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**-Araştırma Makalesi-**

# A Multi-Scale Climate Vulnerability and Risk Assesment (C-VRA) Methodology for Corporate Scale Investments: West Bank-Palestine Case Study

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**Abstract**

Assessing climate vulnerability and risk has become a critical part of feasibility studies for infrastructure investments due to the increased frequency and severity of atmospheric disasters. However, evaluating climate parameters and disturbances can become challenging in vulnerable regions, such as the dry Mediterranean terrain. This is why climate vulnerability and risk assessment (C-VRA) should cover several parameters and factors besides climate analysis. In our case, the political stress and conflicts between Palestine and Israel settlements in the West Bank add additional risks and vulnerabilities. Our paper presents a C-VRA in the Nabi Saleh Village-West Bank of Palestine, where a dairy factory with a wastewater treatment plant will be built. The factory is estimated to use around 120 m3 of water daily and produce wastewater that will be treated and reused for agricultural irrigation. Unfortunately, the current practice in the region is to use untreated wastewater to irrigate trees and vegetables without restraint since the treatment capacity is low, and a large part of the wastewater is discharged untreated into the streams. The dairy factory is planned on a ridge at the upper watershed (headwater) of the 1795.04 km2 Yarkon River basin. The local communities in the region are vulnerable to climate change impacts and related atmospheric disasters due to poverty, agriculture dependency, and political issues. To evaluate future climate projections, we used the latest Intergovernmental Panel on Climate Change Assessment Report 6 (IPCC AR6) methodology. We also used the Mann-Kendal test to analyze the historical trend of climate parameters and projections for three scenarios (optimistic, moderate, and pessimistic) of AR6 for a future period until 2080, considering the life span of the investments and water-specific physical climate risks. Results showed that the historical temperature had a statistically significant increasing trend projected to continue in the next 60 years. Additionally, according to all three scenarios, the precipitation in the region will decrease in the coming decades. As a result, we identified one high (water scarcity) and two moderate-level risks (rainfall decrease and drought) for the corporate, all related to water security. Our methodology incorporates basin-scale assessments with regional and local vulnerabilities, making it a potential tool for critical infrastructure investments elsewhere.

**Keywords:** Climate change, vulnerability, risk, wastewater reuse, watershed management.

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# Kurumsal Yatırımlara Yönelik Çok Ölçekli İklim Kırılganlık ve Risk Değerlendirme (I-KRD) Metodolojisi: Batı Şeria-Filistin Örnek Çalışması


## Öz

Atmosferik afetlerin sıklık ve şiddetindeki artış tahminleri nedeniyle, iklim kırılganlığı ve risk değerlendirmeleri (I-KRD), altyapı fizibilite çalışmalarının önemli bileşenleri haline gelmiştir. Genellikle iklim parametrelerinin ve dış etkenlerin temel bir değerlendirmesi olarak ifade edilebilen bu değerlendirmeler, kurak ve yarı kurak Akdeniz gibi hassas bölgelerde zorlu bir teknik çalışma haline gelebilmektedir. Dolayısıyla, I-KRD sadece iklim parametrelerinin analizinden ibaret olmayıp, ilgili konuya yönelik çeşitli parametre ve faktörleri de kapsayabilmektedir. Bu çalışmada, Batı Şeria'daki Filistin ve İsrail yerleşimleri arasındaki politik gerginlik ve çatışmalar, başta su güvenliği ve güvencesi olmak üzere ilişkili ek riskler ve kırılganlıklar dikkate alınmıştır. Makalede, Filistin'in Batı Şeria Nabi Saleh Köyü'nde inşa edilmesi planlanan bir süt fabrikası ve onunla entegre atık su arıtma tesisine yönelik bir I-KRD çalışmasının yaklaşım ve metodolojisi sunulmuştur. Fabrikanın günde yaklaşık 120 m3 su kullanıp, çıkan atık suyu arıtıp, tarımsal sulama için yeniden kullanımı planlanmıştır. Bölgede arıtma kapasitesinin düşük olması nedeniyle atık suların büyük bir kısmı, halihazırda, arıtılmadan tarımsal amaçlı kullanılmakta veya derelere deşarj edilmektedir. Süt fabrikası, 1795.04 km2' lik Yarkon Nehri havzasının yukarı havzasında (memba kısmında) bir sırt üzerinde planlanmıştır. Bölgedeki yerel topluluklar, yoksulluk, tarıma bağımlılık ve politik sorunlar nedeniyle iklim değişikliğinin etkilerine ve buna bağlı atmosferik afetlere karşı büyük ölçüde savunmasızdır. Analiz kapsamında gelecekteki iklim risklerini değerlendirmek için Hükümetler arası İklim Değişikliği Değerlendirme Raporu 6 (IPCC AR6) metodolojisi baz alınmıştır. İklim parametrelerinin tarihsel eğilimini analiz etmek için Mann-Kendall testi, yatırımların ömrü ve suya özgü fiziksel iklim risklerini göz önünde bulunduracak şekilde 2080 yılına kadarki dönemi yansıtacak şekilde iyimser (SSP1-1.9), orta (SSP2-4.5) ve kötümser (SSP5-8.5) olmak üzere üç farklı senaryo için AR6 projeksiyonlarına yer verilmiştir. Sonuçlar, geçmiş ortalama sıcaklığın önümüzdeki 60 yılda devam etmesi öngörülen istatistiksel olarak anlamlı bir artış eğilimine sahip olduğunu ortaya koymuştur. Dahası, her üç senaryoya göre de bölgedeki yağışların önümüzdeki on yıllarda azalması beklenmektedir. Bundan yola çıkılarak, yatırım için tümü su güvencesi ile ilgili olacak şekilde bir yüksek (su kıtlığı) ve iki orta düzeyde risk (yağış azalması ve kuraklık) belirlenmiştir. Havza ölçeğinde değerlendirmelerle bölgesel ve yerel kırılganlıkları birleştiren çok ölçekli metodolojimiz, çeşitli kritik altyapı yatırımlarına uyarlanma ve uygulanma potansiyeline sahiptir.


**Anahtar kelimeler:** İklim değişikliği, kırılganlık, risk, atıksu yeniden kullanımı, havza yönetimi.

## 1. Introduction

With the effects of global warming becoming more noticeable, countries, cities, and businesses are taking action to reduce their carbon footprint and prepare for extreme weather conditions. This includes thousands of infrastructure projects that are currently being planned or considered, which will need to be able to withstand the increasingly severe climate conditions they will face (Salimi and El-Ghamdi, 2020; Giordano, 2012).

The findings of the Intergovernmental Panel on Climate Change's (IPCC) fifth assessment report (AR5) in 2014 and the sixth assessment report (AR6) in 2021 leave no room for doubt: human activities are the primary drivers of climate change, and the situation is deteriorating rapidly. The potential consequences of continued disruption to our climate are severe and irreversible, threatening our environment, infrastructure, and ultimately our very existence. To address this critical challenge, the Paris Agreement, the IPCC Land Use Report (P.R. Shukla et al., 2019), and other relevant strategies emphasize the pivotal role of effective natural resource and land use management in adapting to a changing climate. The United Nations and the European Union have implemented policies, such as the EU Green Deal, designed to facilitate the transition towards low-emission development. These policies encourage international investment and funding mechanisms that can help identify vulnerabilities and support resilience, making climate vulnerability and risk assessments an essential component of infrastructure investment feasibility studies.

Upon examining the impacts of corporate actions across various spatial scales, it becomes apparent that there is a complex interconnectedness between these actions and the larger basin, as well as the influence of global climate change on corporate operations. In their study, Babut et al. (2007) assert that assessing risks and management objectives at the basin level can help prioritize local socio-economic and ecological actions. They also emphasize the significance of basin-scale considerations in sediment management. While the corporate and basin scales typically collaborate, regulations at the regional level may not always align with hydrological considerations.

In the case of the Yarkon River, management primarily involves downstream activities, such as water usage, recreation, and flood control, on the Israeli side. The groundwater basins are also under Israel's control, with a limited amount assigned to the Palestinian villages in the West Bank. However, water and wastewater services are managed by the Palestinian Authority. As a result, as detailed below, there exists a grey authority gap between the basin and regional administrations.

Further exploration of the topic of the authority gap reveals that Israel manages the Yarkon River and groundwater basins, while the Palestinian Authority provides water and wastewater services to nearby communities. This allocation of responsibilities in managing water resources among basin and regional administrations may lead to challenges in decision-making and coordination, as diverse entities hold sway over different facets of water management.

Effective management of water resources in the region requires the concerted effort of all relevant stakeholders. Collaborative and cooperative efforts among these parties will pave the way for successful water management and address any issues of authority. To tackle the current water-related challenges faced by both Israel and Palestinian villages, it is imperative to establish mechanisms that bridge the gap between the two parties. These mechanisms should promote enhanced coordination, information sharing, and collaborative decision-making.

Addressing the authority gap can greatly enhance the effective management of the Yarkon River and groundwater basins, leading to equitable distribution of water resources, improved water quality, and better collaboration among all parties involved in water and wastewater services.

To optimize water management in the region, both the basin and regional administrations must collaborate and seek mutual understanding. This will bridge any authority discrepancies and foster a more cohesive and efficient approach to water management.

The location of infrastructure in a basin significantly determines the hydrologic risks related to climate change. Floodplains are naturally susceptible to floods, while mudflows and torrents are common at headwaters (Benito and Vázquez-Tarrío, 2022). This location even impacts the type of investment or solutions for the problems. For example, runoff river-type hydropower plants are established at steep slopes of the headwaters or transition zone. In contrast, reservoir-type power plants are generally located at the lower altitudes of basins. Additionally, grey solutions are typically suitable for lower areas, while nature-based solutions are more appropriate for upper watershed sections.

Changes in precipitation and temperature patterns pose potential risks to the climate, affecting both low (droughts) and high flows (floods, mudflows, etc.) in Mediterranean region (Mendes et al., 2022; Tramblay et al., 2020). Additionally, fluctuations in temperature and evapotranspiration can reduce agricultural water availability (Kourgialas, 2021). Our C-VRA process involved reviewing scientific literature and news portals to identify risks and hazards in the region. We also explored options for adapting, with a focus on Nature-based Solutions (NBS).

Previous studies on climate vulnerability and risk assessment have focused on local (Derbile, Bonye, and Yiridomoh 2022), regional (Cains and Henshel 2019; Doorga et al. 2023), or country scales, but have neglected the important basin scale, which is the foundation of the terrestrial hydrologic cycle and the source of water-related disasters such as floods and landslides. In this C-VRA, we emphasize the importance of the basin scale and the methodology for connectivity between scales.

Climate change is causing rising temperatures and changes in precipitation patterns in the Mediterranean region. Climate-induced vulnerabilities will likely worsen especially in the low income and problematic parts of it. West Bank of Palestine is one of them.

In this study we performed a thorough multiscale C-VRA that combines local land and water management data with climate projections and relevant literature, utilizing the well-established Jaspers Guidance methodology to identify the region's vulnerability and future risks. Our C-VRA utilized a multiple-scale (Basin/Region/Corporate) evaluation (Figure 1) to identify a broad range of hydrologic risks. We focused on the corporate, dairy factory and associated wastewater treatment plant (WWTP) that requires C-VRA during both its construction and operational phases, which could last for decades.

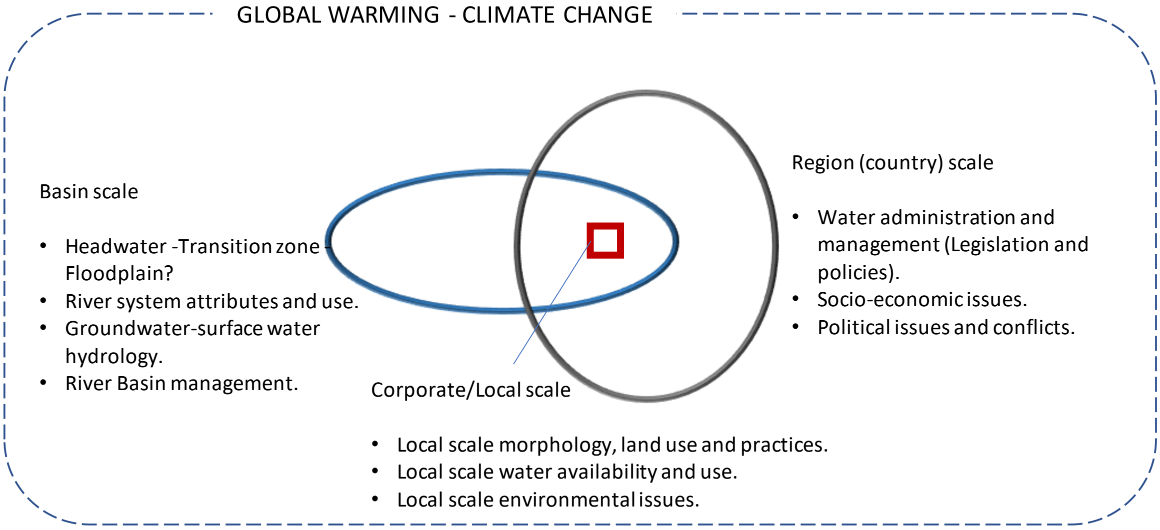


Figure 1. Our multiscale C-VRA assessment approach for corporate scale investments.

The analysis was performed for the study area in Nabi Saleh village, on the West Bank of Palestine, representing the regional scale that controls policies and regulations. The corporate investment is planned at the headwater of the Yarkon River, which drains into the Mediterranean in Tel Aviv, representing the basin scale influenced by global climate change.

## 2. Materials and Methods

### 2.1 Study area

The proposed site for the Dairy Factory and Wastewater Treatment Plant is in Nabi Saleh, a Palestinian village located north of Ramallah City in the West Bank region. The neighboring villages include Sudan Village to the east, Kafr' Ein to the north, Bani Zeid Village to the west, and Deir Nidham Village to the south. Nabi Salih is situated at an altitude of 579 meters above sea level, and experiences an average annual rainfall of 590 mm, with an average temperature of 17 °C and humidity of 61%. The village had a population of 502 inhabitants in 2007, living in around 100 houses according to recent reports by The Applied Research Institute - Jerusalem in 2012.

Land use in and around the Village is mainly olive orchards, arable lands, and forest areas. The olive subsector comprises 15 percent of the total agricultural income, mitigating the impact of unemployment and poverty on Palestinian society by providing 3 to 4 million seasonal workdays per year and supporting 100,000 Palestinian families (Hanieh, Karaeen, and Hasan 2020).

Nabi Saleh is located upstream of the Yarkon River on a ridge. The River is a sizeable fluvial network east to west, flowing into the Mediterranean Sea in Tel Aviv (Figure 2). The area of the Yarkon River watershed is 1794.05 km2. The village is over the Yarkon-Tannınm (YT) groundwater basin. The YT basin is between the coastal and eastern aquifers and produces around 362 Mm3 water. The flow direction is east to west, towards the coastal aquifers. Eighty percent of the recharge area of this basin is located within the West Bank, whereas 80% of the storage area is located within Israeli borders. Israelis exploit the aquifers of this basin using 300 deep groundwater wells to the west of the Green Line and deep wells within the West Bank boundary. Palestinians who have access to pre-existing wells and springs may draw on them but are, as opposed to Israeli settlements, forbidden to drill new wells (Jones 2014).

The dairy factor investment is located on the intersection of the headwater and transition zones of the Yarkon River Basin faced towards west (Figure 2). The river system is composed of two main tributaries draining into the sea near Tel Aviv.

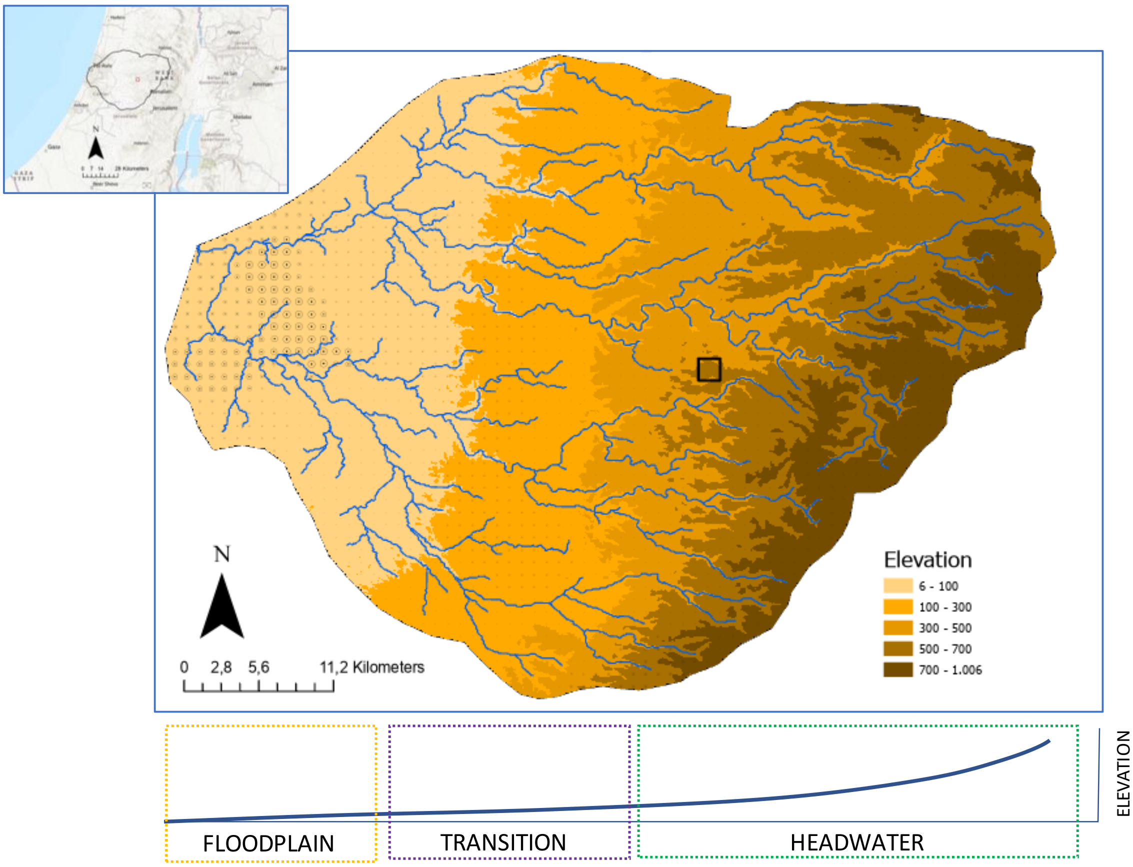


Figure 2. The river network of the Yarkon River basin. The site is given as a black square (Alos Palsar DEM data)

The Western Basin produces approximately 360 mcm annually and contains the highest quality water. The North-eastern Basin produces around 145 Mm3 annually, also of high quality and with the most productive springs in Israel. The Eastern Basin produces approximately 170 Mm3 annually, with the largest springs issuing within the West Bank (UNEP, 2020).

The Yarkon River is a polluted water body, and the Israeli authorities withdraw a large part of the water resources for agriculture and other uses. The River is divided into three parts in terms of water quality. From the Nofarim Pool, near Rosh Ha'ayin, to Nahal Kana, near the town of Hod Hasharon, the eastern section is now fed by natural water sources. The central section is fed by treated sewage from Nahal Kaneh to the Seven Mills site in Tel Aviv's Ganei Yehoshua park, near the Ayalon Highway. However, in the western section, which runs from Seven Mills to the sea, a large amount of seawater still enters during flood tides. The Water Authority of the Yarkon River and the Israeli government are recently working on rehabilitation plans for the River.

While the floodplain of the Yarkon River has pollution and flooding issues to some extent, the headwater portion of the basin seems to be less problematic thanks to the lower population density, human interruptions, and karstic geology. In fast-growing parts of the Basin, problems may arise in time. For example, Anker et al. (2019) suggest that the urban growth in the Shiloh Basin (the north part of the Yarkon basin) may cause more flash floods and less groundwater recharge.

### 2.2 Trend analysis of major climatic parameters

The Mann-Kendall Trend Test analyzes the difference in signs between earlier and later data points to reveal statistically significant trends. If a trend is present, the sign values will increase or decrease constantly. The data values are evaluated as an ordered time series. Each data value is compared to all subsequent data values (Khaled, H., 2008).

### 2.3 Vulnerability and risk assessment

We used the following technical resources to establish our methodology:

- Implementing the EBRD Green Economy Transition. Technical (GET) Guide for Consultants: Reporting on projects performance against the Green Economy Transition Approach by Climate Policy Initiative (EBRD/CPI 2018). The GET provides a 4 step approach to evaluate the potential of projects for funding eligibility in the context of GET.
- JASPERS Guidance Note. The Basics of Climate Change Adaptation, Vulnerability and Risk Assessment.
- A Framework and Principles for Climate Resilience Metrics in Financing Operations.
- The World Bank Climate Data Portal[2] has been used extensively during climate and climate projections data analysis.
- Task Force on Climate-Related Financial Disclosures Report (EBRD 2020)

The GIS tools we used were QGIS and ArcGIS Pro with the following data sources and layers;

- Alos Palsar DEM with 12 m resolution[3].
- Copernicus global climate data[4] for Tel-Aviv and An Nabi Salih. The downloaded and used parameters were annual average temperature and precipitation series.
- IPCC AR6 (IPCC 2021) CMIP6 ensemble model projections of SSP1-1.9, SSP2-4.5, and SSP5-8.5 for Tel-Aviv and An Nabi Salih
- Gridded Population of the World, Version 4 (GPWv4): Population Density, Revision 11. NASA Socioeconomic Data and Applications Center (SEDAC)[5].

The methodology of this assessment relies on Vulnerability and Risk (V&R) analyses based on the Jaspers Guidance Note (2017) and catchment/corporate scale water quality and quantity assessments. The below hazards identified by the (EBRD 2020) have been considered (Table 1).

Table 1. Hazards and data sources to evaluate identified by the EBRD (2020).

| Category | Chronic or acute | PC hazard | Data source |
|---|---|---|---|
| *Temperature related* | Chronic | Increasing mean temperatures | Swiss Re – CatNet |
| | Acute | Extreme heat event | World Bank – Climate Change Knowledge Portal (CCKP) |
| | | Wildfires | Swiss Re – CatNet |
| *Wind related* | Acute | Extreme wind event | Swiss Re – CatNet |
| *Water related* | Chronic | Increasing water stress | WRI – Aqueduct |
| | | Sea-level rise | Climate Central – Coastal Risk Screening Tool |

[2] https://climateknowledgeportal.worldbank.org/
[3] https://asf.alaska.edu/data-sets/sar-data-sets/alos-palsar/
[4] https://www.copernicus.eu/en
[5] https://sedac.ciesin.columbia.edu/

| | | | |
|---|---|---|---|
| | Acute | Drought | World Bank – Climate Change Knowledge Portal (CCKP) |
| | | Flood | Swiss Re – CatNet |
| *Solid mass related* | Chronic | Erosion | Swiss Re – CatNet |
| | Acute | Extreme mass movement | Swiss Re – CatNet |

We used global climatological data downloaded from the Copernicus program of the EU and the climate projections for the three 20-year periods from World Bank Climate Change Portal.

Climate projection data used by World bank Data Portal is modeled data, derived from the Coupled Model Inter-comparison Projects (CMIP). CMIP data is the foundational data used in the IPCC Assessment Reports; CMIP6 supports the IPPC's Sixth Assessment Report released in August 2021. Projection data is presented at a spatial resolution, 1º x 1º (100km x 100km).

In CMIP6, future climate scenarios are presented through five SSPs: SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5, which present different societal development pathways The total radiative forcing level by 2100 (the cumulative measure of GHG emissions from all sources) is presented at the end of each pathway (i.e., -1.9, -2.6, -4.5, 7.0, 8.5, etc.). The explanations of SSPs used are as follows:

SSP1-1.9 is the most optimistic scenario and global emissions are cut to net-zero around 2050. This is the only scenario that aligns with the Paris Accord of keeping global warming to 1.5°C by the end of the century. SSP2-4.5 presents a 'middle of the road' scenario in which emissions remain around current levels, before starting to fall around mid-century, but do not reach net-zero by 2100. SSP5-8.5 presents a future based on an intensified exploitation of fossil fuel resources where global markets are increasingly integrated leading to innovations and technological progress.

The assessments on climate hazards have been performed based on scientific literature and expert judgment. In addition, the Mann-Kendall test has been used to evaluate long-term trends in average annual temperature and precipitation data. The results of the test provided a basis for the risk analysis.

The site involves the construction of a dairy factory and its wastewater treatment plant, which involves permanent structures with a life span of at least 50 years. The projections for the future climate in the region have been assessed for anomalies for a future term until 2100 by considering the "central scenario" about the "ensemble" outcomes presented in the World Bank Climate Knowledge Portal (as per the IPCC framework).

The vulnerability and risk assessments have been done based on JASPERS' (Joint Assistance in Supporting Projects in European Regions) methodology. In the JASPERS Guidance, it is essential to understand the probability of the risk occurring (how likely it is to happen) and the severity of the impact if it did occur (the consequence of the risk).

The Guidance defines five categories in assessing the Probability of "Hazards" affecting the construction site. These are given on a scale with the lowest probability defined as "rare" that is "highly unlikely to occur" or "5% chance of occurring". The highest probability is defined as "almost certain," which means "incident is very likely to occur, possibly several times" or "95% chance of occurring".

Like probability assessment, the severity of the incidents is evaluated in 5 categories. The lowest severity class is "insignificant," meaning minimal impact that can be mitigated through regular activity. While the highest severity category is defined as "catastrophic," meaning disaster with the potential to lead to shut down or collapse of the asset/network, causing significant harm and widespread, long-term impacts.

The significance level of each potential risk is determined through a combination of the two factors: the "severity" and "probability" of each hazard occurring. The significant risks are then plotted on a risk matrix to identify the most significant risks and those where future action is needed in adaptation measures.

## 3. Results

### 3.1 Identification of preliminary priority vulnerabilities

The climate change vulnerabilities of the region have been presented and discussed in all sectors identified as vulnerable, including agriculture, water, waste, and wastewater. Our starting point to identify potential vulnerabilities were the National Communication (NC) report of the Palestine where local stakeholders have determined and ranked the vulnerabilities in West Bank as follows (Palestine NC, 2016):

Agriculture - Agricultural production is sensitive to climate change-induced variability and uncertainties in climate parameters. The decrease in precipitation and increase in ET will affect irrigation water demand and availability in the coming decades. Droughts may also increase in frequency and severity.

Health - The changes in temperature, humidity, and rainfall directly influence the likelihood of water-borne, foodborne, and vector-borne disease transmission as well as disease. In most cases, the wastewater is discharged to the streams without treatment. The surface and groundwater quality can deteriorate in some periods or seasons with decreasing streamflow.

Ecosystems and Habitats - The West Bank region of Palestine is located on the ridges between the Sheriyah River and the Mediterranean Sea. It is a transition region between semi-arid climate and Mediterranean. The micro (local) and regional variations in climate conditions enrich the country's biodiversity. There is a risk of pests, diseases, and mortality at peripheral and marginal ecosystem patches in solid shifts caused by climate change.

Waste and Wastewater management- Waste and wastewater management are sensitive to temperatures, rainfall patterns, wind speeds, and storms. According to the NC of Palestine, around 1,710 tons/day of residential solid waste is generated in the West Bank. The average daily residential solid waste generated per dwelling is 3.9 kg/day at an average rate of 0.7 kg/capita/day. The number has risen to 0.81 kg/capita/day (World Bank 2018).

Water Ground and water supply - The water resources in the West Bank are limited. Reduced rainfall may result in lower groundwater recharge, and higher temperatures may increase water demand and the amount of water discharged from aquifers.

We identified and focused on the below vulnerabilities based on the already reported information summarized above.
i. Water security and safety
ii. Groundwater recharge
iii. Drought
iv. Floods
v. Land degradation and erosion
vi. Decreasing agricultural production
vii. Wildlife and biodiversity

The priority vulnerabilities and climate resilience are assessed through the four steps defined below.

### 3.2 The context of vulnerability to climate change (step 1)

The significant environmental effects of climate change on the region are decreases in precipitation (with significant seasonal variation) and significant warming. The scientific results suggest that precipitation rates are likely to fall in the eastern Mediterranean –20% to 60% decrease in winter precipitation for 2071-2100 – with an increased risk of summer drought (Bağçaci et al. 2021; UNDP, 2009). The climate-induced hazards to decreased precipitation and increased temperatures may emerge as water insecurity and food insecurity.

In this context, climate vulnerability of the project area is assessed through various indicators, including extreme temperature occurrences, average rainfall increase, average rainfall decrease, extreme rainfall events, water scarcity, droughts, flooding, soil erosion, and wildfires.

*Extreme temperature occurrences (including heat waves)*- This is a medium-level risk for the construction of the Dairy Factory and the region since extreme temperatures are not directly affected and the region is not overpopulated. The increase in mean, min, and max temperatures projected for the region may cause heatwaves or heat island effects for the urban areas like Tel Aviv or similar populated city centers but not small towns and villages characterize the Nabi Saleh and the larger West Bank.

We also consider that the site does not add to the vulnerability of heatwaves or similar hazards since it covers a tiny portion of the Village and the Basin. Besides, it is not anticipated to cause any loss of agricultural land or contribute to imperviousness.

*Rainfall decrease* - This is a medium-level sensitivity issue because annual average rainfall decrease may affect the flow pattern and extend the summer season low flow period or cause zero flow conditions. The precipitation and semi-humid conditions variability remains as a threat for agricultural activities. The agriculture in the region is characterized by rain-fed cropping. Some improved cropping techniques can mitigate the decrease in precipitation.

*Extreme rainfall events* - The area where the Dairy Factory and Wastewater Treatment Plant will be built is on a ridge between low-degree streams (small upland streams). Therefore, we are not considering any direct hydrologic risk at the corporate scale since the contributing areas of the small streams are very small. The small catchments in the region may generate flash floods or mudflow that may cause damage on the roads or hydraulic channel structures (bridges, drainage ditches, etc.). However, the construction site or the constructed installations would not be affected directly since they are located high enough over the stream channel. Since this construction site is not expected to cause a significant rate or level of land cover changes, we are not presuming an effect the large Yarkon River Basin on flow conditions.

*Water scarcity* - Water scarcity is a medium-level vulnerability in corporate and the river basin scales. The increasing temperature trend will cause increases in ET in the coming decades. Therefore, the water resources have to be managed sustainably. However, since the region is not drawing population, we are not expecting strong stress on the water resources if appropriately managed.

*Droughts* - The droughts can be effective in all scales through decreased low flows and extended dry periods. The political conflicts and weak water resources capacities may exacerbate the risk. The only positive point is the groundwater resources that are more resilient to drought impacts compared to surface resources.

*Soil erosion and desertification* - The risks related to soil erosion may increase or decrease in the coming decades based on the management of land resources and especially agriculture. The erosion poses a low level of risk for the Project. An improved agriculture policy and management would help compensate for risks and vulnerabilities caused by erosion and desertification.

### 3.3 The construction of the dairy factory activities to address climate vulnerability (step 2)

The Dairy Factory and the WWTP construction involves hard components (buildings mostly concrete and the roads) and some vegetation for the surrounding landscape. Therefore, the construction is expected to add around 10 hectares (roofs, roads, other pavement etc.) to the imperviousness of the area and the basin. This can be considered to affect surface runoff conditions to stimulate floods but since the added impervious area is negligible as compared to the 1795.04 km2 Yarkon River Basin and the parent material is karstic (very permeable), we do not expect any detectable negative impact on flood frequency or severity of the Yarkon river and its tributaries. Furthermore, the Nabi Saleh is at the very upper part of the basin that is far away from the floodplain of the River.

### 3.4 Linkage between the construction of the dairy factory activities and the vulnerabilities (step 3)

The major climate change induced resource that is required for the factory is water. The water used will be subject to irrigation after treatment.

The projected temperature increase-precipitation decrease in the region will have implications on the water resources. There is a strong seasonality in the precipitation pattern in the area, a typical Mediterranean feature. There is no or very rare snow but a good amount of rainfall in the winter season. The summer season precipitation is very low and a water deficit in summer months is inevitable. However, the parent material and soils are permeable to recharge groundwater. The summer period water deficit and stress can be mitigated through groundwater aquifers.

The linkage between the Dairy Factory activities and the vulnerabilities can be explained in two components.

The dairy factory's water safety and security requirement is an issue correlated with the water stress in the region. The amount of water required for the Dairy Factory is 120 m3/day that is 44 000 m3/yr. It is around 0.22 percent (= 0.044 / 20 Mm3/yr) of the available groundwater resources in the West Bank. This amount does not add any significant burden to the water resources in the region. However, there have been issues between Palestinian villages and Israeli settlements on use of wells and springs in recent years. Besides, the Palestinian population's low level of water use may increase in time. These two issues together with the droughts may cause more stress on the water resources.

The second component is the use of treated wastewater in irrigation. A large part of the water used in the factory will be given back to be used in irrigation. This practice does not represent an innovative approach but is a good practice that can be followed in the future investments. Suppose the West Bank region prefers to follow a transition to a clean and sustainable economy from an agriculture based on. In that case, the Dairy factory and WWTP investment can be a good example of sustainable water and wastewater management.

We also presume that the investments such as the Dairy Company that support economic growth will enhance the resiliency of settlements in the West Bank region through employment and technology transfer and improvement of the agriculture/livestock sector.

**3.5 GET adaptation finance (step 4)**

The construction work of a dairy factory and the joint wastewater treatment plant may add to the water scarcity in the region but on the other hand it may have positive impacts on climate change resiliency. It can be a good example of wastewater reuse in agriculture. The Palestine water authority has plans to benefit wastewater reuse to cope with the future water scarcity risk and the WWTP is an initiative for that. The wastewater reuse has a significant potential to avoid freshwater use. Both the water management system and the agriculture sector will benefit from this initiative.

**3.6 Assessment of climate change**

**3.6.1. Historical trends of climate parameters**

The Nabi Salah Village is 14.5 km north of Ramallah on the West Bank. The Village has a warm Mediterranean climate with mild winters and warm summers. The hottest months are July and August with zero or very low precipitation. The region also experiences significant seasonal variation (0 to 100 mm per month) in monthly rainfall. The Nabi Saleh village has a relatively humid climate compared to other locations of the West Bank and is classified as subhumid. In Ramallah, where the closest weather station is located, the summers are long, warm, arid, and clear, and the winters are cold and mostly clear. Over the year, the temperature typically varies from 5°C to 29°C and is rarely below 1°C or above 32°C. The rainless period of the year lasts for 6.5 months, from April 10 to October 24. The month with the least rain in Ramallah is July, with an average rainfall of 0 millimeters (Figure 3).

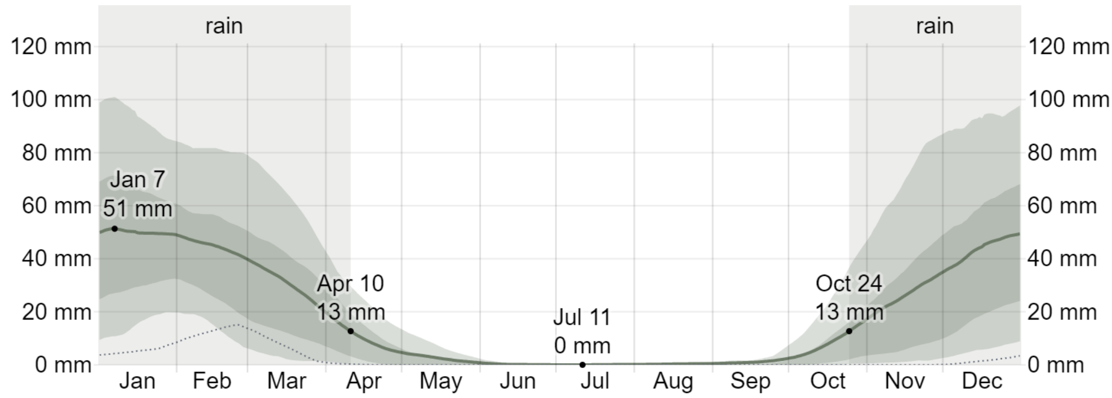


Figure 3. Variation of monthly average precipitation in the region (weatherspark.com).

Ramallah's long-term mean annual precipitation data indicates that there has been a decrease in long term precipitation data for the last century. However, the Mann Kendal trend test (S=-2.59, p=0.05) did not detect any statistically significant positive or negative trend in the annual precipitation time series.

The Mann Kendal trend test results revealed that there is a statistically significant increasing trend in annual mean (S=7.04, p=0.05) (Figure 4), maximum (S=6.20, p=0.05) and minimum temperature (S=7.48, p=0.05) series.

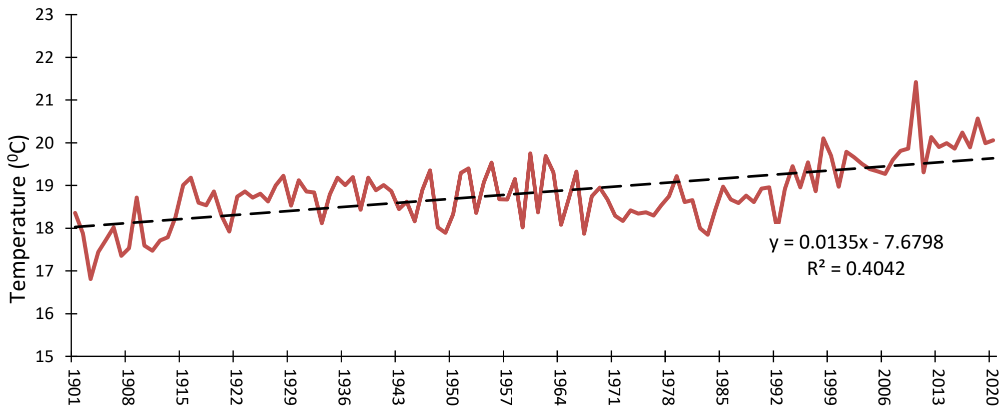


Figure 4. Mean annual temperature record of the region for the period of 1900-2020.

Consequently, the historical precipitation series had a visible decreasing trendline and 2-3 years long dry periods, but the decrease was not significant statistically. On the other hand, all three-temperature series (mean, max, and min) had a statistically significant upward trend.

### 3.6.2. Future projections

In this part, we provided our results on climate parameters that affect floods, extreme temperatures, and drought since these issues are relevant risks that may potentially affect the investment. The model predictions of IPCC scenarios have been assessed for;

i. Mean, minimum, and maximum annual temperature
ii. Mean annual precipitation
iii. Maximum daily rainfall (Pmax)
iv. Maximum daily rainfall with 25 yrs return period (Pmax- 25RL)
v. Probability of heatwave (P-HW)
vi. Severe drought likelihood (SDL)

The characteristics of future climate in the region have been assessed for anomalies in the near-future (2020-2039), middle-future (2040-2059), and far-future (2060-2079) compared to the 1995-2014 reference period by considering the "SSP1-1.9 – good case", "SSP2-4.5 – central case" and "SSP5-8.5 – worst case" scenarios" in reference to the "multi-model ensemble" outcomes presented in the World Bank climate knowledge portal[6] (as per the IPCC AR6 framework), which are used as the main reference to the values presented in Table 2

Table 2. The projected values and changes (anomaly) in significant climate parameters for West Bank.

| | | | *SSP1-1.9* | | | *SSP2-4.5* | | | *SSP5-8.5* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Climate Parameter** | | *2010* | *2030* | *2050* | *2070* | *2030* | *2050* | *2070* | *2030* | *2050* | *2070* |
| **Pmax** | M | 12.46 | 13.84 | 12.69 | 13.72 | 12.47 | 12.41 | 12.09 | 11.95 | 12.33 | 11.93 |
| | LB | 6.21 | 6.61 | 5.68 | 7.01 | 6.07 | 5.75 | 5.70 | 5.76 | 5.93 | 6.09 |
| | UB | 21.77 | 22.99 | 21.30 | 27.16 | 22.42 | 22.02 | 21.41 | 24.04 | 25.13 | 23.34 |
| **RC-5** | M | 26.18 | 27.68 | 28.96 | 27.71 | 25.03 | 25.27 | 24.53 | 24.50 | 26.48 | 23.98 |
| | LB | 12.80 | 10.83 | 11.13 | 12.45 | 12.35 | 12.74 | 11.36 | 11.97 | 12.83 | 12.15 |
| | UB | 47.66 | 45.67 | 45.00 | 52.45 | 46.38 | 48.91 | 48.75 | 56.25 | 50.03 | 49.54 |
| **Prec.** | M | 151.50 | 152.51 | 150.56 | 147.63 | 141.17 | 134.72 | 134.02 | 135.73 | 140.44 | 121.49 |
| | LB | 81.18 | 73.71 | 64.51 | 76.40 | 75.66 | 62.51 | 63.81 | 64.02 | 67.26 | 58.16 |
| | UB | 274.10 | 263.39 | 263.86 | 271.33 | 252.82 | 264.41 | 258.89 | 276.20 | 269.33 | 247.80 |
| **D-20** | M | 0.07 | 0 | 0.07 | 0.15 | 0 | 0.01 | 0.01 | 0 | 0 | 0 |
| | LB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[6] https://climateknowledgeportal.worldbank.org/

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | UB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Tmean (°C)** | M | 20.75 | 21.43 | 21.65 | 21.55 | 21.49 | 22.17 | 22.64 | 21.57 | 22.67 | 23.89 |
| | LB | 20.14 | 20.40 | 20.69 | 20.34 | 20.83 | 21.46 | 21.91 | 20.93 | 21.86 | 22.89 |
| | UB | 21.34 | 21.88 | 22.26 | 22.53 | 22.10 | 22.87 | 23.55 | 22.16 | 23.41 | 24.95 |
| **Tmax>35 (days)** | M | 68.68 | 84.44 | 86.55 | 86.42 | 84.35 | 101.39 | 109.26 | 86.80 | 109.55 | 127.60 |
| | LB | 39.06 | 51.02 | 51.26 | 52.67 | 52.81 | 70.22 | 76.51 | 45.27 | 70.02 | 90.85 |
| | UB | 97.36 | 111.74 | 112.41 | 118.06 | 112.33 | 121.07 | 128.06 | 111.77 | 129.23 | 145.55 |
| **Tmin<0** | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | UB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Pmax: Average largest 1 day precipitation, RC-5: Average largest 5 day cumulative rainfall, Prec: Precipitation, D-20: Days with precipitation over 20 mm, Tmean: Mean annual temperature, Tmax>35: Number of very hot days, Tmin<0: Number of frost days LB: Lower bound, UP: Upper bound, M: median.*

As seen from the table, precipitation parameters have all decreasing trends while temperature parameters are projected to increase significantly.

### 3.7. Vulnerabilities and risks

The vulnerability of the site involves construction of a dairy factory and its wastewater treatment plant is a combination of two aspects: 1) How sensitive are the site's components to climate hazards (sensitivity) and 2) The probability of these hazards occurring at the construction site location now and in the future (exposure).

Potential climate hazards considered in the vulnerability assessment of the construction of the Dairy Factory are given in Table 3.

Table 3. Potential climate hazards that are considered in the vulnerability assessment of Nabi Saleh and the watershed system it is located. Sensitivity is described as low (L), medium (M), and high (H). Exposure is defined as existing (X) or not existing (-)

| Climate Induced hazard | Description | Corporate Sensitivity | Watershed Sensitivity | Exposure | |
|---|---|---|---|---|---|
| | | | | **Current** | **Future** |
| **Extreme temperature occurrences (including heat waves)** | Changes in the frequency and intensity of periods of high temperatures, including heat waves | L | M | X | X |
| **Average rainfall decrease** | Trends over time of less precipitation | M | H | - | X |
| **Extreme rainfall events** | Changes in the frequency and intensity of periods of intense precipitation | L | M | X | X |
| **Water scarcity** | The relative lack of water | H | H | X | X |
| **Droughts** | Prolonged periods of abnormally low rainfall, leading to shortages of water | M | H | X | X |
| **Flooding** | Flooding of the channel | L | M | X | X |
| **Torrential flows** | Instantaneous flows caused by intense rainfall | L | M | X | X |
| **Landslides and debris flow** | A mass of material that has slipped downhill by gravity, often assisted by water when the material is saturated. | L | M | X | X |

| | | | | | |
|---|---|---|---|---|---|
| **Soil erosion** | The process of removal and transport of soil and rock by weathering, mass wasting, and transport by surface runofff, streams, and wind. | L | M | X | X |
| **Soil salinity** | Increase in the salt content in the soil | L | M | X | X |
| **Average wind speed** | Changes in average wind speeds over time | L | L | - | - |
| **Maximum wind speed** | Increases in the maximum force of gusts of wind | L | L | - | - |
| **Storms** | Changes in the location of storms, their frequency and intensity | L | L | - | - |
| **Humidity** | Changes in the amount of water vapour in the atmosphere | L | L | - | - |
| **Dust Storms** | A storm of strong winds and dust-filled air | L | L | - | - |
| **Wild fire** | Unwanted, unplanned and damaging fires such as forest fires and fires of shrub and grasslands | L | L | - | - |
| **Air quality** | Increased concentrations of pollutants locally, including incidents such as smog | L | L | - | - |
| **Urban heat island effect** | Cities or metropolitan areas which are significantly warmer than the surrounding rural area, caused by higher absorption of solar energy by materials in the urban area, such as asphalt | L | M | X | X |
| **Growing season length** | Changes in the seasons during which certain flora species grow, either longer or shorter | L | L | - | - |
| **Solar radiation** | The energy emitted by the sun from a nuclear fusion reaction that creates electromagnetic energy | L | L | - | - |
| **Cold spells** | Prolonged periods of extremely cold temperatures | L | L | - | - |

| | | | | | |
|---|---|---|---|---|---|
| **Freeze-thaw damage** | Repeated freezing and thawing may cause stress damage to structure such as concrete | L | L | - | - |
| **Hail** | A type of precipitation formed when drops of water freeze together in the cold upper regions of thunderstorm clouds | L | L | - | - |

Nabi Saleh is prone to extreme temperature occurrences including heatwaves since the summer temperatures reach over 40ºC. Besides, mean, minimum, and maximum temperatures are projected to increase in the region. The increasing temperatures will increase the ET and reduce the amount of soil moisture and streamflow to increase demand for irrigation. The agricultural areas in the region can be affected, but this can be compensated with climate-friendly agriculture techniques to some extent. The exposure of the construction area to extreme temperatures is an issue during the construction phase, but the facilities are not sensitive to high summer temperatures. The region's sensitivity and the larger watershed are defined as "medium." In contrast, the sensitivity of the corporate is "low" because it is a closed dwelling and can be cooled with air condition. According to historical precipitation records, there is no statistically significant increasing or decreasing trend detected for West Bank, but the projections reveal a decrease for the next decades. We concluded that there is enough water in the region (also watershed), but a rainfall decrease is projected for the next decades. The decrease in precipitation and increased temperatures may exacerbate the strength of the summer water deficit in the region. Therefore, we considered the future precipitation decrease as a "high sensitivity" for the watershed and the region but medium for the corporate. The primary water resources in the region are groundwater-based, so the water required for the corporate is considered to be more stable, not directly affected by droughts and rainfall decreases.

The central scenarios resulted in no or very slight changes in extreme rainfall events for the next decades. Also, considering that the construction of the Dairy Factory is on a ridge, we are not considering any flooding or torrent issues that can affect the area. The site involves a minor land area to become impervious, but it is negligible compared to the catchment area. Therefore, we are not considering any adverse effects to the downstream.

Drought may negatively impact on the construction of the Dairy Factory by decreasing the streamflow and groundwater recharge to cause stress on water availability. We presume that the water needed for the corporate will be provided mainly from groundwater resources.

The West Bank territory is exposed to soil erosion and desertification because of anthropogenic activities, including agriculture. Sustainable agricultural practices should be developed and used in the whole region.

### 3.8. Climate risks matrix

"Risk" is different than vulnerabilities. It considers the probability and severity of climate risks affecting the project while "vulnerability" considers which climate hazards the project is most vulnerable to because of its components and location.

While we gave and discussed the vulnerabilities above the whole set of risks has been given and assessed in Table 4 below. We evaluate the risks for current and future conditions separately.

The current values have been calculated based on historical climatological data from the Copernicus database. The rainfall decrease, temperature increase, water scarcity, and drought have been evaluated:
Rainfall decrease – Current

Table 4. The whole set of potential risks for the Project. The risks that have probability or severity level equal to three or more have been indicated with orange color

| **Climate Induced hazard** | **Description** | **Probability** | | **Severity** | |
|---|---|---|---|---|---|
| | | **Current** | **Future** | **Current** | **Future** |
| Extreme temperature occurrences (including heat waves) | Changes in the frequency and intensity of periods of high temperatures, including heat waves | 2 | 2 | 2 | 2 |
| Average rainfall increase | Trends over time of more precipitation | 1 | 1 | 1 | 1 |
| Average rainfall decrease | Trends over time of less precipitation | 2 | 3 | 2 | 3 |
| Extreme rainfall events | Changes in the frequency and intensity of periods of intense precipitation | 2 | 2 | 2 | 2 |
| Water scarcity | The relative lack of water | 2 | 3 | 2 | 4 |
| Drought | Prolonged periods of abnormally low rainfall, leading to shortages of water | 2 | 3 | 2 | 4 |
| Flooding | Flooding of the channel | 2 | 2 | 2 | 2 |
| Torrential flows | Instantaneous flows caused by intense rainfall | 2 | 2 | 2 | 2 |
| Landslides and debris flow | A mass of material that has slipped downhill by gravity, often assisted by water when the material is saturated. | 1 | 1 | 1 | 1 |
| Soil erosion | The process of removal and transport of soil and rock by weathering, mass wasting, and transport by surface runofff, streams, and wind. | 2 | 2 | 2 | 2 |
| Soil salinity | Increase in the salt content in the soil | 2 | 2 | 2 | 2 |
| Average wind speed | Changes in average wind speeds over time | 1 | 1 | 1 | 1 |
| Maximum wind speed | Increases in the maximum force of gusts of wind | 1 | 1 | 1 | 1 |
| Storms | Changes in the location of storms, their frequency and intensity | 1 | 1 | 1 | 1 |
| Humidity | Changes in the amount of water vapour in the atmosphere | 1 | 1 | 1 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| Dust Storms | A storm of strong winds and dust-filled air | 2 | 2 | 2 | 2 |
| Wild fire | Unwanted, unplanned and damaging fires such as forest fires and fires of shrub and grasslands | 1 | 2 | 1 | 2 |
| Air quality | Increased concentrations of pollutants locally, including incidents such as smog | 1 | 1 | 1 | 1 |
| Urban heat island effect | Cities or metropolitan areas which are significantly warmer than the surrounding rural area, caused by higher absorption of solar energy by materials in the urban area, such as asphalt | 1 | 1 | 1 | 1 |
| Growing season length | Changes in the seasons during which certain flora species grow, either longer or shorter | 1 | 1 | 1 | 1 |
| Solar radiation | The energy emitted by the sun from a nuclear fusion reaction that creates electromagnetic energy | 1 | 1 | 1 | 1 |
| Cold spells | Prolonged periods of extremely cold temperatures | 1 | 1 | 1 | 1 |
| Freeze-thaw damage | Repeated freezing and thawing may cause stress damage to structure such as concrete | 1 | 1 | 1 | 1 |
| Hail | A type of precipitation formed when drops of water freeze together in the cold upper regions of thunderstorm clouds | 1 | 1 | 1 | 1 |

The risks given above have been filtered for the significant ones in Table 5-6.

The severity and probability of each potential hazard are occurring, and the significance level of each potential risk has been determined by combining the two factors. Risks have been plotted on a risk matrix to identify the most significant risks and those where future action is needed in terms of adaptation measures.

The risk matrix for Water scarcity (WS) and drought (D).

Table 5. Risk matrix for water scarcity (WS).

| | **Probability** | **Rare** | **Unlikely** | **Probable** | **Likely** | **Almost Certain** |
|---|---|---|---|---|---|---|
| Severity | | 1 | 2 | 3 | 4 | 5 |
| Insignificant | 1 | 1 | 2 | 3 | 4 | 5 |
| Minor | 2 | 2 | 4 | 6 | 8 | 10 |
| Moderate | 3 | 3 | 6 | WS | 12 | 15 |
| Major | 4 | 4 | 8 | 12 | 16 | 20 |
| Catastrophic | 5 | 5 | 10 | 15 | 20 | 25 |

Table 6. Risk matrix for drought (D).

| | **Probability** | **Rare** | **Unlikely** | **Probable** | **Likely** | **Almost Certain** |
|---|---|---|---|---|---|---|
| Severity | | 1 | 2 | 3 | 4 | 5 |
| Insignificant | 1 | 1 | 2 | 3 | 4 | 5 |
| Minor | 2 | 2 | 4 | 6 | 8 | 10 |
| Moderate | 3 | 3 | 6 | D | 12 | 15 |
| Major | 4 | 4 | 8 | 12 | 16 | 20 |
| Catastrophic | 5 | 5 | 10 | 15 | 20 | 25 |

Our assessments identified the risks for the corporate not the watershed, because the project has an area of approximately 10 ha that is quite small to cause any change in the 1795.04 km2 Yarkon watershed. The main risks for the Dairy factory are the ones related to water availability. Water availability is affected by 2 major parameters;

I. The increase in evapotranspiration caused by the decrease in precipitation and the increase in temperatures.
II. The drought periods.

Drought is a widespread risk for almost all climate types around the globe. It may involve multiple seasonal or year below-average precipitation conditions. We estimate the future drought probability to be at the same level as today, but the severity may increase due to increased ET conditions. However, we considered it a moderate-high risk for the corporate because the water resources in the WB mainly originate from groundwater. The groundwater is much more stable than surface water resources like dams or ponds.

We had a similar assessment for water scarcity. The precipitation has a decreasing tendency while temperatures are increasing. Therefore, the water balance in the region will shift to the side of ET. This will ultimately cause a reduction in water resources. We still consider a more stable water availability due to stable groundwater resources. The government should place adequate measures to keep the groundwater table stable. The water withdrawal from the aquifers has to be monitored and controlled because there is a moderate level risk of water scarcity. The strengthening of the agriculture/livestock sectors will benefit from the factory.

### 3.9. Adaptation measures

As per international best practice and EBRD guidelines, some of the commonly used climate resiliency measures (CRM) can be categorized as structural, non-structural (eco-based), and technology driven solutions.

The wastewater treatment plant is a structural measure that enables water reuse in a scarce region.
From the climate adaptation perspective, the of the Diary Factory and the WWTP will not add further vulnerability or risk for the region but may enhance the resiliency by;

- Providing jobs for the local communities especially in agriculture sector,
- Providing technology and good example to water reuse,
- Economic benefits for the locals and the region.

These three items may enhance the agricultural and technical capacities in the region. Agricultural production is sensitive to climate change-induced variabilities and uncertainties in climate parameters. The forecast capacity of the meteorological department (PMD)[7] is limited to accurately predicting heat waves, frosts, or flash floods. The changes in rainfall pattern and temperature significantly impact planting dates, and low temperatures delay maturation and harvesting.

Irrigation water is sensitive to rainfall amount and distribution and shifts in the rainy season. Drought decreases the quantity of water that can be allocated to agriculture yet at the same time increases crops' water requirement, increasing costs of production (inclusive of electricity for pumping).

Heat and cold waves reduce productivity in cattle and poultry, cold waves reduce the amount of milk production. Sheep are sensitive to cold (newborns and small lambs). Adult sheep are sensitive to heat waves (during the fertilization period). The cost of agricultural production increases in climatic extremes; for example, due to heatwaves, there may be a requirement for more electricity for cooling in livestock barns.

## 4. Conclusions

Climate change is causing rising temperatures and decreased precipitation in the region, which is putting villages at risk due to limited water resources and reliance on weather conditions for agriculture. International agencies support agriculture in Palestine, but more technical support and funding are needed to improve the resiliency of the national systems and strengthen institutions. Climate-induced vulnerabilities will likely worsen in the future, but implementing climate-smart agriculture practices can help mitigate water scarcity. Agriculture plays a major role in the economy and welfare of the people, making it crucial to address this issue.

The West Bank region, including the village of Nabi Saleh, may experience climate change-related problems in the coming decades. Thus, the region's agriculture sector needs to adopt mechanisms such as water treatment and reuse and other approaches to ensure food security.

The temperature is rising, and precipitation is expected to decrease in the next few decades. This will lead to annual and seasonal water scarcity due to the increased difference between potential ET and precipitation. The shift in ET-precipitation balance will extend and intensify the dry summer period, leading to increased demand for irrigation. The dry summer period's duration may double within a few decades, making the region more susceptible to precipitation variations and droughts that could affect agricultural productivity.

Recent years have seen a decrease in spring and well water levels, and there is pressure on groundwater resources due to new Israeli settlements. Additionally, there is a risk that the

[7] https://www.pmd.ps/en

population of Nabi Saleh and surrounding villages may shift away from agriculture to other sectors or migrate to larger cities. To ensure sustainable agricultural production, the Palestinian authorities must address the sector's aforementioned issues. One strategy proposed by the Palestinian Water Authority is the increased use of wastewater, which has the potential to mitigate water scarcity and droughts.

In this assessment, climate-induced hazards have been identified and evaluated based on literature review, analysis of climate parameters, and expert judgment. The Project has been found to be exposed to the below risks in a medium level:

- Rainfall decrease (moderate level severity and probability)
- Water scarcity (moderate level severity and probability)
- Droughts (moderate level severity and probability)

In conclusion, Nabi Saleh is at risk of periodic (drought) and decreasing precipitation conditions and increasing temperature. One way of mitigating this can be establishing drought early warning systems. Drought is not an instantaneous event and can be forecasted through climatologic data. We checked the Palestinian existing systems and concluded that to establish an Early Warning System (EWS), some of the existing meteorological stations in Palestine must be upgraded. New sensors and accompanying equipment need to be added to the existing stations. Furthermore, Palestine needs a comprehensive drought management strategy because drought directly impacts many humans and animals and a significant portion of the environment.

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