State of Palestine

Environment Quality Authority (EQA)

Climate Technology Centre & Network (CTCN)

"Technology Roadmap for the Implementation of Climate Action Plans in Palestine"

Key Barriers Identification and Assessment Report

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Contents

Acronyms

CMWU	Coastal Municipalities Water Utility
CSA	Climate-Smart Agricultural
CTCN	Climate Technology Center and Network
EQA	Environmental Quality Authority
EU	European Union
EV	Electrical Vehicle
GHG	Greenhouse Gas
GHI	Global Horizontal Irradiance
GIZ	Germany Development Agency
GPS	Global Positioning System
ICA	Israeli Civil Administration
IEA	International Energy Agency
IEC	Israel Electric Corporation
FIT	Feed-In-Tariff
INCR	Initial National Communication Report
MOH	Ministry of Health
MOPWH	Ministry of Public Works and Housing
MW	Megawatt
NAP	National Adaptation Plan
NDC	Nationally Determined Contributions
PEC	Palestinian Energy and Environmental Research Center
PENRA	Palestinian Energy and Natural Recourse Authority
PETL	Palestinian Electricity Transmission Company Ltd.
PPA	Power Purchase Agreement
PV	Photovoltaic

PWA	Palestinian Water Authority
RO	Reverse Osmosis
SUNREF	Sustainable Use of Natural Resources and Energy Finance
SWH	Solar Water Heating
UNFCCC	United Nations Framework Convention on Climate Change
WASH	Water, Sanitation and Hygiene
WSRC	Water Sector Regulatory Council

1. Introduction

The State of Palestine is vulnerable to the impacts of climate change with severe implications for its economy and livelihood of its people. Impacts significant to the region include decreased precipitation, significant warming, more frequent and more intense extreme weather events, and rise in sea level. These could lead to greater water scarcity, decreased agricultural productivity, and saline water intrusion.

The Palestinian Government is committed to addressing these climate change vulnerabilities while at the same time, achieving its national development and policy objectives. This is reflected in its submissions to the United Nations Framework Convention on Climate Change (UNFCCC) namely, Initial National Communication Report (INCR), National Adaptation Plan (NAP) and Nationally Determined Contribution (NDC).

To achieve sustainable economic development while contributing to the efficient adaptation to climate change impacts and reduction of greenhouse gas (GHG) emissions, it is important to prioritize various adaptation and mitigation measures through the development and diffusion of climate friendly technologies. In order to identify relevant technologies which could be applied in the Palestinian context and can be implemented to achieve the country's climate change mitigation and adaptation objectives, there is a need to identify and assess the different barriers that exist hindering the development and transfer of these technologies.

This report identifies and assesses the key barriers that exist in introducing prioritized technologies in the State of Palestine. This will include the identification and assessment of barriers in terms of economic, financial, market, human skills, technical, legal and regulatory, among others.

2. Energy sector

Technologies for the energy sector have been identified based from priorities and strategic goals as described under Palestine's INCR, NAP, and NDC, in line with the National Development Plan and sectoral strategies. These were also based on inputs received during the consulting team's stakeholder engagement during the inception workshop and bilateral meetings with key ministries and agencies.

The following technologies related to energy have been prioritized by the stakeholders for further assessment and are analyzed as part of this report:

- National grid assessment and electricity grid upgrade
- Various applications of photovoltaic (PV) technologies
- Energy efficiency
- Solar water heating

2.1 National grid assessment and electricity grid upgrade

Upgrading the Palestinian grid is crucial for the efficient distribution of electricity throughout its network meeting domestic demand, as well as to diversify energy sources and develop the integration of renewable energy sources as part of its energy mix. However, the development of the grid is faced with the following barriers that needs to be addressed.

Political barrier

The main political barrier related to the introduction of this technology is access to energy generated, including from renewable energy sources, connected to the grid once it is upgraded. The upgrade of the grid will focus on a number of grids that are in Area A under the Palestinian control. These grids are not connected to the Israel side and will enable Palestine to introduce this technology. However, electricity generation will require additional land and this poses a challenge as there are only few spaces available in Area A.

Regulatory barrier

Palestine has its existing regulation (Electricity Law number 12/1995) which establishes the Palestinian Energy and Natural Resources Authority (PENRA) having the authority over the production, transfer and distribution of energy. It also states PENRA's responsibility in rural electrification, regional interconnection, energy conservation, and with focus on the rehabilitation of the existing networks. The regulation recognizes the importance of improving the national electricity grid networks. However, it does not provide concrete implementation measures on how this will be achieved.

Institutional barrier

The institutional setup of the electricity sector in Palestine is currently fragmented. For example, as described in a World Bank study in 2017[1], the West Bank has over 250 low- and medium-voltage connection points with Israel and 1 connection point with Jordan, while Gaza has 10 connection points with Israel, 3 with Egypt and 1 with the Gaza Power Plant. These represent a large number of direct

[1] Badiei, Sara; Foster, Vivien; Ewuah Ogua, Samuel Kwesi; Coma Cunill, Roger. 2017. *Securing Energy for Development in the West Bank and Gaza* : Main report (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/351061505722970487/Main-report

bilateral low and medium-voltage connection points between Palestinian distribution companies, and municipalities and village councils. There is a need to establish an institutional framework for Palestine on a national level to coordinate responsibilities of the key stakeholders which includes regulators and utilities if an integrated network is to be achieved.

Technical barrier

The current state of the power grid in Palestine generally have poor network maintenance due to several factors such as lack of capital, which led to inefficiencies in its operation and results in increased technical and non-technical electricity losses, as well as network outages and deteriorating quality of supply in some cases. This is in spite of the several rehabilitation programs that have been implemented in different regions.

For the efficient assessment and upgrading of the Palestinian grid to be achieved, technical capacities and know-how of all key stakeholders involved should be enhanced. Understanding the importance of upgrading, operating and maintaining an efficient and stable electricity network from a technological perspective will be crucial in achieving Palestine's goals for the sector.

It is also important to emphasize that upgrading the grid requires an extensive pre-assessment study and feasibility study. However, there is a lack of know-how and experience related to the methodologies required to assess the grid.

Financial barrier

The implementation of the assessment of the grid infrastructure and its upgrading requires significant financial resources. Palestine clearly has limited economic resources which entails the need for international financial support for the implementation of this technology.

2.2 Solar PV technologies

With 3,000 sunshine hours per year and Global Horizontal Irradiance (GHI) over 2,000 kilowatt-hours per meter squared, Palestine rank amongst the world's top locations for construction of solar systems[2]. Moreover, amongst the available renewable energy sources, solar energy can be produced fully independently in Palestine. However, the development of PV solar power plants faces the following barriers that need to be addressed.

Financial barrier

The worldwide trend regarding the cost of solar PV technology has seen a significant drop over the past few years. In the United States, for example, the cost of rooftop photovoltaics and utility scale solar have decreased for more than 80 percent compared to 2010[3]. Even if a decrease in solar PV technology cost can be expected in Palestine following this global trend, it will not be as significant compared to the rest of the world due to the risk perceived by investors. Palestine's political tensions with Israeli occupation increases the risk perceived by potential investors, making it a difficult environment for investment and private sector involvement. Some of the risks perceived by the private sector include significant construction delays and payment default. Palestine is already receiving international support, especially for rooftop solar systems for critical departments in hospitals, and the European Union (EU) is implementing a derisking programme, Sustainable Use of Natural Resources and Energy Finance (SUNREF). However, as Palestine has limited economic resources, it needs further international

[2] Securing Energy for Development in West Bank and Gaza, World Bank, 2017

[3] Annual Technology Baseline, NREL, 2016

financial support for the implementation of solar PV based technologies.

Political barrier

The renewable energy sector, including solar PV technologies, is still young in Palestine. The renewable energy strategy has been adopted by the Council of Ministers in 2012, and the Palestinian Renewable Energy Laws have only been promulgated in 2015. Thus, the renewable energy sector in Palestine is still on the development stage and has to be strengthened through the implementation of strong national policies and incentives for private investors. Palestine currently faces two significant challenges, including its inability to secure a Power Purchase Agreement (PPA) with a bankable off-taker, and a lack of available transmission infrastructure for power evacuation. Therefore, there is a strong need for the Palestinian Electricity Transmission Company Ltd. (PETL) who is responsible for the off-taking of power and providing transmission infrastructure in the West Bank, to become financially sustainable in order to be able to fulfill its role. PENRA set its renewable energy targets in 2012, aiming to generate 130 MW of power supply from domestic renewable resources by 2020. However, as of 2017, less than 15 percent of this target have been achieved mainly due to these two remaining challenges[4]. Although, there is recent indication from PENRA that this target will be surpassed, and may reach up to 185 MW taking into consideration current projects under implementation.

Moreover, even if PENRA and Palestinian electricity distribution companies are responsible for the electricity distribution network in Palestine, Israeli Electricity Company (IEC) controls the electricity generation and transmission in the country and has high expectations related to the stability of renewable energy to integrate it to the grid. This limits the scale of solar PV power plants that can be implemented and connected to the grid. To be able to implement grid connected large scale solar PV power plant, it is necessary for the Palestinian stakeholders to coordinate with IEC. Moreover, the absence of full control on the grid makes impossible the introduction of a feed-in-tariff (FIT) system by the Palestinian government that would work as a strong incentive for investors to invest in solar PV power plants in Palestine.

The fact that Palestinians need to obtain building permits from the Israeli authorities in area C also represents a significant barrier, as building permissions for infrastructure are extremely challenging to obtain. Building solar PV installations without permits represents a significant risk. For example, in July 2017, Israel seized solar panels donated to Palestinians in West Bank by the Dutch government as they did not have proper building permits[5].

Regulatory barrier

PETL is responsible for the off-taking of power and providing transmission infrastructure in the West Bank. However, as of 2017, PETL has no track record in either of these roles. PETL also has to become capable to meet the transmission requirements of solar PV technologies and to negotiate appropriate transmission arrangements with IEC concerning the Gaza Strip.

Geographical barrier

The main component of solar PV technologies, solar panels, require significant land space to be set-up. Palestine, especially Gaza, faces extreme land constraints, limiting the size of solar PV power plants that can be implemented. As Gaza has a vertical pattern for urbanization, rooftop solar can be installed as an alternative, but this would also limit the power plant size and production capacity. Indeed, according to PETL and the Palestinian Energy and Environmental Research Center (PEC), about 0.12 percent of Areas A and B are available and suitable for solar production with a maximum potential

[4] Securing Energy for Development in West Bank and Gaza, World Bank, 2017

5 Israel seizes solar panels donated to Palestinians by Dutch government, Independent

production capacity of 103 MW[6]. Area C would be the most suitable location to install large scale solar PV power plants, but the number of construction permits delivered to Palestinians by the Israeli Civil Administration regarding Area C is extremely low. With only 3 percent of the land in Area C covered with solar PV panels, 3,000 MW of energy could be produced.

2.3 Energy efficiency

Achieving energy efficiency in Palestine is extremely important as the country is completely dependent on imported energy products. In Palestine, buildings consume approximately 43 percent of the total energy consumption per year and this is expected to double by 2020. Additionally, buildings and construction is the fastest growing sector in Palestine, with 2,585 building licenses issued in the last quarter of 2017 in the West Bank.[7]

Regulatory barrier

PENRA set an indicative target in energy efficiency and rationalizing electric energy consumption by end user that aims at achieving 5 percent saving in overall electricity demand by 2020[8]. Approximately 95 percent of energy savings are targeted at buildings. However, despite the development of this target, the efforts towards developing Palestinian buildings and constructions codes and standards are still insufficient. Currently, there are still no mandatory standards for energy efficiency in buildings and no clear standards for green buildings. Formulating the relevant policy environment for energy efficiency, which define the standards for each building, will be extremely important to support the transfer and replicability of the technology in the country.

Financial barrier

In achieving energy efficiency in buildings, there is a significant initial investment required in retrofitting building insulation to help reduce space heating and running costs for buildings. This will require large financial investment upfront by individuals and buildings owners, which may be an added burden to an already high average energy prices in Palestine.

Information barrier

In general, when considering energy efficiency technologies, research suggests that consumers are often poorly informed about market conditions, technology characteristics and their own energy use. The lack of adequate information about potential energy-efficient technologies as well as lack of standards inhibits investments in energy efficiency measures while insufficient and inaccurate information provide lack of transparency[9].

Behavioral barrier

There are barriers related to behavior that may pose challenges in deployment of energy efficiency

[6] Securing Energy for Development in West Bank and Gaza, World Bank, 2017

[7] Mohammed F. Alsayed, Rawan A. Tayeh. *Life cycle cost analysis for determining optimal insulation thickness in Palestinian buildings*. 2019. Accessed from https://staff.najah.edu/media/published_research/2019/01/22/Life_cycle_cost_analysis_for_determining_optimal_insulation_thickness_in_Palestinian_buildings.pdf

[8] Cleaner Energy Savings Mediterranean Cities (CES-MED). "Palestine Report: Recommended National Sustainable Urban and Energy Savings Actions". 2015. Accessed from: <https://www.ces-med.eu/sites/default/files/National_report_Palestine_SEAP_v.3.0%20-%20FINAL%20Layouted.pdf>

[9] Thollander, P., Palm, J., and Rohdin, P. (2010). "Categorizing Barriers to Energy Efficiency: An Interdisciplinary Perspective, Jenny Palm (Ed.), Accessed from http://cdn.intechweb.org/pdfs/11463.pdf

technologies. This refers to individuals and organizations having particular habits and routines which make it challenging to change such behaviors[10] to enhance energy efficiency. These could be behaviors such as simply not turning off technologies when not in use, such as turning off computers and monitors or lights at the end of the day.

2.4 Solar water heating

SWH systems is currently a proven technology in Palestine. It is extensively used in the residential sector, while limited in the service and industrial sectors. This technology is highly relevant in the Palestinian context as most of the electricity is supplied from external sources which the country has no control of, and thus fetch high costs, the most expensive compared with other countries in the region. With Palestine possessing high potential for solar energy, and the fact that the SWH technology is not constrained by the country's limitation on electricity supply, there is high rationale in prioritizing this technology. Additionally, there exist local manufacturers for SWH systems in Palestine. However, there are barriers which prevent further up-scaling of the technology.

Regulatory barrier

Use of solar technologies for water heating purpose is integrated as a national priority in Palestine. However, there is a lack of regulations which allows for the integration, either voluntarily or mandatorily, of SWH technologies in the design, planning and construction of new infrastructures such as buildings.

Market barrier

The market for solar water heaters reflects limitations as, currently, it might not be large enough to accommodate and to drive enough businesses. Local market is also limited as it has been proven difficult to expand through export.

Technical barrier

There is a lack of technical capacities in terms of effectively designing and installing SWH systems, especially for collective systems for larger installations such as buildings, hotels and hospitals. The availability of information on the technical aspects of SWH systems such as manuals, handbooks and software that could be applied in the Palestinian context, as well as enhanced capacities and skills of staffs through trainings, will be crucial for its mainstreaming.

Financial barrier

Solar technologies including SWH systems entail high initial investment costs considering the economic situation of the country and relatively low income level of its end users. There is currently a lack of incentives and financing schemes that would support investments in SWH technologies, especially for larger installations. There is a need for government initiatives together with international support to encourage investments in solar water heaters and trigger private sector participation.

[10] Thollander, P., Palm, J., and Rohdin, P. (2010). "Categorizing Barriers to Energy Efficiency: An Interdisciplinary Perspective, Jenny Palm (Ed.), Accessed from http://cdn.intechweb.org/pdfs/11463.pdf

3. Agriculture sector

For the agriculture sector, the following technologies have been prioritized by the stakeholders for further assessment and are analyzed as part of this report.

- Climate smart agriculture (precision agriculture)
- Efficient irrigation
- Resilient animal fodder
- Conservation agriculture
- Water harvesting

3.1 Climate smart agriculture (precision agriculture)

Climate change both directly and indirectly impacts agricultural productivity, ranging from increased temperatures, changing rainfall patterns, drought, flooding and spread of pests and diseases. Climate-smart technologies have been applied in many parts of the world to manage climate change impacts on landscape such as, cropland, livestock, forests and fisheries. These technologies aim to achieve increased and sustainable productivity, enhanced resilience and reduced emissions. This is significantly important in the context of Palestine where agriculture plays an important role in the country's culture, food security, economy and employment. Most importantly, Palestine has identified applying climate-smart agricultural (CSA) practices to at least 50 percent of farmers by 2040 as a target in its NDC.

Financial barrier

Implementing CSA practices will require initial financial support to make the transition to climate-smart agriculture. Financial assistance will be needed to install CSA technologies such as solar powered water pumps and water tanks as storage facilities. Investment will also be required for capacity-building activities such as training and publications of documents and materials. Financial investments are also needed to address gaps in knowledge and technology to support uptake at the local levels. Additionally, financial support is needed for capacity-building and training to develop the necessary skills for efficient use of climate smart technologies.

Cultural barrier

Cultural barriers also impact the adoption of climate smart technologies. It is challenging to change traditional agricultural practices as some farmers may be resistant towards implementing CSA technologies. In addition, in order to support efficient adoption of CSA technologies, support from organizations such as farmers' organizations and cooperative societies is important.

Barrier related to access to land, water and equipment

Limited access to CSA tools and equipment is considered as significant barrier in scaling up CSA practices. CSA may not necessarily require more equipment and tools than conventional agriculture, but some of the equipment and tools are specific and may not always be available. Implementation costs also depend on availability of these tools and equipment. Additionally, having physical access to land and water is also important in advancing CSA technologies. Some CSA technologies may require additional space for installation of technologies and for establishment of storage and processing facilities, as well as reliable water supply in some cases.

3.2 Efficient irrigation

Improving irrigation efficiency aims at minimizing water use within the agricultural sector while continuing to maintain optimal crop productivity rates. Water efficient irrigation also provides a number of environmental and socio-economic benefits. High irrigation efficiency is becoming increasingly important due to the current decrease in available water resources and growing populations that drive expansion of agricultural activities[11].

Technological advances for improved irrigation include more efficient irrigation systems where water release can be controlled so that crops receive only the amount needed. Other modern irrigation systems are self-propelled and include wireless sensors and Global Positioning System (GPS) technology to improve site-specific and volumetric precision of water applications to match the needs of the soil and crops. Irrigation efficiency can also be improved through altering farming practices, such as crop rotation and conversation tillage that help improved soil moisture conservation[12].

Regular monitoring equipment and repairing damages/leakages in irrigation systems are also important in improving water use efficiency for crops. Improving access to information in regards to these measures, for example through farmer education programs, can help create incentive and influence the behavior of farmers toward greater water-efficient management or irrigation systems[13].

Financial barrier

Investment is required in technologies that promote efficient irrigation practice, especially in large-scale projects. This initial investment may present as a barrier to some farmers as they may not have access to the necessary financing.

Cultural barrier

Similar to implementation of climate smart technologies, greater water-use efficiency depends on better agricultural practices alongside extra technology. Technology itself does not bring various benefits but rather sustainable agricultural practice, combined with technologies for irrigation efficiency, result in positive outcome. Hence, it will be important to educate and train farmers so that farmers are not only focused on maximizing net income but rather on water productivity.

3.3 Resilient animal fodder

Israeli occupation control over land resources, in addition to recurring droughts and overgrazing in the West Bank have resulted in herders facing decreased access to grazing land, which increases their dependency on imported fodder and making them more vulnerable to fodder price volatility. To help address this issue, the use of hydroponic technology (soil-less plant propagation) by vulnerable herders and their cooperatives has been promoted in Palestine[14]. This provides them with a low-cost, high quality, sustainable source of fodder which is available year-round.

[11] Climate Change Adaptation Technologies for Water: A practitioner's guide to adaptation technologies for increased water sector resilience (2017), UN Environment – DHI Centre, Climate Technology Centre and Network (CTCN) and the UNEP DTU Partnership
[12] Climate Change Adaptation Technologies for Water: A practitioner's guide to adaptation technologies for increased water sector resilience (2017), UN Environment – DHI Centre, Climate Technology Centre and Network (CTCN) and the UNEP DTU Partnership
[13] Climate Change Adaptation Technologies for Water: A practitioner's guide to adaptation technologies for increased water sector resilience (2017), UN Environment – DHI Centre, Climate Technology Centre and Network (CTCN) and the UNEP DTU Partnership
[14] Food and Agriculture Organization (FAO). "Alternative fodder production for vulnerable herders in the West Bank: Increasing profitability of livestock production to strengthen resilience to drought and market volatility within protracted crises". Resilience promising practice, 2015.

Financial barrier

Each hydroponic unit, a system incorporating a soilless method of growing plants and crops using inert substrates such as sand, gravel and aqueous medium, costs around USD 15,000, with an expected lifespan of 30 years. Additionally, there is an estimated average annual maintenance cost of around USD 200. This may be a constraint to some farmers as initial financial investment is required for the design and production of hydroponic units.

Each hydroponic unit also requires access to water as well as stable supply of electricity. This increases the operational cost associated with the technology.

Access barrier

Providing access to the necessary water and electricity may be a constraint to some farmers as land is limited in the West Bank. Water and electricity are both strictly controlled by Israeli occupation. Inability to sufficiently secure access to these resources is a significant barrier for the successful introduction of this technology in Palestine. Palestine is currently exploring the option to use treated wastewater for agricultural use to address this issue. However, external support will be needed for improving technical capacity in Palestine related to wastewater treatment. In addition, the quality of seeds used in hydroponic fodder production is critical. Imported seeds fluctuate in quality, thus making it preferable to utilize local seed suppliers. However, there is limited local seed market available in the West Bank to improve the quality of fodder produced.

Cultural barrier

Farmers and herders can be apprehensive or skeptical about innovative and unfamiliar practices. Use of a hydroponic unit as an alternative fodder production method is not a well-known or established practice in the local context of the West Bank. Hesitation to adopt new practices is mainly rooted in financial considerations, since the agricultural community has an established set of practices for trade and production. Farmers and herders fear that it could negatively affect their livelihoods[15].

3.4 Conservation agriculture

Conservation agriculture is a farming system that maintains a permanent soil cover to assure its protection, avoids soil tillage, and cultivates a diverse range of plant species to improve soil conditions, reduce land degradation and increase water and nutrient use efficiency. It enhances biodiversity and natural biological processes above and below the ground surface for improved and sustained crop productivity[16]. Most importantly, conservation agriculture can enhance productivity of farmland already in use and can generate land left in poor condition by past misuse[17].

Cultural barrier

Experiences and studies from many countries show that the adoption and diffusion of conservation agriculture practice require a change in commitment and behavior of farmers. Farmers need to be open to experimenting, learning and adapting techniques to local conditions, which are identified as prerequisites to successful practice of conservation agriculture. This change in behavior may constrain

[15] Food and Agriculture Organization (FAO). “Alternative fodder production for vulnerable herders in the West Bank: Increasing profitability of livestock production to strengthen resilience to drought and market volatility within protracted crises”. Resilience promising practice, 2015.

[16] Food and Agriculture Organization (FAO). Conservation Agriculture. Accessed from http://www.fao.org/3/a-i6169e.pdf

[17] Food and Agriculture Organization (FAO). Conservation Agriculture. Accessed from http://www.fao.org/3/a-i6169e.pdf

the wider adoption of this practice[18].

Information barrier

Poor information flow to farmers on benefits and components of conservation agricultural practice is a barrier that constrains wider adoption of the practice, as well as creates misconception about the practice amongst farmers. Farmers, therefore, are exposed to perceived risk of adopting conservation agriculture which may further serve as a barrier for technology adoption[19].

Financial barrier

Limited financial means is also a major hindrance to the practice of conservation agriculture as it dictates the ability to acquire no-till farm equipment and external inputs[20]. Conservation agriculture relies heavily on herbicides for weed control. These are often costly and out of reach for the majority of the resource-constrained farmers. Smallholder farmers often find themselves battling with weed control under the conservation agriculture technique[21]. Financial resource is needed to access the required and specialized equipment to support the introduction of this technology.

3.5 Water harvesting

Water harvesting is a technique of developing surface water resources that can be used to provide water for livestock, for domestic use, and for agriculture. Rainwater conservation and harvesting for agriculture use provides opportunities to reduce the high risk of yield losses associated with low rainfall and uneven distribution throughout the season. This reduces the financial risks associated with crop failure[22].

When water harvesting techniques are used for farming, the storage reservoir is the soil itself, hence eliminating the need to construct storage facilities. The appropriate choice of water harvesting techniques depends on the amount of rainfall and its distribution, soil type and depth, land topography, and local socioeconomic factors, and therefore these technologies are particularly site specific.

The basic principle is to capture precipitation falling in one area and transfer it to another, thereby increasing the amount of water available in the latter. The basic components of a water harvesting system are a catchment or collection area, the runoff conveyance system, a storage component and an application area.

Water harvesting, specifically rainwater harvesting, for agricultural use is highly relevant to the Palestinian context. Climate change provides additional stress to already limited rainfalls in the region. Additionally, drought and growing population will be challenging in meeting the agricultural need for the country. Use of alternative water resources, such as rainwater, has been identified as an important adaptation solution in Palestine's NDC.

Cultural barrier

[18] Kassam, A., Friedrich, T., Shaxson, F., Bartz, H., Mello, I. Kiezle, J. and Pretty, J. (2014). "The spread of Conservation Agriculture: policy and institutional support for adoption and uptake." Journal of Field Actions, 7.

[19] Food and Agriculture Organization (FAO), "Chapter 2: Factors influencing the adoption of conservation agriculture". The economics of conservation agriculture. Accessed from <http://www.fao.org/tempref/docrep/fao/004/y2781e/y2781e02.pdf>

[20] Muzangwa, L., Mnkeni, P.N.S. and Chiduza, C. (2017). "Assessment of Conservation Agriculture Practices by Smallholder Farmers in the Eastern Cape Province of South Africa". *Agronomy 7*(46).

[21] Muzangwa, L., Mnkeni, P.N.S. and Chiduza, C. (2017). "Assessment of Conservation Agriculture Practices by Smallholder Farmers in the Eastern Cape Province of South Africa". *Agronomy 7*(46).

[22] Baako, A.M. (2015). "Promoting On-Farm Water Harvesting and Conservation Techniques for Sustainable Agricultural Production Systems through Capacity Development of Field Extension Officers and Farmers". Journal of Developments in Sustainable Agriculture 10, pg. 55-60.

The success of a water harvesting project mainly depends on the full support of the user for proper operation and maintenance. However, as this practice differs from traditional agricultural practice, there may be resistance toward the implementation of the technology. Capacity-building and awareness raising are needed for both training on the concept as well as on the maintenance of the technology. An investment will be needed in training labor with the necessary skill for successful implementation, operation and maintenance of the technology.

Geographical barrier

As mentioned above, each water harvesting technology is site specific, as applicability depends on the amount of rainfall available, soil type and depth as well as land topography of the region. This may limit the area in Palestine in which this technology is deemed applicable. In addition, from small to large scale projects, most of the development related to agriculture is in Area C. This limits Palestine's ability to introduce the technology in this area due to occupational challenge.

Financial barrier

Socially, the adoption of water harvesting technologies decrease when land is privately owned, as upfront costs are high when accounted for it alone. Additionally, farmers are more interested to invest as a group or on communal lands and are more willing to share the cost of adoption[23]. Financial investment is also required, not only for the technology itself, but also for support in the development of knowledge and capacity building on the use and operation of the technology.

[23] Akroush, S. Dehehibi, B., Dessalegn, B., Al-Hadidi, O. and Abo-Roman, M. (2017). "Factors Affecting the Adoption of Water Harvesting Technologies: A Case Study of Jordanian Arid Area." Sustainable Agriculture Research 6(1).

4. Water and wastewater sector

The following technologies for the water and wastewater sector have been prioritized by the stakeholders for further assessment and are analyzed as part of this report.

- Rainwater harvesting
- Water resources monitoring technologies
- Wastewater collection and treatment plants and advanced wastewater treatment technologies

4.1 Rainwater harvesting

Rapidly growing population and Israeli control over water and land resources have worsened Palestinian water supply and management issues. A large number of Palestinians suffer from shortages of drinking and agricultural water, especially during the summer when the water shortage is at its worst, and most of the households live isolated from the water network. The implementation of rainwater harvesting systems can allow these isolated households to have an independent access to water resources However, the development of rainwater harvesting faces the following barriers that need to be addressed.

Political barrier

Following the second intifada, Israel strengthened land restrictions in the West Bank in 2002, making it illegal to build or rehabilitate any structure without the permission of the Israeli Civil Administration (ICA) in Area C. Structures built without permits face the risk to be demolished by Israeli Occupation Authorities. For example, 56 rainwater cisterns have been destroyed by the Israeli army between 2009 and 201124. The construction of the West Bank Barrier resulted in the destruction of cisterns and/or cisterns no longer accessible by the local population. It is thus primordial to apply for construction and rehabilitation permit for the construction of rainwater harvesting systems in area C, but it implies a long process with a high probability of refusal. Due to the blockade of the Gaza Strip by Israel, it is also very difficult to import spare parts needed for maintenance.

Financial barrier

The cost of rainwater harvesting technologies depend on the type and size of catchment, conveyance and storage tank materials used, but in general the cost is relatively low for small scale structures, while high for large scale structures. However, construction costs can significantly increase depending on the location (mountain areas for example). As rainwater harvesting is suited for not densely populated remote areas, construction costs are expected to be higher than the market average. Palestine has limited economic resources which entails the need for international financial support for the implementation of rainwater harvesting technologies.

Geographical barrier

Rooftop method rainwater harvesting does not imply any geographical barrier as the technology is implemented in already existing non-used space. However, ground surface and rock surface methods require land space to be setup for both catchment area and storage device. Palestine, especially Gaza, is a country that has to face extreme land constraints, limiting the size of both catchment area and storage device, and thus limiting the capacity of the rainwater harvesting system. In the West Bank, the implementation of the technology requires approval from Israel in Area C, where land is the most

[24] Barrier Impacts on Water Resources, The Applied Research Institute Jerusalem

available.

Awareness barrier

Rainwater harvesting technologies require frequent cleaning and maintenance to avoid water contamination that can lead to health issues. It is thus important to conduct trainings targeting the technology users.

4.2 Water resources monitoring technologies

Water is one of the key components in both the Palestinian economy and the regional geopolitical setting. Moreover, West Bank and Gaza are facing significant and growing shortfalls in the water supply available for domestic use, and it is thus primordial to assure water security in Palestine. This can be done partly by implementing water resources monitoring systems to manage freshwater resources, collect essential information in characterizing the physical, chemical and biological status of water resources, and determine trends and changes over time. However, the development of water resources monitoring technologies faces the following barriers that need to be addressed.

Political barrier

Water supply in Palestine falls under the bilateral agreements with Israel for groundwater abstraction (internal resources) and imports from Israel for the remaining supply. Palestine's groundwater supply is fully controlled by Israel. The development of Palestinian water resources is defined in the 1995 Israeli-Palestinian Interim Agreement on The West Bank and The Gaza Strip (Oslo II Accord)[25]. According to this Interim Agreement, water development has to be managed through a coordinated Palestinian-Israeli process and mechanism. The implementation of water resources monitoring technologies (mainly monitoring for water quantity) in Palestinian ground water resources would imply to coordinate and obtain cooperation from Israel. This process will certainly be very slow with lots of political obstacles.

Institutional barrier

Palestine has its existing regulation (the 2014 Water Law) which clarifies and establishes an autonomous water utility. However, its incomplete legal structure, lack of financing, the lack of clarity of rules and responsibilities at the local level have slowed down its implementation. The Water Sector Regulatory Council (WSRC) was established under this law as an independent legal entity that reports directly to the Palestinian Cabinet of Ministers. WSRC is the one responsible for water service providers' monitoring and regulation. Thus, water resources monitoring technologies must be implemented by the local government units, who are responsible of the water services, through the WSRC. However, neither the Palestinian Water Authority (PWA) nor the WSRC has technical or administrative control over the local government units, creating a governance gap in the sector. It is unclear which entity has the responsibility to implement water resources monitoring technologies, and this situation makes it difficult for external funding to come in.

Financial barrier

The implementation of water resources monitoring technologies requires significant financial resources, for both the technologies themselves and human resources required to analyze collected data. Palestine clearly has limited economic resources which entails the need for international financial support for the implementation of these technologies.

[25] The Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip, Article 40 Water and Sewage

Technical barrier

According to the Palestinian Ministry of Health (MOH), more than half of reverse osmosis (RO) plants are monitored, but a study conducted by PWA, WASH Partners and GIZ found out that "nearly half the RO plants produce contaminated water (total coliform)"[26]. This result shows that although some water resources monitoring technologies are already being implemented in Palestine, they do not seem to work efficiently. Collecting data is only the first step of the monitoring process, data analysis is also a very important component of the process, primordial to identify policies and measures to enhance water quality. Thus, capacity-building needs to be conducted in Palestine in order to allow the efficient use of water resources monitoring technologies.

4.3 Wastewater collection and treatment plants and advanced wastewater treatment technologies

The Government adopted the Palestinian National Water Strategy from 2013 to 2032, in which the importance of wastewater management and treatment is emphasized in the national policy, especially access to water and wastewater services, and sustainable wastewater management. However, the development of wastewater collection and treatment plants faces the following barriers that need to be addressed.

Financial barrier

Although the Palestinian Government's high awareness level, shown by the adoption of the Palestinian National Water Strategy, suggests that the Government would be willing to invest in wastewater collection and treatment plants, the technology itself remains relatively expensive. Palestine has limited economic resources which require international financial support for the implementation of these technologies.

Geographical barrier

Although the Palestinian Government was able to obtain written consent from Israel Authorities to allow for imports of all related equipment needed for the implementation of wastewater treatment plants, and confirmation that Israeli Military Forces would not threaten this type of project, the issue related to land availability still remains. Wastewater treatment plants require significant land space to be implemented. Palestine, especially Gaza, has to face extreme land constraints, limiting the size of wastewater treatment plant that can be implemented.

Institutional barrier

There is a multitude of governmental and non-governmental institutions involved in the Palestinian water sector, which leads to significant institutional fragmentation and a lack of coordination between different stakeholders in the wastewater collection sector. The roles and responsibilities of each institution regarding the treatment and reuse of wastewater is unclear. Municipalities are currently in charge of supplying water and collecting wastewater, but their lack of financial and managerial capacities prevent them from efficiently collecting wastewater.

Access to energy barrier

Since 2008-Gaza conflict and the embargo and siege on Gaza from Israel, the four existing wastewater treatment plants in Gaza are operating discontinuously, mainly due to the lack of electricity and fuel[27].

[26] Securing Water for Development in West Bank and Gaza, World Bank, 2018

[27] Assessment of Restrictions on Palestinian Water Sector Development, 2009, World Bank

Thus, the energy issue also represents a barrier to the proper working of this technology.

Technical barrier

For both wastewater collection and wastewater treatment plants, Palestine is facing a lack of adequately trained human resources[28]. Very often, when implementing this kind of project, only investment and implementation costs are considered, excluding technical staff training. This situation leads to improper maintenance, resulting to unsustainable and not properly working systems for both wastewater collection and treatment plants. Training should be an important component of a project involving these technologies. Four out of the five existing wastewater treatment plants are performing very poorly due to their poor efficiency and quality[29].

[28] Prospects of Efficiency Wastewater Management and Water Reuse in Palestine, 2005, Efficient Management of Wastewater, its Treatment and Reuse in the Mediterranean Countries

[29] Assessment of Restriction on Palestinian Water Sector Development, 2009, World Bank

5. Transport sector

The following technologies for the transport sector have been prioritized by the stakeholders for further assessment and are analyzed as part of this report.

- Upgrade of the existing vehicle fleet
- Public transportation (modal shift)
- Flood prevention

5.1 Upgrade of the existing vehicle fleet

The transport sector is one of the main causes for air pollution and greenhouse gas emissions. While the worldwide trend in addressing this is a high increase in the sales numbers of electrical vehicles (EVs), characterized by an increase of almost 60 percent in 2017[30] (compared to 2016), Palestine seems to be left away from this global trend. Palestine installed its first EV charging stations at the beginning of 2019, at the same time as full EVs started being sold for the first time in the country[31]. Upgrading a large number of the existing vehicle fleet to newer and environment friendly models and importing hybrid/electric cars appears to be one of the potential solutions to tackle the pollution issue and a way for Palestine to keep up with the world's eco-friendly approach regarding transport. However, the development of this kind of measure on a large scale faces the following barriers that need to be addressed.

Infrastructure barrier

According to the Ministry of Public Works and Housing (MPWH), almost 50 percent of the road network in Palestine is in poor, very poor or failed condition[32]. This is not a sustainable situation for the transport sector, and extensive rehabilitation and reconstruction of road pavements are required to fix the road network. The efficient use of cars, not being limited to EVs, require an operating road network. Damages are estimated to be as high as US$130 million[33], thus Palestine needs to implement usable road infrastructure before diversifying its car shares.

In addition to road infrastructure, introduction of EVS at a large scale requires the implementation of infrastructure specific to hybrid/electric cars, including EV charging stations and power networks. Palestine currently does not have such infrastructures in place, and implementing power networks could be a problem as the majority of electricity is still being imported from Israel.

Financial barrier

According to Adala Al-Attireh, Chair of the Palestinian Environment Quality Authority, in addition to reducing emission and fuel consumption, EVs can be economic for ordinary citizens[34]. Thus, the Palestinian Authority is improving regulations and supports the private sector so that it can meet the policy improvements recommended by the International Energy Agency (IEA). Moreover, the Ministry of Transport is currently implementing required rules and regulations to facilitate the importation of EVs. However, upgrading the existing vehicle fleet to newer and more efficient ones, in particular, to hybrid/electric cars, implies to install numerous EV charging stations and power networks over the country, requiring significant construction costs. Palestine has limited economic resources which entails

[30] The $6 Trillion Barrier Holding Electric Cars Back, 2018, Bloomberg

[31] Feature: Palestinians embrace eco-friendly cars as first electric car charging stations installed, 2019, Xinhua

[32] West Bank and Gaza – Transport Sector Strategy Note, 2007, World Bank

[33] West Bank and Gaza – Transport Sector Strategy Note, 2007, World Bank

[34] Feature: Palestinians embrace eco-friendly cars as first electric car charging stations installed, 2019, Xinhua

the need for international support for the implementation of these technologies.

Geographical barrier

Upgrading the entire existing vehicle fleet to newer and hybrid/electric cars will take significant time. In addition to the existing gasoline stands, EV charging stations will need to be constructed all around the country to allow efficient use of the EVs. However, Palestine, especially Gaza, faces extreme land constraints, limiting the number and size of charging stations that can be installed. Moreover, the construction of such infrastructure requires approval from Israel in Area C.

Informational barrier

There is a barrier related to availability of information. This refers to both on the technology itself, such as benefits of the technology, and also on the issue of climate change and impacts of greenhouse gas emissions to the environment related to the technology and transportation sector. Providing access to these information to end users will significantly support the shift in behavior and adoption of this technology.

5.2 Public transportation (modal shift)

In Palestine, vehicles plying the roads are mostly comprised of private vehicles. According to statistics, about 67 percent of vehicles in Palestinian roads are private vehicles, with only around 7.4 percent are public vehicles serving the general population. These statistics reflect on traffic congestion on main roads in Palestine, especially during rush hours, as a result. It is evident that there is a need to shift from the current private vehicle heavy mode of transportation to more efficient public transportation system. Doing so would result in significant benefits including the reduction of amounts of vehicles plying the roads and hence reducing traffic congestion, better connectivity between cities contributing to economic development, and reduction in greenhouse gas emissions and other harmful air pollutants. However, barriers currently exist preventing modal shift to public transportation which needs to be addressed.

Financial barrier

To provide the necessary facilities and infrastructure to secure access to public transportation services, as well as develop the related policies and strategies to support the development of the transport sector, significant investments will be required. Due to Palestine's limited economic resources, international financial support will be required for the modal shift to public transportation.

Informational barrier

There is an existing barrier related to availability of information pertaining to the benefits in patronizing public means of transportation. In addition to the economic and social benefits that modal shift leads to, it is also relevant for the public to understand its significant contribution to addressing the issue on climate change and how it reduces greenhouse gas emissions.

5.3 Flood prevention

Palestinians, especially those who live in the Gaza Strip, live with the threat of temporary displacement, property losses and health risks due to the flooding risk in winter. According to WASH, 60 communities in low-lying locations across Gaza, including 560,000 people, have been identified as being at risk of flooding, even from light rainfall[35]. Therefore, flood prevention represents a key issue not only for Palestine, but also

[35] Poor infrastructure and lack of funding put over 56,000 people at risk of flooding in the Gaza Strip, 2017, OCHA

for international humanitarian agencies. Nowadays, several technologies exist to prevent flooding.

In Japan for example, a country especially vulnerable to flooding risk employ a special project aiming to protect Tokyo from flooding, the “Metropolitan Area Outer Discharge Channel”[36]. The idea is to drain water from flooded residential areas into five vertical shafts built underground and then discharge the water into rivers through an underground tunnel connecting the shafts.

The same technology could be implemented at a smaller scale in Palestine. However, the implementation of flood prevention technologies faces the following barriers that need to be addressed.

Political barrier

Over the past years, the Coastal Municipalities Water Utility (CMWU) and other WASH partners have tried to implement infrastructure projects for flood prevention in the Gaza Strip, including interventions to separate storm and wastewater networks, extend storm water drainage networks and infiltration ponds, provide spare parts, maintenance and fuel for pumping equipment in low-lying areas, provide support for service providers in prevention and response activities. Unfortunately, all these projects have been undermined because of Israel restrictions on the import of materials, due to their designation as “dual civilian and military items”[37].

The same situation occurred for two other projects that are being implemented by the CMUW. The projects are in stand-by as some materials, including mobile and high-pressure jetting pumps and other equipment regarding flood prevention, were awaiting clearance from Israel for ten months as of December 2016[38]. This shows it is very difficult and long to obtain approval from Israel to import materials required for flood prevention in Palestine, especially in Gaza.

Moreover, the technology implemented in Japan implies the use of underground spaces, which are monitored by Israeli occupation in Palestine. Getting approval from Israel to use these underground spaces will be a long and difficult process.

In addition, approval is required to perform any renovation or upgrade in Area B and C, which is highly required for the introduction of this technology. This is significantly difficult to achieve even with strong international donor and agency support.

Financial barrier

Although the Palestinian Government is aware that flood prevention is a key issue and would be willing to invest in flood prevention technologies, these technologies remain relatively expensive (for sustainable flood prevention) as they require extensive infrastructure construction works. Palestine has limited economic resources which require for international financial support for the implementation of these technologies.

[36] World-Class Underground Discharge Channel, 2013, Trends in Japan

[37] Poor infrastructure and lack of funding put over 560,000 people at risk of flooding in the Gaza Strip, 2017, OCHA

[38] Preparedness for potential floods in Gaza undermines by import restrictions, 2016, OCHA

6. Solid waste sector

The following technologies for the solid waste sector have been prioritized by the stakeholders for further assessment and are analyzed as part of this report.

- Waste sorting
- Composting
- Recycling

6.1 Waste sorting

Palestine would greatly benefit from improving its solid waste sorting practices as about 50 to 55 percent are comprised of organic waste while the rest can be recycled. Having an effective and environmentally safe management of solid waste will allow for other waste handling alternative options such as recycling and composting technologies become for financially viable. The following barriers are identified that hinders the development of waste sorting technologies.

Regulatory barrier

There are no regulations which require the sorting of solid waste either from the household level or central/communal level. There are also no standards for dealing with special, hazardous, and medical wastes, or for transfer stations, recycling operations, etc. Most of the unsorted wastes end up being dumped in landfills.

Institutional barrier

The roles and responsibilities of solid waste management in Palestine are distributed among several national institutions. Therefore, ambiguity in roles and responsibilities exist resulting in overlap in efforts due to variations in interpretations of responsibilities of relevant institutions. There is a need to strengthen the institutional arrangement for solid waste management to clearly define these roles and responsibilities.

Technical barrier

The effective separation of useful materials from unsorted waste is considered difficult in Palestine. There is a need to introduce efficient waste sorting methodologies and technologies in the country in order to promote alternative options for reusable wastes such as recycling and composting. The barrier is related to lack of capacity building, experience, general awareness and participation of local communities.

6.2 Composting

Composting effectively reduces the overall waste volume that ends up in landfills. As waste material required for the production of compost is organic, this consequently reduces the decomposition of organic waste in landfills thereby reducing greenhouse gas emissions. At the same time, the final product, compost, are valuable inputs to the soil and serves as fertilizer providing nutrients for agricultural products. The following barriers are identified in implementing composting project in Palestine.

Regulatory barrier

Although the Palestine Standards Institution has issued the standard specifications for organic fertilizers and composts in 2012 to control organic waste composting in Palestine, there is a lack of regulation that

would enforce compliance to the standards.

Technical barrier

Operation of a composting facility requires technical expertise and know-how specific to the technology. It requires adequate separation of compostable materials from the non-compostable fraction in the municipal solid waste stream. It also requires controlled conditions and careful management to produce a successful end product. Additionally, it is difficult to control quality of the compost. Marketability of the compost is directly influenced by its quality.

6.3 Recycling

There are existing recycling facilities in Palestine. However, these are mainly small in scale and have limited capacities. In order for the country to improve its recycling capacity and introduce large scale recycling facilities, the following barriers needs to be overcome.

Regulatory barrier

Palestine has policies relevant to solid waste management, in particular, its National Strategy for Solid Waste Management in the Palestinian Territory 2017-2022. It constitutes the framework for all decisions, programs, activities, and medium-term investment plans, aiming at developing the solid waste sector in the Palestinian Territory. It has established a national vision and objectives to improve its solid waste sector. However, current legislations governing the solid waste management sector do not constitute a sufficient comprehensive legal framework to cover all aspects of solid waste management as some legal texts are ambiguous and partially contradictory[39]. This has created gaps and problems in the management of the solid waste sector in Palestine at all levels. There is also a need to develop standards for the various stages of solid waste management such as those for recycling operations, as there are currently no Palestinian standards for many aspects of solid waste management.

Technical barrier

As the overall recycling experience in Palestine is limited, which is evident from its current recycling capabilities, there is lack of technical expertise and know-how on recycling technologies. There is a need to enhance the technical know-how for recycling technologies to be mainstreamed and for the country's recycling industry to develop. The appropriate recycling options need to be identified given much of Palestine's solid waste are recyclable.

Social barrier

The adoption of this technology is limited by lack of acceptance from users and stakeholders. This is mainly due to end users not being familiar with recycled material and use of recycled material. In addition, there is a lack of local market availability for recycling in Palestine. Companies currently do not have value chains that integrate recycled material. Capacity building will be required to ensure stakeholders understand the benefit and the need of this technology, as well as to develop value chains that integrate recycled material. Development of local market availability for recycling will be key in addressing this barrier.

[39] State of Palestine. National Strategy for Solid Waste Management in Palestine 2017 – 2022.

7. Other technologies

Other technologies not belonging to certain specific sector has also been identified for prioritization. The following technologies have been prioritized.

- Provision of beach nourishment, reclamation and beach drift rehabilitation
- Development of water, food and sanitation monitoring and safety systems using high technology related to health
- Low-carbon cold chain

7.1 Provision of beach nourishment, reclamation and beach drift rehabilitation

Palestine has limited coastline area confined in the Gaza region, and has been identified as highly vulnerable to the impacts of climate change. Sea level rise will result in increased wave impact and accelerated coastal erosion. This leads to damaging the beaches, harbors and other coastal structures, and may lead to the collapse of the coastal beach cliff. The vulnerability of these coastal areas has been exacerbated by excavation of sand from coastal dunes and removal of rocks for construction purposes. This has reduced the dunes' functions to protect the coast from erosion, to purify water reaching the subsoil, and to provide wildlife habitat. As such, the Palestinian Authority has included provision of beach nourishment, reclamation and beach drift rehabilitation as a national priority. However, there are barriers identified that should be addressed for this to be implemented.

Institutional barrier

The Palestinian coastal areas cover several jurisdictions of local government units which should be responsible on the local level. On the national level, the Ministry of Local Government is responsible for the LGUs' capacities and actions in addressing coastal related issues. At the same time, the Environmental Quality Authority is responsible for the overall environmental issues in Palestine. There is a need to have coordinated efforts among the responsible institutions, as well as identify which government institution would take the lead.

Access to materials barrier

The import of materials related to beach nourishment, reclamation and beach drift rehabilitation such as sand, rocks, cement and steel are restricted by Israel. It is important to address this restriction to successfully implement beach protection measures.

Financial barrier

The implementation of beach nourishment, reclamation and beach drift rehabilitation technologies will require significant amounts of investments, which cannot be met by national resources alone.

Awareness barrier

There is a general lack of awareness among the public, especially stakeholders of coastal areas in Gaza on the condition of beaches. This is evident by the ongoing extraction of sand and rocks in these areas for construction. There is a need to spread awareness on this issue, in particular, the risks associated with exploiting coastal resources, as well as the necessary measures for proper coastal management.

7.2 Development of water, food and sanitation monitoring and safety systems using high

technology related to health

The development of water, food and sanitation monitoring and safety systems using advanced, high-end technology is essential in ensuring the health and well-being of the Palestinian population. Access to safe water, food and sanitation are human rights. In order to fulfill these rights, the institutions delivering these services need to be well-resourced and capable in ensuring that these resources are safe and properly managed. The development of monitoring and safety systems of these resources are essential. Such monitoring and safety systems will help reduce the country's vulnerability to major diseases related to water, food and sanitation. The following barriers were identified for the dissemination of such adaptation technologies in Palestine.

Technical barrier

There is a need to identify available water, food and sanitation monitoring and safety systems using advanced technologies in other countries, as well as to determine which among these proven advanced technologies are best suited to the Palestinian context.

Capacity barrier

Capacities of key stakeholders need to be enhanced through training programs of institutions and regulators. This would allow them to be able to identify the appropriate technologies that could be applied to Palestine.

Awareness barrier

As the vulnerability of stakeholders and the general population is increased as resources such as water, food and sanitation become less abundant, people need to be made aware of potential measures that they can take to prevent major diseases. There is a need for awareness campaign in order for the general population, especially those in resource-poor areas to become aware and make informed decisions when there are scarcities in resources.

Financial barrier

There is a significant cost associated with the introduction of this technology. This is a barrier for Palestine as it will need external support to overcome this challenge and be able to introduce the technology to the country.

7.3 Low-carbon cold chain

Palestine's National Adaptation Plan points out that the current post-harvesting storage techniques in the country are inadequate, such as the lack of large-scale grading and refrigerated cold storage. The impacts of climate change such as rising temperatures and more extreme weather events may increase post-harvest losses due to increased likelihood of spoilage and increased risk of pathogen or pest infestation. Conventional measures have been taken to address such losses such as increasing cooling and improving storage capacities. However, these measures translate into higher costs. There is a need to introduce lower-cost, low-carbon solution through cold chain technologies to improve food security and reduce GHG emissions.

Political barrier

With the constraints of Palestine due to the Israeli occupation, in importing internationally sourced resources such as those for cold chain technologies, this may entail additional challenges in introducing the technology into Palestine. This could either hinder actual import of the technology or translate into higher costs as it faces importation challenges.

Regulatory barrier

Low-carbon cold chain technologies are driven by private sector technology providers involving patented high-end technologies. As such, there is a need for such patents to be protected under country policies if it is to be applied in the Palestinian context.

Awareness barrier

Stakeholders of the agricultural value chain from production to end users need to be made aware of new developments in cold chain technologies for them to understand its benefits. Although introduction of the technology involves higher initial investment costs, it would ultimately result into better savings and revenues in the long run.

8. Conclusions and recommendations

As key barriers for each of the prioritized technologies are identified, it is evident that the successful transfer of climate adaptation and mitigation technologies and inclusive businesses highly depend on establishing an enabling environment for technological advancements to happen.

Among the key barriers identified, the political situation of Palestine stands out. The current Israeli occupation of the State of Palestine is clearly a major factor in hindering the transfer and implementation of low-carbon technologies into Palestine. In addition to the severe economic impacts that the occupation situation presents to Palestine, it also hinders the potential of introducing climate mitigation and adaptation technologies into the country due to the limitation it brings. As the State of Palestine have limited control over its own natural resources, it is apparent that the prioritization of technologies that have the least barriers faced on the political aspect is at the forefront.

The development of low-carbon technologies is often incentivized by strong policies that would set the enabling environment to derisk investments in these technologies. From the identified key barriers, regulatory barriers present challenges in promoting the dissemination of climate mitigation and adaptation technologies into Palestine. There is clearly strong commitment from the Government of Palestine to pursue the use of low carbon technologies to achieve its development goals such as from its NDC, NAP, and INCR, as well as its national strategies and plans. However, specific regulations that would allow the enabling environment for low carbon technologies to be transferred, as well as encourage private sector participation will be essential in achieving these targets.

The successful diffusion and implementation of technological innovations would necessitate technical capacities of key stakeholders to be enhanced. This includes those in charge of developing and implementing policies and regulations such as ministries and government agencies, to non-government organizations and private sector actors. Building capacities of key stakeholders would allow them to make informed decisions for the deployment of climate friendly technologies in terms of policy making, development of business strategies, as well as general technical knowledge for end-use.

Finally, as with most developing countries, the transfer of advanced technologies usually translates into higher investment costs. In order to overcome the financial barrier that low carbon technologies face, there is a clear need to introduce financial mechanisms and incentives in order to derisk investments associated with the risk in transferring these technologies.

Annex 1 – list of prioritized technologies

Sector	Technology
Energy	1. National grid assessment and electricity grid upgrade
	2. Various applications of solar PV technologies
	3. Energy efficiency
	4. Solar water heating
Agriculture	1. Climate smart agriculture (precision agriculture)
	2. Efficient irrigation
	3. Resilient animal fodder
	4. Conservation agriculture
	5. Water harvesting
Water and wastewater	1. Rainwater harvesting
	2. Water resources monitoring technologies
	3. Wastewater collection and treatment plants and advanced wastewater treatment technologies
Transportation	1. Upgrade of the existing vehicle fleet
	2. Public transportation (modal shift)
Solid waste	1. Waste sorting
	2. Composting
	3. Recycling
Others	1. Provision of beach nourishment, reclamation and beach drift rehabilitation
	2. Development of water, food and sanitation monitoring and safety systems using high technology related to health

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