reliance on external inputs (except for the limitations in access to processing equipment, including oil pressers) as well as external markets, given the high internal demand for olives and olive oil, which can also be stored for long periods.[49]

Nevertheless, several respondents pointed to the need to open the sector to other markets due to the continuous increase in supply, which already meets internal demand. As expressed by one of Oxfam's partners: *'We have already reached the sufficient level [to meet internal demand] and we now need to open new external markets by exporting our olive products.'* Another interviewed expert (from the Environment Ministry) said that olive cultivation is currently expanding, due to the greater tolerance of olive trees to harsh conditions compared with more vulnerable crops: *'Due to the olive plants' tolerance, farmers tended to replace other crops, such*

as citrus, with olive trees.' Nevertheless, the Israeli occupation still poses a significant threat to the sector, as future incursions and military actions could mean further destruction of trees or land seizure.[50]

Main risks and vulnerabilities in grape farming

'The risks of climate change are bigger than other risks due to lack of the needed precautions. Farmers are unable to control the risks completely and could lose their agriculture production.'

Female grape farmer, Gaza

Interviewed women grape farmers identified climate risks as their biggest risks. One of the main climate-related risks for grape production in Gaza is increasing water and soil salinity, as grapevines are much more vulnerable than olive trees to the effects of saline water. Existing problems such as diseases and pests are also exacerbated by climate change. For grape farmers, the most important diseases are downy and powdery mildew, which affect both leaves and fruit, and become more widespread with high temperatures and humidity. Other climate risks include frost, drought and unstable rainfall patterns (amount and distribution of rainfall).[51]

Climate risks intersect with low adaptive capacities, including the use of inappropriate cultivation methods and the lack of skills for improved production. Grape farmers – especially women – complain about the lack of support for capacity strengthening in climate-resilient practices and in modern planting and orchard management techniques, as well as in the efficient use of inputs (fertilizers, pesticides). In addition, most grapevine cultivation in Gaza is non-arboured (i.e. grapes are grown on the ground, without the support of arbours), as farmers lack the skills and investment capacity to implement the arboured system. This results in grape production that is less productive, less profitable and less climate resilient.

As with olives, access to grape varieties and inputs for improved production are limited by Israeli restrictions on market movements.[52] Access to climate-resilient varieties is dependent on imports from Israel, given the unfavourable local weather conditions for seedling production, the low access to the appropriate technology for local nurseries, and weak genetic engineering capacities in the development of improved varieties and rootstocks (Gaza nurseries still depend on low-quality, traditional seedling production methods).[53] Similar to olive farmers, almost all grape farmers interviewed mentioned the high cost of agricultural inputs among the main factors reducing their capacity to adapt to adverse climatic conditions.

Enabling processes

'Palestinians are increasingly vulnerable due to the social political divisions and conditions (occupation) we are living in. We don't have certain policies or actions related to climate change because of our political conditions.'

Oxfam partner organization, Gaza

Climate change is a relatively recent priority in the Palestinian political agenda. Prior to 2008, there was no significant policy work on climate change. It started to be considered after the government received international capacity-strengthening support from the UNDP Programme of Assistance to the Palestinian People (PAPP, which was developed to strengthen institutional responsiveness and the development of a Climate Change Adaptation Strategy and Programme of Action.[54] In 2016, the State of Palestine submitted its first National Adaptation Plan under the United Nations Framework Convention on Climate Change (UNFCCC), only a few months after becoming a state party under this convention and after ratifying and signing the Paris Agreement.

This was an important milestone, as described by an interviewee working in the Ministry of Environment: *'We succeeded in joining the international agreement on climate change as an official member last year… politically, we succeeded in joining this agreement and it became a*

reference for our policies.' The inclusion of Palestine in the UNFCCC has also allowed it to access funds from the Green Climate Fund, resulting in a project on reuse of treated wastewater.[55] In 2017, the State of Palestine also submitted its first Nationally Determined Contribution.[56] Both submissions in such a short time show that the State of Palestine is committed to delivering national climate action. The National Adaptation Plan identifies an implementation cost of $3.5bn to address adaptation needs, most of which is for the agriculture and water sectors.[57]

However, current institutional capacities to develop robust and effective climate policies, plans and strategies in Gaza are weak due to the political division between Gaza and the West Bank, the economic situation in Gaza and the Israeli-imposed blockade. According to one of the interviewees, the Palestinian Environment Quality Authority was recently disbanded in Gaza, in part as a result of a lack of tangible outcomes over the last 11 years of its operations. Some interviewed experts also stated that that whenever policies exist, their implementation is not successful due to the difficult economic and political situation.

Currently there is also a low integration of gender considerations at a climate policy level. For example, gender equality recommendations in Palestine's National Adaptation Plan are weak in terms of addressing structural gender inequalities and promoting women's empowerment. Recommendations for the Gaza Strip are mostly based on capacity strengthening and technical support in climate-resilient production. These elements are helpful to address key capacity development needs for women's involvement in the agricultural sector, but do not cover the full spectrum of actions needed to address gender inequalities within the sector as a whole and within the olive and grape value chains.[58]

Existing capacities need to be analysed in the context of the current political and economic situation. Current climate change adaptation, disaster risk reduction and agricultural growth capacities in the OPT, and especially in Gaza, are seriously impaired due to the impacts of the blockade, the restrictions and limitations on access to key resources imposed by the Israeli occupation, and the successive attacks that have taken place during the last three wars. These impacts include:[59]

- Destruction of agricultural infrastructure and food-processing facilities during air raids, as well as the destruction of thousands of olive trees and grapevines in areas occupied by Israel.
- Lack of access to and control over water and land resources, due to the physical occupation and the continuous restrictions to access. Israel controls most of the water resources in OPT; only 20% of water resources in the West Bank are controlled by Palestinians,[60] enabled by the 'trans-boundary water resources' allocation under the Oslo Accords; while recurring conflict in the Gaza Strip left the population without access to water during the 2014 conflict, reflecting 'stark inequalities' between Palestinians' and Israelis' water consumption.[61]
- Market closure, including restrictions on importing food and basic inputs for agricultural production, affecting the sourcing of essential production inputs and food availability (quantity, price); and restrictions in the exporting and marketing of agricultural products beyond the Gaza Strip.
- Refusal by Israel to import and build essential water management infrastructure (including wastewater treatment and desalinization plants).
- Dependence on power supply from Israel, with frequent electricity cuts.
- Limitations to Palestinians obtaining work permits to increase mobility.

The majority of interviewed grape and olive farmers stated that the government does not provide any support for production. The only support received relates to extension and guidance on production and risk management, although this process lacks transparency and can be

biased in an informal way in favour of some farmers. There is also a lack of subsidies for smallholder farmer production, due to the fiscal crisis. Some interviewees said that they had received limited support with assets and technology including renewables, waste reuse, recycling and climate-resilient varieties. Most of the existing projects and programmes, however, are funded by international development organizations and international donors.

Concerning risk management, local weather forecasting systems and related agro-climatic advice are weak. Olive and grape production is 'highly vulnerable' according to the National Adaptation Plan, but in the OPT there is no functioning disaster risk management system. In the West Bank, an agricultural insurance scheme has been launched to deal with climate-related disasters and other risks, but this has not yet been implemented in Gaza.

In terms of grape and olive value chains, specific issues include: weak extension services and support from MoA on meeting market quality standards; inadequate infrastructure for post-harvesting storage of fruit and for processing it into marketable products; and strong dependency on Israel for most agricultural input imports (seedlings, pesticides, herbicides, fertilizers, equipment, etc.). The MoA has been mitigating this by preventing imports of grapes during peak production, ensuring that market prices meet the necessary profitability margins for farmers. However, farmers complained that in 2019 the MoA lifted the ban on grape imports, negatively affecting their livelihoods.

3.3 IMPACTS OF THE CLIMATE CRISIS ON OLIVE AND GRAPE FARMING

Past and current impacts on production

According to statements from farmers and other stakeholders, the main negative impacts on olive and grape production relate to the following six factors:

1. **Direct impacts of increasing temperatures and heat waves,** resulting in:

- Reductions in the amount of fruit produced, because delays due to the late onset of the winter season and the consequent exposure of crops to high temperatures during late spring have an impact on flower apparition and pollination rates. An interviewee from an agricultural development organization said: *'In May 2018, we faced sudden high temperature levels for 14 days. As a result, the coloured grape in Rafah lost 50% of production. [In 2019] we faced the same issue, and the loss in Skaikh Ejlin area was between 30-80% in some areas*.'
- Direct tree stress, including plant and leaf drying or burning, and increased susceptibility to diseases and death. A representative from the National Institute for Environment and Development stated: *'Approximately two years ago, the grapevine yield in the Gaza Strip was totally destroyed by intense heat waves. This resulted in economic and social effects [including a] decrease in agricultural production and income generation, and increased social problems within farmer families. For some farmers they couldn't even afford basic needs.'*
- Reduced quality of grape and olive fruits, including lower quality of olive oil.[62] A smallholder olive farmer stated: *'Sometimes the hot weather can burn the olive flowers. In the previous season we faced high temperature levels during the olive flowering phase, resulting in big losses.'*

Increasing temperatures during winter also mean a reduction in the accumulated number of cold or 'chilling accumulation' hours that are essential for grapevines and olive trees to break dormancy and begin vegetative and fruit development, thus altering the normal crop production calendar. As mentioned above, farmers reported a delay in the start of flowering and fruit production as a result of this.

2. **Spread of diseases and pests due to increased temperature and humidity,** resulting in:

- Increased occurrence of powdery and downy mildew in grape, and knot disease and leaf spot in olive. Fungal diseases such as downy mildew and Peacock Eye disease have significantly increased due to rising levels of specific humidity. As explained by one study interviewee: '*Peacock Eye disease is a fungus that causes defoliation, reduced crop production and deterioration of tree limbs. Moisture threatens the plants' environment by spreading Peacock Eye disease.*'

- The increased incidence of pests and diseases is also creating an environmental problem due to the excessive application of pesticides, as explained above.

3. **Loss of production due to strong winds and hot *Khamaseen* winds:**

- When violent winds occur, they rip off the tree flowers and leaves, resulting in production losses. Many smallholder farmers explicitly mentioned these impacts: '*The Khamaseen wind is harmful for plant growth because it forces grape leaves to fall in the first stages of growth. If this happens, the trees cannot produce grapes, resulting in a decline in farm production.*' One olive farmer pointed to strong winds as the single cause of losing 50% of his production in a previous season.

4. **Loss of production due to drought and related soil salinity:**

- When droughts occur, the soil becomes dry and farmers are forced to use more groundwater for irrigation. However, most of the water used is saline, creating an additional problem of soil salinity and damaging the crops (especially grapevine). In addition, under water stress trees become weaker and more susceptible to disease. This was clearly stated by female olive farmers during a focus group discussion: '*Many rainfed plants and trees are mainly dependent on full irrigation. Because of climate change and a decline in precipitation, agricultural land and soil become very dry. One of the most serious ramifications of reduced rainfall is associated with water salinity, which mainly affects the completion of plant growth. Thus, agricultural production under these severe conditions is declining greatly year by year.*'

5. **Irregular production seasons affecting the quantity and quality of produced fruits:**

- Many farmers and stakeholders working in the olive and grape sectors reported important changes in seasonal climate patterns compared to 20 to 30 years ago, affecting normal rainfall distribution patterns and temperatures for olive and grape production. A representative from one of Oxfam's partner organizations stated: *'There is a real problem of weather variability compared to 30 years ago, which currently affects the primary production of olives and grapes by smallholder farmers.'*

- The winter season is becoming shorter and less favourable for olive and grape production. According to interviewees, unstable weather during the production season has important effects on the quantity and quality of fruit produced. For some farmers, production has declined by up to 50% due to the shifting of seasons. The early harvesting of traditional olive varieties (which need longer seasons) has had an impact on olive oil production. One smallholder olive farmer said: *'We don't see rain till late November. All these variations have affected our olives, and this season the oil production was very low. This also due to the cessation of rainfall from mid-February, a time when the olive plant needs water. Without additional irrigation, the olive plants become dry and we lose our season.*'

- The shifting of production seasons is also having a chain of other negative consequences for production, especially on in terms of water resources. A representative from an agricultural development organization stated: *'The variation in precipitation levels across the year has led to changing or shifting seasons, which has directly affected the seasonal calendar of the plants. This has led to the overexploitation of water resources to cover the shortage... Other indirect effects caused by seasonal shifting include groundwater salinity due to seawater intrusion, high use of fertilizers and high consumption of pesticides.'*

6. **Impacts of extreme cold events** which hamper shoot development and cause drops in production, as they affect plants' ability to flower.

To a lesser extent, some farmers also mentioned the impacts of heavy rainfall and flooding, leading to soil erosion and water runoff. One olive farmer reported that in 2014, intensive rainfall and floods destroyed his entire farm.

Overall, these factors translate into a variety of socio-economic impacts affecting the main household income source of many smallholder farming families. According to interviewees, large losses in production result in an inability to cover production costs and family living expenses, including basic needs. Farmers have to wait until the next year to recover their family income, and suffer due to unstable income generation during the year. Some of the secondary social impacts mentioned by interviewees include social tensions within families and increased gender-based violence.

Table 5. Climate-related impacts on olive and grape production

CLIMATE-RELATED IMPACTS ON OLIVE AND GRAPE PRODUCTION			
FACTORS	**INTERMEDIATE IMPACTS**		**FINAL IMPACTS**
Increasing temperatures	• Spreading of insects and diseases due to increased temperatures (Women olive and grape farmers, Male olive and grape farmers)	• **Olive:** knot disease	• Production losses
		• **Grape:** Powdery & downy mildew (Male grape farmers)	
		• Loss of production due to contamination from excessive pesticide use (Women olive farmers)	
	Grapevines: • Destruction of trees and burning of leaves (Women grape farmers) • Heatwaves causing plant dryness and death		• Decreased grape quality • Production losses
	Olives: • Drying of olive leaves • Tree stess fom high temperatures • Impact on flowering phase (Male olive farmers)		• Decreased olive quality • Production losses
Increase of humidity	• Increased spread of insects and diseases (Women grape farmers) (Male olive and grape farmers)		
Low temperatures and frost	• Direct plant stress and impact on flowering/fruit production (Women olive farmers)		
Reduction of rainfall	• Drying of agricultural land and soil (Women olive and grape farmers)		
	• Increased soil salinity (Women olive and grape farmers)		
	• Trees weaken and become more susceptible to diseases		
Shifting rainfall patterns and irregular seasonal climate	• Impact on effectiveness of olive flowering, fruit production and ripening periods		• Immediate and long-term production losses
Violent winds, including khamaseen (hot) winds	• Loss flowers and tree leaves in early stages by strong winds (Women olive farmers, Male olive farmers)		• Production losses • Higher sensitivity in grapevine
	Impacts of khamaseen winds on olive and grape trees: • Drying of flowers and buds of plants (Male olive grape farmers)		
Heavy rainfall	• Water runoff	• Soil erosion	• Grape and olive tree uprooting
	• Spreading of diseases - Peacock eye disease in olive		• Production losses
Late onset of winter	• Late flowering • Late end of dormancy period		• Reduction of olive oil production (up to 15%)
Reduction in cold hours	• Impaired bud and fruit development		• Production losses

KEY
Impacts stated by smallholder farmers (semi-structured interviews, focus groups)
Red (female smallholder olive/grape farmers) and Purple (male smallholder olive/grape farmers) refer to responses from female and male focus group discussions

As previously mentioned, climate-related impacts on production are not isolated, but occur in tandem with other intersecting factors (socio-economic, political, institutional, ecological). These include the effects of the blockade, as described above (affecting access to inputs, assets, market opportunities); the poor economic situation in Gaza; demographic pressure on land and natural resources due to population growth and urbanization; water salinity and environmental pollution; lack of farmer skills in improved production techniques; and lack of institutional support for smallholder production and climate change adaptation. Climate-related impacts are summarized in Table 5.

Future olive and grape suitability scenarios

Modelling conducted for this research shows that the Mediterranean Basin is vulnerable to changes in precipitation patterns and rising temperatures. Considering this, climate change trends are likely to have a significant negative impact on olive and grape production.[63] Detailed information on the quantitative crop suitability assessment carried out for this study is available in the **Annex**. The main findings from this assessment are summarized below.

The chilling accumulation[64] during the coldest months of the year will be significantly reduced, and therefore the required chilling accumulation to break the winter dormancy period may be compromised. Depending on the emissions scenario (moderate scenario: RCP 4.5; worst scenario: RCP 8.5) [65] and location, chilling accumulation will decrease by a range of 20-30% by the middle of the twenty-first century, and by a range of 40-80% by the end of the century, according to the chilling model considered most appropriate for grapevines (see the **Annex** for methodological details). However, this analysis suggests that bud-breaking will happen five days earlier by mid-century, and 10 days earlier by the end of the century, as a response to additional heat accumulation after cold requirements are met (thus largely compensating for the possible delay in breaking the winter dormancy). According to the chilling models used for olives, chilling accumulation for this crop will decrease by 20-60% by mid-century, and by 60-100% by the end of the century. However, there are olive varieties with small or no chill requirements, so lack of chilling is not expected to be a major hazard for this crop in the studied area.

Heat stress for crops is likely to increase due to the rising temperatures, altering the phenological response of olive and grape trees and resulting in significant productivity declines. Higher temperatures will also accelerate reproductive development (date of flowering), which may result in decreasing yields for both traditional olive and grape varieties if extreme events occur around flowering and/or at the beginning of fruit setting (see next paragraphs). By mid-century, for both olives and grapes a flowering advance of 10 days is projected, whereas by the end of the century the expected advance is up to 15 days (RCP 4.5) or 25 days (RCP 8.5). This is consistent with other projections for the Mediterranean Basin, which indicate a flowering advance of 11 days for olives by the second half of the century.[66]

Maximum temperatures ('Tmax') during flowering were also analysed, as they can pose a major threat for fruit setting of olives and grapes. It is important to stress that temperatures that are not considered to be climatological extremes, can be so for crops. For instance, for olives, the damage threshold for flowering is 35ºC. Modelling results show that the number of days with Tmax above this threshold is expected to rise by between 1-2 and 4-5 days by mid-century, depending on the scenario. Each year there will also be up to one more long-lasting heat event (three consecutive days) harmful to olive flowering. However, when looking at the moderate scenario (RCP 4.5), earlier flowering dates due to increased temperatures show that harm caused by such events may be avoided, due to the flowering phase occurring during periods with less frequency of heat waves, especially by the end of the century.

For grapevines, the damaging threshold for flowering is lower (27ºC). The number of days with Tmax over 27ºC and the number of three-day heat events does moderately increase in the next 30 years under RCP 4.5. However, for the severe warming scenario (RCP 8.5), even though the

occurrence of these events is higher, crops would not be affected; this is due to the projected advance of flowering dates. The latter is an important factor when considering adaptation in grapevines, as for moderate warming (RCP 4.5) the number of Tmax hazardous events increases for future conditions, while this is not the case for a more severe warming (RCP 8.5). The distribution of these events demonstrates why adopting varieties whose phenology allows them to escape damage from Tmax events is an excellent tool for adaptation.

In terms of precipitation (frequency of events with two consecutive weeks without rain), no significant changes are expected to occur for the period covering flowering and fruit setting, except for a moderate increase of dry events in RCP 4.5 during flowering (this is again avoided in RCP 8.5 due to earlier flowering dates). The main reason for this is that fruit setting already occurs during the dry part of the year in the current climate, which will remain the same under future scenarios. Therefore, water availability will depend on how climate change affects the soil water storage of rainfall which occurs during the rest of the year.

However, in some parts of the Mediterranean, climate change and related temperature rise is more likely to increase the water deficit for rain-fed olive and grape trees due to increased evapotranspiration, especially during summer. The Standardized Precipitation-Evapotranspiration Index, a common indicator for water deficit, is projected to change from dry, as in the mid-twentieth century, to very dry by the end of the twenty-first century in the Gaza Strip.[67]

All of these factors will significantly influence grape and olive production in Gaza. For grapevine, some studies for the Mediterranean are pointing at yield decreases of up to 60%.[68] For olives, average yield losses of 20% are expected for the Gaza Strip.[69] Previous studies have also projected a northward shift of land suitable for olive tree cultivation.[70]

Evolution of pests and diseases under future climate conditions, such as highly variable specific humidity and temperatures, is also an important threat for both crops. Fungal diseases will be one of the major phytosanitary threats, especially mildews in grapevine.

Impacts at supply chain level

Climate-related impacts at supply chain level are highly influenced by the rate of production losses faced by Gaza farmers. Loss of production particularly affects the selling capacity of smallholder olive and grape farmers, due to the increase in product prices and lack of capacity to compete with larger-scale producers or imported products, as happened in 2019. Other factors influencing selling capacity include the low purchasing capacity of consumers, owing to the general economic crisis, as well as restrictions on exporting products abroad, due to the Israeli blockade. This situation thus forces many smallholder farmers to sell their products at lower prices and below the cost of production.

Beyond production losses, climate change impacts create additional pressures and risks that negatively affect smallholder farmers' market opportunities. One of the important steps in the olive and grape supply chains is storage and processing. In the olive oil sub-sector, rising temperatures and humidity during storage have a detrimental effect on olive oil quality. Due to the lack of cold storage facilities in Gaza, olive fruits need to be pressed for olive oil extraction within 48 hours in order to avoid fruit perishing and loss of product quality. However, smallholder olive producers do not have the same access to olive presses as traders or large-scale producers (who are prioritized due to offering larger quantities). This means smallholder producers have to wait longer to press their olives and as a result face losses in olive oil production and quality, which consequently affect the sale price.[71]

Fresh grapes are also very sensitive to high temperatures and humidity during storage. One of the most important issues for grapes as well as for olives is the increase in vectors and diseases (e.g. mildew) affecting the fruits during storage, transfer and processing. Potential future higher temperatures and humidity after harvest thus represent important risks for the

quantity, quality and ultimately the price of olive and grape products sold by smallholder farmers.

These factors are aggravated by smallholder farmers' unfavourable position in the market compared to large-scale producers. The latter sell most of their produce in bulk to traders and at lower prices. Traders assume some of the risks, and provide money in advance to cover the necessary labour and input costs; this is not the case for smallholder producers, who have to assume all the production risks and costs on their own.[72] Small-scale producers thus have less support in managing market-related risks, as well as being more vulnerable to climate impacts.

Another factor affecting market inclusion for small-scale farmers is lack of coordination among producers. While collaboration is needed for joint marketing and product processing, farmers are not used to working together and organizing themselves in professional and structured cooperatives besides family solidarity networks. As a consequence, farmers have low bargaining power with suppliers and buyers/traders. Moreover, there are no adequate financial services to enable olive and grape producers to invest in improving production and processing.

Declining product supply also has an impact on other actors within the olive and grape value chains. For instance, entrepreneurs working on grape and olive transport and companies exporting abroad also lose their capacity to compete in the Palestinian market when there is a lack of supply. In the olive sector, declining production due to climate change can affect other businesses such as olive presses and mills, such that their owners also face economic problems.

Potential lower production under more drastic climate change scenarios is likely to affect the affordability of olive and grape products for final consumers, especially those with less purchasing power. In the case of grapes, production is currently not meeting domestic demand, translating into higher prices for local grapes which affects local farmers' ability to compete in Gaza market, considering the competition from grapes imported to fill the supply gap.

3.4 GENDER IMPLICATIONS OF THE CLIMATE CRISIS

Underlying gender inequalities and compounded risk factors

'There is a high degree of injustice faced by women – especially women farmers – in Palestinian society, as they cannot govern, make decisions or control their economic situation: they can only contribute to processing. Their role is neglected and marginalized throughout the value chain, while unpaid care and domestic work is not equally distributed between women and men.'

Mohammed Jarrar, Value Chain Project Manager at The Economic & Social Development Center of Palestine

According to the Gender Profile of Palestinian Territories conducted in 2016 by the Japan International Cooperation Agency, gender situations, gender norms and empowerment/disempowerment of women in the OPT are tremendously diversified, depending on various factors including groups' attributions and experiences.[73] Social, political and economic differences between Gaza and the West Bank also influence gender issues.[74]

Findings from an Oxfam Participatory Gender Analysis highlighted that although women in the OPT are quite confident about accessing the labour market, there are still external and internal cultural and political barriers preventing them from becoming more active in the labour force and decision making in the public sphere.[75] Women are generally responsible for all domestic duties and household chores, while men are more publicly visible as farmers, herders, heads of households and decision makers (even though women perform at least 70% of duties related to

farming and agriculture).[76] OCHA has reported steady efforts by the different humanitarian clusters to understand gender issues and provide gender-sensitive services; however, there are still gaps in outreach and knowledge that may eventually result in failure to design effective gender-sensitive services.[77]

Women in the Gaza Strip are suffering from compounded inequalities as they are impacted by political oppression, social oppression and a patriarchal system which dominates women's lives economically, socially and politically.[78] For example, 61% of women subjected to gender-based violence in the Gaza Strip believe that the blockade and electricity cuts contribute to increased domestic violence towards women, resulting in them becoming 'shock-absorbers' of Gaza's chronic crisis.[79] While the overall unemployment rate in the Gaza Strip is 52% (2018), participation of men in the labour force is about three times higher than the participation of women.[80] Furthermore, due to the blockade and deteriorating economic situation, there is little protection for workers' rights, particularly in relation to minimum wage, and women only receive 70% of the average male daily wage.[81]

Generally in the OPT, employed women are clustered in the service sector, followed by commerce, hotels and restaurants, with the agricultural sector accounting for 6.4% of skilled female workers.[82] The Israeli blockade has left the Gaza Strip isolated, with limited access to natural resources and inputs, a collapsing economy and extremely weak infrastructure. As shown above, such multifaceted constraints have eroded agricultural production, affecting all smallholder farmers. However, women working in the agriculture sector are even more vulnerable to these constraints and their impacts. The majority of them are unpaid family workers whose contributions are neither documented nor recognized in national statistics.[83]

The role of women and girls in olive and grape farming

Caveat: Women in the Gaza Strip cannot be treated as one homogenous group; on the contrary, communities, norms and traditions vary from one area to another – hence there are also variations in people's perceptions about the roles, opportunities and limitations of women within these two value chains.

All the interviewed experts and farmers highlighted women's role as providing the 'family support system' in agriculture – i.e. as assistants to their husband, father or other male family member – stressing that there are only a few cases of female farmers. However, a previous Oxfam study that explored the role of women in agriculture in OPT argued that there is an inherent bias in the definition of 'farmer'; only the owner or manager of a farm is seen as a farmer, which precludes most women from being considered as such.[84] An interviewed policy maker described women's participation in the harvesting of olives as a family activity that is carried out in women's 'leisure time', and as 'beneficial for saving the cost of hiring workers'. While social cohesion and family bonding are fundamental, the failure to recognize the many hours women spend in harvesting as productive work perpetuates the invisibility of women's role in the agriculture sector and undermines their status.

Women contribute significantly to the harvesting and post-harvesting stages of olive and grape value chains, although women in the grape sector appear to have more limited roles than women in the olive sector. For example, in the olive value chain, women support activities such as olive picking, sorting and cleaning, as well as the traditional processing of olive oil and pickled olives, while in the grape value chain, women participate in picking grave leaves and preserving them, or making jam and molasses.

In other stages of the value chain such as marketing, agricultural input procurement, trading and exporting, women's presence is very limited. Some of the experts attributed this to the lack of specific skills and expertise that can only be acquired through full engagement in the farm, while others attributed it to women's lack of physical strength. Another expert felt it was the result of the overall socio-economic deterioration, and particularly unemployment, in the Gaza context. Where societal codes reinforce men's role as breadwinners, farmers are more likely to engage

male family members as workers. As stated by one farmer: *'Why would I let my wife work in the field, when my sons or I are unemployed? They should be given the opportunity to work.'*

The findings show that women's limited role in value chains, and their concentration in value chain stages where profit is minimal or the work is unpaid, undermines women's value and role in agriculture. Social norms that consider men as more competent than women at farming is evidence of this. This view extends to how communities prioritize rights for employment within the suffocating economic crisis, where men's employment is prioritized over women's. One male interviewee displayed this discriminatory attitude when he noted: *'It is not gender inequality [to not employ women]; opportunities are based on gender abilities.'*

Gender inequalities in the agriculture sector

'Success in the agriculture sector depends on three main components: natural resources, human resources and financial capital. Women don't normally inherit land and when they do, they don't have control over it. They have less exposure to accumulated knowledge and expertise, while men have more freedom and acceptance to engage with and contact markets, fields, farming input companies, traders, the Ministry of Agriculture, neighbours, agronomists, etc.'

Ahmed Shaban, Head of Plant Production, Faculty of Agriculture at Al-Azhar University, Gaza

According to an Oxfam study,[85] there is a clear gender division of labour across the different agricultural value chains and roles. It found that gender inequalities in the agriculture sector are manifested in women having fewer assets, whether land or livestock, and limited access to agricultural information, extension services, credit, agricultural inputs and new technologies.[86] In order to understand and explore the potential direct and indirect impacts of climate change on small-scale women producers, it is also necessary to understand the underlying barriers that women face in the Gaza Strip, which is characterized by complex economic, social and political issues.

According to female respondents, the main risks for agricultural production other than climate change are: the Israeli occupation, including the blockade; the high prices and poor quality of pesticides and their excessive use, which is harming plants; and the lack of farmer adoption of new agricultural practices and technologies. This shows the importance of the lack of access to assets and knowledge for smallholder women farmers.

The research found the following gender inequalities, based on the focus group discussions and responses from farmers and other stakeholders:

Women have limited access to productive and natural resources, such as land, water, farming inputs, and the necessary infrastructure and technology for production

Findings demonstrate that women have limited access to natural resources, in particular land, and to technology, for a number of reasons. First, women in the Gaza Strip have very low ownership of land and physical assets, and subsequently a low presence in agricultural value chains. This is because women are either deprived of their land inheritance completely or partially, or because they don't have control over it. As reported by the Palestinian Central Bureau of Statistics, women own less than 8% of agricultural land while men own over 92%. This is due to women's inability to obtain their rights to land ownership, a problem which is exacerbated by 'cultural complexities and an array of legal challenges'.[87] One male smallholder farmer explained: *'Some Palestinian women give up their inheritance rights due to fear of familial and social pressure.'* Conservative social norms put women under pressure to give up their inheritance rights, either for fear of damaging their social relations due to family feuds, or due to a sense of shame or embarrassment. This aligns with other studies, where it was found that women fear physical assault and legal barriers which would make demanding their legal rights expensive and unaffordable, given their limited resources.[88]

Second, the majority of interviewees agreed that women who do receive their land inheritance lack control over it, and in many cases women landowners are used as a 'token' and a means to gain support from local and international organizations' projects that prioritize women beneficiaries. A coordinator in a local NGO stated: *'Even if women are the official landowner, they are not the sole decision maker in developing or farming the land. Family members intervene, influencing women's decisions regarding their land.'* This means that many women have little power to manage, invest in or even take any decisions related to their land, such as which crops to plant and when to plant; such decisions on the whole farm management are taken by male family members.

Lastly, the suitability of the agricultural land influences women's engagement in farming and access to resources. Previous studies conducted by Oxfam observed that women in the Gaza Strip are often given inheritance lands near the eastern perimeter fence, within the Access Restricted Area (ARA),[89] which is described by OCHA as 'no go area' and a 'high risk area'.[90] Interviewees reported that these areas are continuously targeted and if women farm there, they risk their crops, financial capital and even their lives. Khaled Qahman, Assistant to the Palestinian Minister of Environmental Affairs, said: *'Women have limited access to land, particularly in the ARA, where they can be subjected to security risks. Furthermore, the infrastructure in these areas is very weak, with no electricity.'*

Women's lack of access to capacity building and support

Access to agro-climatic advice, capacity-building opportunities and market information is weak for both men and women. Yet social and cultural barriers further hinder women's engagement in training and extension services. This is because many women have limited mobility outside of the home, a limited role in the farm, and are unable to attend training without male family members. As a result, women tend to defer to their husbands, sons or fathers for agriculture-related advice or extension services, regardless of the accuracy of information. One of the interviewed farmers reported receiving technical advice and educational brochures about grape cultivation from different sources, such as the MoA and other local organizations supporting farmers. His wife, who is a pioneer female grape farmer, described her husband as the main source for agricultural information, though she stressed her ability to access any technical advice when needed. Even though some of the female farmers reported ease in accessing extension services, it remains unclear whether this was due to them benefiting from projects that provide extension services as part of their activities.

Weak outreach efforts by organizations working and supporting farmers such as banks, business development associations, microfinance institutions, and marketeers also impede women's economic growth. Local agricultural organizations' outreach mechanisms include Facebook and farmers networks or cooperatives. The MoA argued that agro-climatic and market information is available for all (women and men) and noted that most of the inquiries the Ministry receive online are sent by women. However, there is no data on the educational background of these women and whether they are female farmers or agronomists. Despite the multi-channels utilized for outreach, many female farmers who are illiterate, poor and marginalized have no access to the internet or networks. This results in women working almost exclusively in the traditional areas of olive and grape farming, supporting their husbands and families. As a result, women remain relatively unskilled.

Women's limited access to financial resources

While access to finance is generally poor for both women and men, it is even more limited for women, as men have social capital and networks that increase opportunities to access financial services. Some interviewees indicated that women's lack of proper financial capital impedes their ability to receive information and gain knowledge. Male dominance over financial decisions at the household and business levels adds further impediments to women's investment in their land (such as buying inputs or equipment). Farmers referred to cultural norms and religious practices reinforcing farmers' reluctance to obtain loans and credit, while also indicating the lack

of any agricultural saving or insurance schemes.[91] This adversely affects production quality and market penetration.

Women's limited role in decision making

Whether in spaces in value chains or in the construction of relevant policies, strategies and plans of action, women are perceived only as contributors, not as people who can govern, make decisions and control their economic situation. This is a perception that is echoed in other life spheres, where women are marginalized from the political decision-making process. The long-held belief that 'the breadwinner is the decision maker' creates communities where men predominate over decision making in the family. This extends to farm management, where men are seen as the key decision makers. Such power and control are detrimental to women's engagement with other stakeholders beyond the farm, as women are not allowed to deal with traders or agricultural input-supply marketers. This means their role is neglected and marginalized, lessening their abilities to influence decisions.

Interviewees mentioned only one example, stressing its rareness, where a female farmer had full control over decision making about her land, with her husband working to support her. One agricultural academic stated that the absence of women in governance at the national level and across the value chains resulted in misguided understandings of women's needs and abilities. This means that while women themselves have strong beliefs in their physical abilities to work hard, endure and adapt to difficult conditions, men do not.

Women's collective voice, however, can be enabled by supporting women's groups and cooperatives to influence decision-making dynamics and get involved beyond the food-processing level. In response to this need, many organizations are working to increase women's incomes, enhance their capacities and improve their representation in the various decision-making processes and markets.

Gender inequalities in the olive sector

In the olive sector, data from the seasonal calendar exercise indicates higher vulnerability among female farmers compared to male farmers. Most income-generating activities indicated by women take place during olive harvest and the following two months (including olive processing, packing and marketing activities). However, women spend eight months a year (February to September) carrying out non-income-generating activities. The busiest months for women are after harvest and during May and June (school exam period and current Holy Month of Ramadan). Women indicated that the periods with lowest income and food availability start from May and last until the end of harvest (October). Men perceived shorter food and income scarcity periods (from June until the beginning of harvest). Thus, May and June are critical months for women olive farmers. In addition, women indicated that the onset of seasonal risks related to water shortages and diseases occurs between May and August, prior to the harvest period. These seasonal risks appear during the busiest time for women, and when the household resources (income, food) needed to face them are scarcest.

Gender inequalities in the grape sector

In the grape sector, men occupy most of the employment and income-generation activities, whereas women tend to carry out unpaid work at household level such as harvesting, processing and informal marketing activities. Small-scale producers do not typically have the resources to hire seasonal labourers, and thus depend mostly on family labour.[92] Women carrying out unpaid tasks during harvest are exposed to climate extremes such as high temperatures. In addition, such tasks often compete with household and care work, creating an additional burden for women.

According to the seasonal calendar exercise, the busiest months for women involved in grape farming include March to June (harvest), as well as November and December. Apart from harvest, the most labour-intensive periods for women coincide with children's exams and with

the Holy Month of Ramadan. For women, the period with lower income and food availability is during the three months after harvest (July-September), whereas men indicated much later dates (from October to the next harvest). Women highlighted having more income during the months of May and June because they work as labourers in the grape sector, so most of the work they do and earn wages for is the harvesting activity; furthermore, women indicated having more income during winter, as they do intercropping to take advantage of rainfall. This difference suggests gender inequalities in how women and men manage household economic resources, including how they prioritize household expenditures after the harvest.

Climate crisis impacts on smallholder women farmers

Bearing in mind that the majority of participants in the research were men, interviewees unanimously said that climate change affects both women and men. One male interviewee said: *'We all feel scared of losing our production due to the climate crisis, as this is the only way we have to generate income.'* An agricultural expert added: '*There is no difference in the impact of climate change on men and women. The whole family is affected.*' While some interviewees justified the common narrative of there being no difference in the way climate change affects women and men because of their perception that women were less involved in agriculture, others said that women were more vulnerable in cases of extreme weather events due to their limited mobility, and that women were inherently more vulnerable due to their limited access to resources and climate adaptation knowledge.

The climate crisis risks most mentioned by female farmers are: high humidity, water and soil salinity, precipitation declines, temperature rise, violent winds and heat waves. These factors highlight: (1) how water-related risks are important for women, owing to women's role in water management; (2) the relevance of climate factors adding physical stress to agricultural labour (working in high temperatures and humidity); and (3) women's vulnerability to climate extremes (heat waves, violent winds).

A summary of the main observed climate crisis impacts on smallholder women farmers is as follows:

- **Extreme weather events** cause severe damage to grape and olive sectors, usually as a result of flooding, causing economic stress and loss of livelihoods. As most women working in the olive and grape sectors are employed in processing, extreme weather events reduce production and jeopardize women's ability to secure raw materials for their processing operations, making them economically unfeasible. One interviewee stated: *'The olive season is essential to us. Losing olive flowers due to weather changes will reduce production quantities, affecting family income. Female farmers who work in olive harvesting will [therefore] not have jobs and their families will be affected*.*'*
- **Increased social tension and gender-based violence:** There appears to be a link between the adverse economic impacts of the climate crisis and social issues, where lost income prevents small-scale farmers from meeting their family's needs, creating tension within the household. Recurring economic vulnerability is positively correlated with incidents of gender-based violence.
- **Increased mental burden:** The loss of expected income caused by crop damage increases women's mental burden, as household management is their main role. As women navigate livelihood and food insecurity, their husbands tend to prioritize personal expenses, such as smoking, over household needs, further depleting income. An expert from meteorological and climate services elaborated on this, saying: *'I believe there is a relation between economic status and women's welfare. When farmers lose their agricultural crops due to climate change, they lose their income. Women in poor families have more responsibilities and more burdens on their shoulders.'* Additionally, one interviewee raised the issue of chronic water shortages in the Gaza Strip, and how women are under constant pressure to

think of adaptation methods and alternatives to secure water, again increasing their mental burden.

- **Increased unpaid care and domestic work:** As a result of social norms and traditions, women in the Gaza Strip are responsible for all household chores. This unequal distribution of unpaid care and domestic work, coupled with women's engagement in farming during the months of harvesting and processing, creates conflicting priorities for women. Women tend to be unable to go to the farm early in the morning, because they are busy getting children ready for school. Because they have to start work later in the day, they suffer from longer periods of exposure to hot temperatures, especially during harvesting. This forces them to choose between working under these conditions and suffering health problems, or working fewer hours and forsaking potential income. One participant shared her experience of fainting as she was harvesting grapes, due to long periods of exposure to extreme hot weather. Moreover, the expectation that women will do all the domestic work doesn't lessen despite their working on the farm, generating a 'double burden' for women.

During the focus group discussions, women recalled the 2016 flood, touching on compounded vulnerabilities stemming from poverty and poor living conditions, and their exposure during extreme climatic events. Women shared their experiences of displacement, stress and trauma as they tried to cope with all their usual responsibilities on top of added work during the crisis. One female interviewee said: *'When the flood came in that day, the floor of our house filled up with water. We could not adapt, so we left our house and migrated to my parents-in-laws' house, which is located on higher ground.'* Another interviewee revealed how she spent most of her time caring for her children while constantly trying to remove water dripping onto the floor. In marginalized areas where there is no infrastructure, displacement during flooding is more likely than in other areas. Furthermore, lack of health and hygiene-related infrastructure increases children's exposure to skin diseases and infection in cases of extreme heat. One female participant shared how poor living conditions caused her to live in constant stress, which impacted negatively on her children.

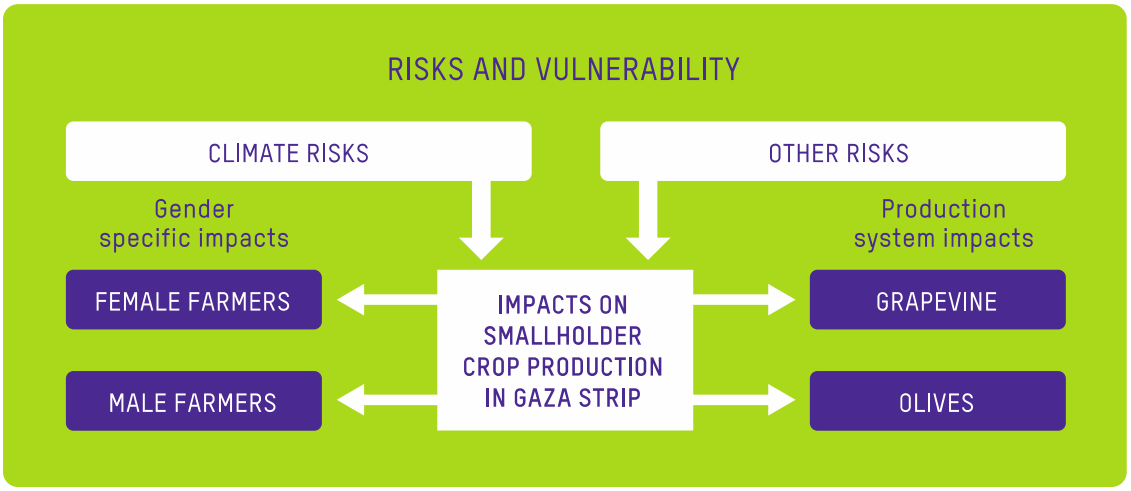
At a policy level, there are many gaps in terms of gender equality, including in agricultural policies. This leads to agricultural interventions and climate resilience building strategies that are gender-blind or even harmful to women. While some entities (e.g. the Palestinian Water Authority) have conducted gender assessments and designed specific interventions to promote equal participation of women and men in agriculture, these appear to be isolated cases. The main policy instrument relevant to the climate crisis – the National Adaptation Plan – still lacks a thorough assessment on gender inequalities and how to address them. This area of work tends to be the preserve of NGOs and international development projects, which is not ideal; the government should be leading on this to ensure that gender equality efforts are institutionalized and sustainable.

4 ASSESSMENT OF SMALLHOLDER FARMERS' CLIMATE RESILIENCE

So, what does all this mean in terms of the resilience capacity of smallholder farmers? Using the three components of the analytical research framework outlined in section 2.2, it becomes evident that their resilience capacity is low, and that for their livelihoods to survive and thrive, much needs to change. This is not only in terms of building smallholder farmers' resilience to climate change in general; specific interventions are needed to adapt olive and grapevine value chains to the specific effects of climate and other risks, along with policy and government interventions and actions that address social norms and practices restricting women's participation and decision making, both in smallholder farming and more broadly.

4.1 RISKS AND VULNERABILITY

Figure 3: Risks and vulnerability for smallholder farmers in the Gaza Strip



Agriculture, in particular smallholder agriculture, is the sector which is most vulnerable to the effects of climate change. Temperature rise, more irregular and unstable rainfall patterns, and sea-level rise paint a bleak picture for grape and olive smallholder farmers in Gaza. Olive and grape farmers are already seeing impacts on flowering and growth, direct tree stress, and reduced quality and quantity of fruits. Diseases and pests are more evident, leading to an increase in the use of pesticides (in turn causing other negative environmental impacts). Scarcer water resources, at a time when crops are already under threat, adds to vulnerabilities. Violent winds cause loss of leaves and flowers and directly damage and destroy fruit, while drought dries out seedlings and plants, putting them under stress. Ultimately, all these effects lead to production losses.

With less water available for consumption and crops, changing seasons, extreme weather events and the displacement of people and farmers due to sea-level rise and land degradation, smallholder farmers need significant support to build their capacity to plan, adapt and transform their livelihoods to manage increasing stress and uncertainty. Impacts on the supply chain from losses in production negatively affect the market opportunities of smallholders. With less to sell, farmers have less selling capacity; coupled with the poor economic environment resulting from the occupation, this is bad news for farmers.

In addition, smallholder farmers are highly vulnerable to the Israeli occupation. This affects their basic needs, causing market closures, lack of access to inputs, and even lack of access to and control over the very resources they need for production. Years of violent conflict and

occupation has already deprived smallholder farmers of the knowledge and skills they need to adapt and transform their livelihoods to the various risks. In the future, these risks are set to worsen due to climate change.

The research has demonstrated that women are particularly vulnerable, not only because of traditional social norms and inequalities, but also because climate change exacerbates their existing vulnerabilities. It increases women's workloads (particularly unpaid care and domestic work), jeopardizes their roles in the production cycle (climate change reduces supply and women's ability to secure raw materials for processing operations), increases their mental and physical burdens in general, and puts them at greater risk of experiencing gender-based violence.

4.2 CLIMATE RESILIENCE-BUILDING PROCESSES

Smallholder farmers' perceptions of resilience

Using the six social change processes from Oxfam's Framework for Resilient Development,[93] smallholder farmers' perceptions of resilience were evaluated. A participatory exercise known as the 'spidergram' was used to facilitate discussion and individual reflection and assessment of resilience.

Table 6: Smallholder farmers' perceptions of resilience

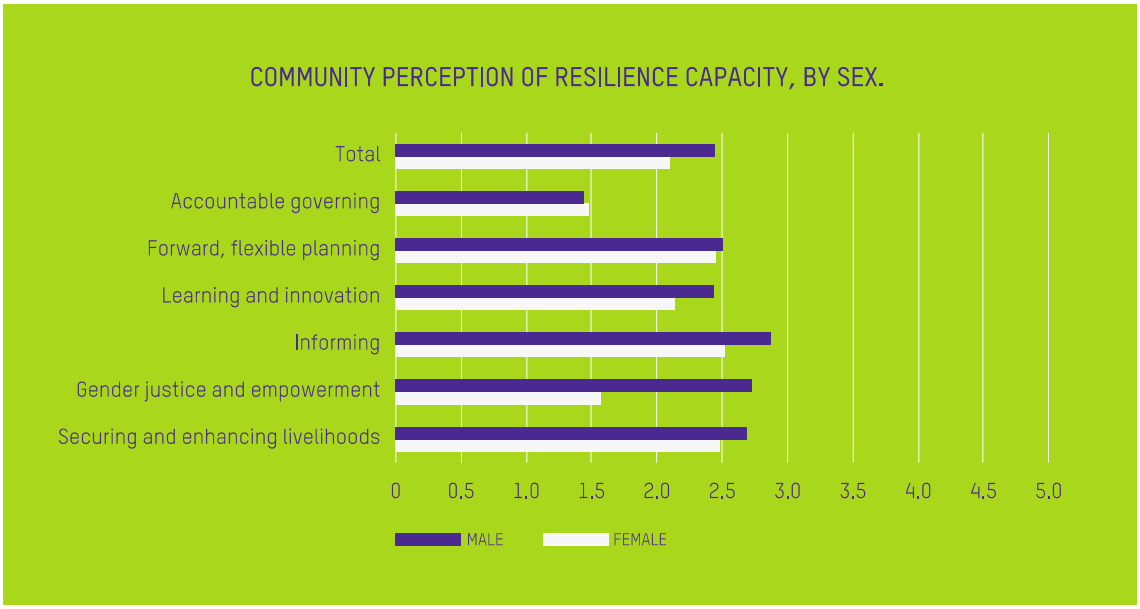
Social change processes for resilience building[94]	**Overall score (from 1 to 5)**
Securing and enhancing livelihoods	2.58
Gender justice and empowerment	2.15
Access to information	2.69
Learning and innovation	2.28
Flexible and forward-looking planning	2.48
Accountable governing	1.46
TOTAL	2.27

Overall, when asked to rate different statements related to resilience building (1 = never, 2 = sometimes, 3 = half of the time, 4 = most of the time, 5 = all the time), most participants feel that they are resilient 'sometimes', as seen in the average score across all six social change processes (2.27), which is quite low. The lowest-scoring element by far is 'accountable governing' (1.46 – nearly absent), as participants gave very low scores to statements related to: (1) whether the government listens to them and responds to their needs; and (2) whether they can receive support from people in their communities and from outside. This reaffirms the lack of supporting systems and the weak governance for climate resilience building in Gaza, as highlighted above. The areas where participants feel relatively more resilient include 'access to

information' and 'securing and enhancing livelihoods', although the scores for these are still quite low.

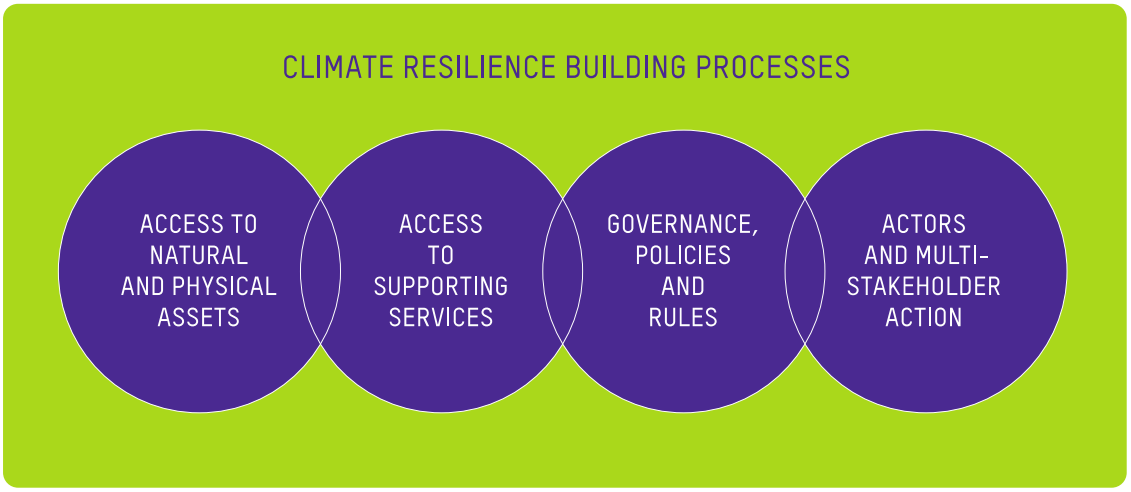
Overall, men perceived themselves to be more resilient than women perceived themselves to be (Figure 4). In fact, gender justice and empowerment was rated quite differently by women and men. Women gave a much lower score for the statements: 'I feel included in decisions affecting me within my community' and 'My community promotes the inclusion of all people regardless of gender, ethnicity, age or disability', showing the clear intrinsic gender discrimination at community level when it comes to decision making. Women also stated having less access to learning and innovation opportunities than men, as well as poorer access to knowledge and technical information to continually improve and adapt their livelihoods.

Figure 4: Perceptions of resilience, by sex



Climate resilience building processes

Figure 5: Climate resilience building processes



There are four interrelated climate resilience building processes for smallholder farmers, as shown in Figure 5 above. These determine how resilient smallholder farmers are to climate change and other related risks.

Access to natural and physical assets

Access to water is strongly impaired due to the blockade and the depletion of aquifers, coupled with demographic pressure. The depletion of the aquifers (the only source of water for most citizens in Gaza) is creating additional problems of saline water intrusion, soil and water salinity, water contamination and associated health problems. Consulted farmers often have access to land, although this is becoming more limited due to the demographic pressure and the constant threat from the Israeli occupation. Agricultural land is already in many cases competing with urban expansion. In addition, women have lower entitlement to land than men, limiting their livelihood opportunities in agriculture. Not only do women face a culture of shaming and societal pressure to give up their land inheritance rights, they also lack control and decision making over land resources, which crops to plant, and general farm management. This undermines women's ability to have a more active role in the agriculture sector. Furthermore, access to 40% of the agricultural land in the Gaza Strip is limited for both women and men, due to its location in the Access Restricted Area.

Agricultural infrastructure is limited in Gaza, and many facilities were destroyed during the previous wars with Israel. Smallholder farmers frequently complained about the lack of water infrastructure and supply in their farming units, including electricity shortages for water pumping. There is also inadequate storage and processing infrastructure for olive and grape products. Concerning inputs and technology, some farmers can access these, while many others complained about their high cost (especially pesticides and fertilizers) and the lack of climate-resilient varieties. Most of these assets are not (or are only very minimally) subsidized by the government. Access to them is extremely limited due to the Israeli restrictions, which is the main factor raising their cost. At the household level, most women have only indirect access to these assets through their husband (usually the head of household); older heads of household similarly access assets through a proxy, mainly a family member.

Access to supporting services

Farmers in Gaza have weak technical and financial support; the Gaza-based MoA provides only limited capacity-building and extension support for small-scale and poor farmers. A couple of interviewed farmers mentioned receiving technical advice from the MoA, whereas much of the support mentioned comes from the Union of Agricultural Work Committees and from local agricultural development associations (NGOs). Women's limited mobility, aggravated by social

and cultural barriers, means they tend to be concentrated in lower positions in the value chain. In addition, weak outreach efforts towards women's inclusion by organizations supporting agriculture results in women having poor access to agro-climatic advice, capacity-building opportunities and market information. Male dominance over financial decisions and women's lack of proper financial capital impede women's ability to invest in their land. Interviewees stressed men's dominance in decision making at the family, farm, community and political levels. Interviewed women said they can access the same technical advice and support as men, although this information is usually channelled through the male head of household.

There are also weak research and development capacities to test and develop new and adapted olive and grape varieties in the face of the changing climate, an issue that was highlighted by several technical experts (for grape, most production remains non-arboured, which is proven to be less productive). Concerning risk management, there are weak local weather forecasting systems and related agro-climatic advice (only general meteorological information is available, from local media). There is no access to savings, credit and agricultural insurance for Gaza farmers. Some farmers expressed never having heard of them, while farmers may also opt not to take loans due to their religious beliefs.

Women involved in small-scale processing lack the access to private finance that could enable them to invest in processing equipment and materials for storage and packaging. When women heads of household need financial support, their most accessible sources are friends, neighbours or family. Overall, financial resources to manage risks are scarce. According to one smallholder interviewee: *'A support fund should be launched to cover farmers' losses and damages due to climate change. This support should not come late, because most farmers purchase their farming inputs by taking on debt, and wait till the end of the season to pay back their debts.'*

Governance, policies and rules

Capacities to integrate climate change and gender dimensions into policy making and implementation are still weak. Risk management structures and plans are also highly dysfunctional, owing to the lack of resources. There are some favourable agricultural market protection measures for local producers, such as the prevention of grape imports during peak production. However, such a ban was recently lifted in the grape sector, reducing the ability of small-scale producers to compete in local markets.

Actors and multi-stakeholder action

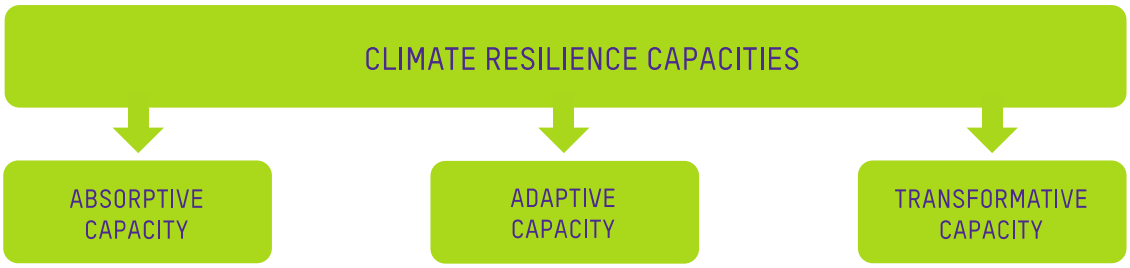
With regards to concerted action, first it is important to note that there is a lack of coordination among smallholder farmers in Gaza. Farmers lack the tradition of organizing themselves in cooperatives or support groups beyond family solidarity networks, thus limiting their bargaining power over access to inputs and product sales. Several small-scale farmers are linked with supporting actors such as local and international NGOs or the Union of Agricultural Work Committees. Some farmers are also linked with agricultural engineers from the MoA, although there are important mobility limitations (lack of resources for transport to visit farms).

Some farmers reported being able to carry out actions towards influencing government policies, for example in relation to commodity market imports (i.e. prevention of oil imports) and exports (opening up to foreign markets). In many cases, this is done in association with NGOs (agricultural development NGOs and Oxfam), while one farmer mentioned being a founder member of an olive producers' association: *'I am a founder member of the Olive Branch Association. We always take action and put pressure on the government to prevent the importing of olive oil from outside.'*

However, interactions among actors at the value chain level are limited. According to an Oxfam value chain report on the grape sector in Gaza: *'Relationships between value chain actors are generally weak, resulting in the fact that producers, especially small-scale producers, are always price takers and lack true power to negotiate better deals.'*[95]

4.3 CLIMATE RESILIENCE CAPACITIES

Figure 6: Climate resilience capacities[96]



In terms of the three climate resilience capacities – absorptive, adaptive and transformative – while smallholder farmers cannot be considered a homogenous group, the research demonstrates that all three capacities are low.

'Absorptive capacity' is the capacity to take intentional protective action to cope with known shocks and stresses. While olive and grape smallholder farmers have generations of knowledge and experience and have taken action to cope with climate change and other risks, including the occupation, the research demonstrates that many famers, especially women, are barely coping. Even small changes in the climate have affected their crop production. Coupled with the crippling effects and impacts of the occupation, this means that their absorptive capacity is low and evidently decreasing.

'Adaptive capacity' refers to the capacity to make intentional incremental adjustments in anticipation of or in response to change, in ways that create more flexibility in the future. While olive and grape smallholder farmers are learning every day about how to adapt to climate change and how to become more resilient to the ongoing uncertainty caused by external political forces, in particular the occupation, it remains very difficult for farmers, particularly women, to plan for their future. Farmers survive season to season and even when they want to plan more intentionally for change, their circumstances prevent this. All these factors mean that their adaptive capacity is low.

'Transformative capacity' is the capacity to make intentional changes to stop or reduce the drivers of risk, vulnerability and inequality, and ensure the more equitable sharing of risk so that it is not unfairly borne by poor and vulnerable people. This lies at the heart of the issues facing not only smallholder farmers, but the population of Gaza in general. Factors other than climate change are currently their biggest obstacle to building transformative capacity. The Palestinian government is struggling to maintain its operations and is unable to provide the policy and practical support its citizens need. For smallholder farmers to build their transformative capacity – which is very low – the enabling environment of the OPT needs to significantly change.

5 RECOMMENDATIONS FOR ACTION

To address the multiple challenges faced by women and men smallholder farmers, the research makes the following recommendations to: (1) increase climate-resilient olive and grape production; (2) strengthen the resilience capacities of farmers; (3) foster more resilient and inclusive olive and grape value chains; and (4) create an inclusive and resilient enabling environment.

INCREASE CLIMATE-RESILIENT OLIVE AND GRAPE PRODUCTION

- Farmers should choose and use existing olive and grapevine varieties that are able to cope with combinations of stresses and extreme events, where available, as these are better able to deal with the effects of climate change. This includes varieties where flowering occurs before the beginning of the dry period, and those whose life cycle allows them to avoid or significantly reduce damage caused by temperature extremes.
    - Relevant actors to this recommendation, particularly with regards to balancing customer preferences for traditional varieties with the need to adopt new resilient varieties, includes the private sector, nurseries and input suppliers.
- Farmers should adopt/be supported to adopt improved management techniques, such as modification of canopy temperature (e.g. pruning and adapted shading techniques in order to limit heat stress impacts) or supplementary irrigation (i.e. a single irrigation event to protect flowering of current varieties or of extreme years under future conditions), that will support adaptation beside adapting crop cultivars.
    - Relevant actors for this recommendation are: farmers, extension service providers, the private sector.
- Farmers should apply/be supported to apply soil and water management techniques in order to mitigate the effects of increased evapotranspiration and heavy rainfall (with associated soil erosion and flooding risks). This includes mechanical measures (bunding, terracing, ridging, pitting), mulching, intercropping, fertilizing with compost and manure, cover crops (green manure) and conservation agriculture, among others.
    - Relevant actors for this recommendation are: farmers, extension service providers, the private sector, Ministry of Agriculture.
- Farmers should apply/be supported to apply integrated pest management techniques. These should focus on ecological pesticides and biological control methods, especially given the current excessive dependence on chemical pesticides and environmental issues stemming from this. Complementary approaches could include adopting physical control methods, such as installing insect traps to stop the vectors that cause olive and grape diseases.
    - Relevant actors for this recommendation are: farmers, extension service providers, the private sector (particularly input suppliers), Ministry of Agriculture and NGOs.
- Farmers should plant/be supported to plant windbreaks around plot boundaries, as a strategy to protect trees and crops from *Khamaseen* winds.
    - Relevant actors for this recommendation are: famers, Ministry of Agriculture and NGOs.

STRENGTHEN THE RESILIENCE CAPACITIES OF FARMERS

- Farmers' resilience capacities should be strengthened in agricultural and olive/grapevine orchard management through the adoption of climate-resilient practices such as the ones mentioned above, and through better climate risk management. This can be achieved by strengthening the capacities of female smallholder farmers and processors in the adoption of improved and climate-resilient techniques, and promoting their role in the development of innovative approaches. A strong 'gender lens' should be applied to review existing outreach mechanisms, women's learning needs, and delivery methods.

    - Relevant actors for this recommendation are: cooperatives, community-based organizations, INGOs, local NGOs, Ministry of Agriculture and the private sector.

- Local breeding capacities for improved and adapted olive and grape varieties should be developed, including new varieties that have shorter production cycles (particularly to avoid the expected higher frequency of heat events during flowering times, as well as to cope with shorter production seasons), are more tolerant of high temperatures and drought, and have greater disease immunity. Investment in research and development is required to develop local genetic engineering capacities and new breeding programmes that are capable of testing new varieties, adapted to the local context (i.e. adapted to local consumer preferences and local culture).

    - Relevant actors for these recommendations are: Ministry of Agriculture experts, nurseries, external experts, and research and development institutions.

- Oxfam and other stakeholders should work alongside farmers to improve community disaster risk management mechanisms, including early warning systems. This includes identifying key seasonal climate risks, providing relevant agro-climatic support, and developing appropriate contingency measures and adaptation practices. Efforts to strengthen or develop disaster risk management mechanisms should place women at the centre of planning and decision-making structures, ensuring that their differentiated vulnerabilities and needs are prioritized and integrated in all processes, including analysis of risks and the development of contingency and response measures. Gendered consideration is necessary when developing the content of disaster risk management and preparedness trainings.

  Under this recommendation it is critical to pay close attention to access to information, in relation to climate information, weather forecasts and early warning systems. Access to information interventions should consider how different farmers, particularly female farmers, receive and are able to understand and interpret such information. Multiple channels should be used to deliver climate information, consider the best mechanisms to reach both small- and large-scale, male and female farmers and taking into account literacy levels and mobility across different geographical locations.

    - Relevant actors for these recommendations are: national meteorological units, Ministry of Agriculture, Palestinian Disaster Risk Reduction and Insurance Fund (PADRRIF), municipalities, women's rights organizations working on the environment and climate, community-based organizations, NGOs and research institutions.

- Technological innovation capacity in grape orchard practices, including promotion of specialization in arboured grape production systems, should be increased, provided that these have better profitability margins. This should be linked with appropriate investments in developing locally adapted varieties, including research and development, and in extension services that facilitate farmers' adoption of new technologies.

- Climate-resilient community-based funds that are gender and vulnerable-community responsive, should be created and supported in order to compensate communities whose

livelihoods are suffering as a result of the climate crisis. This includes raising awareness about the PADRRIF in the Gaza Strip and its operationalization.

  - Relevant actors for this recommendation are: Ministry of Agriculture, PADRRIF and INGOs.

FOSTER MORE RESILIENT AND INCLUSIVE OLIVE AND GRAPE VALUE CHAINS

- Oxfam and other stakeholders should support research that analyses how women within different value chains are being impacted by the climate crisis. These value chain analyses should include specific gender and climate change analyses as well as considering intersectionality, looking at aspects such as differentiated vulnerabilities to climate risks and impacts and inequality in opportunities to strengthen climate resilience (considering access to assets, information, capacity building, etc.). Oxfam's Vulnerability and Risk Analysis (VRA)[97] provides a useful tool for this.

  - Relevant actors to this recommendation: INGOs, Food and Agricultural Organization of the UN (FAO) , women's rights organizations, farmers and processors, particularly women.

- Access to post-harvesting infrastructure, particularly for processing, where women are highly concentrated, should be improved. This could include putting in place storage facilities, or solar energy infrastructure (to allow cold storage) as a complementary strategy, to enable women to access a continual supply of raw materials for food processing businesses led by them, thereby reducing vulnerability to price instability and risk of fresh fruit loss. This is likely to create economic opportunities for women and strengthen their empowerment in the olive and grape value chains.

  - Relevant actors for this recommendation are: INGOs, cooperatives, private sector, investment companies, financing institutions, and female farmers and processors.

- Support should be given for the organization of farmers in producers' groups or cooperatives, particularly women's groups, to improve their market opportunities and bargaining capacity over access to key inputs and product sales, as well as to strengthen their negotiating position with other value chain actors. Such groups, once they are exercising collective bargaining power, can also influence agricultural and climate-related policies. Organized farmers can also collectively tackle and reduce risks by developing savings and loans associations or informal mutual insurance mechanisms. Creating platforms to regroup different supply chain actors (producers, processing units, retailers, etc.) could also represent an important step towards seeking joint action and maximizing synergies among actors intervening in the olive and grape value chains.

  - Relevant actors for this recommendation are: INGOs, cooperatives, private sector, women's rights organizations, investment companies, and farmers and processors.

CREATE AN INCLUSIVE AND RESILIENT ENABLING ENVIRONMENT

- Oxfam and others should support advocacy for the integration of gender issues through needs and capacity assessments during the development of climate change policies/strategies, including through women's involvement in policy decision-making spaces. This can be enabled by investing in women's rights organizations' research capacities to uncover linkages between the climate crisis and gender inequalities, and by supporting

women-led influencing and mobilization to promote gender justice in climate policy making (local to national development plans, adaptation plans).

There should be a specific focus on the integration of gender and vulnerability analysis in future projects of the government and implementing organizations.

  - Relevant actors for this recommendation are: INGOs, FAO, Palestinian Environment Quality Authority, women's rights organizations, research institutions and Ministry of Agriculture.

- Oxfam and others should advocate to facilitate women's access to and control over land, including development of strong regulations to protect women's rights in land cultivation and economic agricultural activities. Addressing these gender inequalities increases women's access to assets, finance, extension support, climate information and their participation in decision and climate policy making, and reduces women's compounded vulnerabilities.

  - Relevant actors for this recommendation are: women's rights organizations, INGOs, Ministry of Women's Affairs and community-based organizations.

- Oxfam and others should advocate to increase government support for climate-sensitive polices, as these will provide the enabling environment needed for farmers to absorb risk, adapt their livelihoods and transform women's involvement. With aquifer depletion and related soil and water salinity being among the most important problems for Gaza's agricultural production and livelihood wellbeing, state efforts to improve water reuse (wastewater treatment), provide rainwater-harvesting equipment/infrastructure or install water desalinization plants should continue to be pursued. However, as a result of the blockade, there are significant limitations in access to the necessary infrastructure.

  - Relevant actors for this recommendation are: INGOs, Palestinian Water Authority, Ministry of Agriculture, Palestinian Environment Quality Authority and community-based organizations.

- Oxfam and others should support advocacy to increase government provision of funds, incentives, risk-sharing schemes and subsidies for smallholder farmers to invest in climate adaptation techniques and mechanisms (e.g. shading, soil and water management, integrated pest management), as well as to cover farmers' losses and damages due to climate change.

  - Relevant actors for this recommendation are: PADRRIF, Ministry of Agriculture, donors and INGOs, local groups and community-based organizations,

- Whenever possible, the government should provide support funds, incentives or subsidies to enable smallholder farmers to invest in climate adaptation techniques and mechanisms (e.g. shading, soil and water management, integrated pest management), as well as to cover farmers' losses and damages due to climate change.

  - Relevant actors for this recommendation are: PADRRIF, Ministry of Agriculture, donors and INGOs, local groups and community-based organizations.

- Oxfam and others should support the government's efforts to strengthen national agricultural risk management structures. There is a strong need to reinforce the operationalization of existing national meteorological units and to develop national early warning systems and agro-climatic advice (including extension services). These have to be capable of translating climate risks into timely, relevant and user-friendly information for farmers, and particularly for women, on how to prepare for and manage extreme weather events and adopt adequate management techniques according to seasonal meteorological variability.

    - Relevant actors for this recommendation are: Ministry of Agriculture, Palestinian Environment Quality Authority, donors and INGOs, and national meteorological units.

- Oxfam and others should advocate for the Ministry of Agriculture to operationalize and strengthen the national agricultural insurance mechanism PADRRIF in West Bank and Gaza. However, such a risk management mechanism may only prove viable for smallholder farmers if highly subsidized, a lesson learned from other micro-insurance initiatives piloted by Oxfam.

    - Relevant actors for this recommendation are: PADRRIF, Ministry of Agriculture, donors and INGOs.

- Oxfam and others should advocate for government and private sector extension services that provide capacity building in climate-resilient techniques and appropriate management practices. This would include developing capacities to provide relevant and timely agro-climatic advice based on climate forecasts (e.g. pruning management), as well as support to enable producers to adopt improved and climate-resilient varieties. As existing extension capacities are limited due to lack of financial resources for farm visits, efforts to broadcast extension advice through other communication channels (radio, SMS, information-sharing structures at community level, etc.) should be promoted whenever possible.

    - Relevant actors for this recommendation are: Ministry of Agriculture, private sector, cooperatives, donors, INGOs and farmer communities.

- Oxfam and others should advocate for the government to reinforce phytosanitary regulations to avoid the excessive use of harmful and internationally prohibited pesticides. This should include improved supervision of the quality of imported products, and promotion of the development and adoption of eco-friendly phytosanitary products.

    - Relevant actors for this recommendation are: Ministry of Agriculture, the private sector, cooperatives and farmer communities.

- A mass cropping plan/map should be developed through an agricultural survey analysing soil and temperature characteristics across the different geographical locations of the Gaza Strip. This can support Ministry of Agriculture planning of crop plantation based on climate variables.

    - Relevant actors for this recommendation are: Ministry of Agriculture, INGOs and donors.

NOTES

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6 Desk review of existing literature and data sources, focusing on previous impact analyses for grapevine and olive trees in similar agro-climatic conditions to Gaza Strip (mostly Mediterranean Basin), given that there are few publications for the Gaza context. A focus has been put on the most recent literature (last five years, after publication of AR5 IPCC report).

7 Modelling of grape and olive suitability to future climate change: a quantitative modelling assessment was completed through simulations from the Coordinated Regional Climate Downscaling Experiment (CORDEX) using two emission scenarios (RCP 4.5 and RCP 8.5). For the climate model, field meteorological data for Gaza obtained from the Gaza Strip meteorological services was used, as well as historical input climate data (maximum and minimum temperatures, precipitation) from the observational data set EOBS. Climate data has been linked with crop phenology data and agro-climatic indexes used to define crop suitability (chilling accumulation, bud-break and flowering dates, and heat stress temperature thresholds). Simulations were made for the periods 1976-2005, 2020-2049 and 2070-2099.

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