TNA-Project-Jordan

Report I

Technology Needs Assessment

Prepared by

Water Food & Energy for Env. Res. Mgmt. Co.

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List of Acronyms

ASEZA	Aqaba Special Economic Zone Authority
BUR	Biennial update Report to UNFCCC
CBOs	Community-based Organizations
CDM	Clean Development Mechanism
CEGCO	Central Electricity Generating Company
COPD	Chronic Obstructive Pulmonary Diseases
CORDEx	Coordinated Regional Climate Downscaling Experiment
DEM	Digital Elevation Models
DNA	Designated National Authority
FDI	Foreign Direct Investment
GAM	Greater Amman Municipality
GCM	Global Circulation Model
GFJW	General Federation of Jordanian Women
HFDB	Jordan Hashemite Fund for Development of Jordan Badia
HFO	Heavy Fuel Oil
IMF	International Monetary Fund
INDCs	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
JMD	Jordan Meteorological Department
JNFW	Jordanian National Forum for Women
JOHUD	Jordanian Hashemite Fund for Human Development
JVA	Jordan Valley Authority
LEDs	Low Emission Development Plans
LFA	Logical Frame Analysis
LULUCF	Landuse, Landuse Change and Forestry
MEMR	Ministry of Energy and Mineral Resources
MIC	Ministry of Industry and Commerce
MoA	Ministry of Agriculture
MoEnv	Ministry of Environment
MOH	Ministry of Health
MoPIC	Ministry of Planning and International Cooperation
MoSD	Ministry of Social of Development
MoT	Ministry of Transport
MOTA	Ministry of Tourism and Antiques
MRV	Monitoring, Reporting and Verification
MWI	Ministry of Water and Irrigation
NAMAs	Nationally Appropriate Mitigation Actions
NCARE	National Center for Agricultural Research & Extension Center
NCCC	National Committee on Climate Change
NCSA	National Capacity Self-Assessment
NEEDS	National Environmental and Economic Development Study
NEPCO	National Electricity Power Company
PAs	Protected Areas (PAs),
PMR	Partnership for Market Readiness
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
RSS	Royal Scientific Society
SBA	Stand-By Arrangement
SCAs	Special Conservation Areas
SEPGCO	Al-Samra Electric Power Generation Company
SPI	Standardized Precipitation Index
STI	Science, Technology and Innovation

TNC	Third National Communication Report to UNFCCC
UNFCCC	United Nations Framework Convention on Climate Change

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EXECUTIVE SUMMARY

Jordan, despite of its significant socio-economic challenges, is yet a regional pioneer in its climate change combat efforts. Jordan is embarked on an integrated approach to address the issue of climate change. Aa a major step in its path of addressing the affairs of climate change, Jordan has developed and launched in 2013 the holistic *Climate Change Policy of the Hashemite Kingdom of Jordan (2013-2020)*; the first of its kind in the Arab Region and the Middle East.

In December 2014, Jordan finalized and submitted its Third National Communication (TNC) Report to the UNFCCC and started preparation for the first Biennial Update Report (BUR), which is expected to start in early 2016. In addition, Jordan has recently (May 2015) launched a new national vision and strategy (*Jordan Strategy and Vision 2025*) which sets out long term policy goals for economic and social development addressing indirectly some climate change adaptation and mitigation-related targets mostly in the energy, water and agriculture sectors.

Finally, in September 2015, Jordan demonstrated a good example of its commitment to making a contribution to global efforts to combat climate change and reducing GHG emissions by submitting its ambitious *Intended Nationally Determined Contribution (INDC),* which sets targets for reducing its GHG emissions by 14% in 2030 compared to its baseline scenario. Although this pledge is considered conditional (12.5% of the target vs unconditional percentage of 1.5) depending on international support and availability of implementation means including technology transfer, it is believed the country can still present more, if means of implementation, with emphasis on finance and facilitation of technology transfer, are made available to the country.

Based on the base year 2006, Jordan's greenhouse gas emissions is 28,717 Gg of CO_2 eq. The Country's total share of GHGs represents only around 0.06% of global total according to a global GHG analysis conducted in 2010. The CO_2 metric tons per capita emission is 3.4 in 2010. Energy (including transport)-related activities have the dominant share of GHG emissions in Jordan totaling 73% followed by almost close percentage totaling 10% and 9% for both waste and industrial activities respectively. Activities from Agriculture and LULUCF have the lowest, also close percentages, of 5% and 3.0 % respectively. These emissions are expected to grow according to the 2006 baseline scenario used in the TNC (2014) to 38,15 Gg, 51,03 Gg and 61,57 Gg of CO_2 eq. in the years 2020, 2030 and 2040 respectively due to normal growth models. It is obvious that Energy and Transport sectors are the dominate contributors to the bulk GHG emissions in Jordan. The role of the energy sector and sub-sectors (including transport) as the leading emitter of GHGs is expected to increase in the future from 73 % of total emissions in the year 2006 to 83 % in the year 2040 according to a BAU scenario. Therefore, it is anticipated to focus the mitigation efforts of the Country on these two sectors. Thus, it was expected that these two sectors will be the focus of the national stakeholders with regard to TNA consideration.

Even though historically Jordan was amongst the most active countries in the region with regard to involvement in international climate change efforts and response actions, however, Jordan, as a non-Annex I country, has, so far, no commitments for GHG emission reduction targets. Nevertheless, Jordan believes that there is a large potential for mitigation to contribute to international climate change combating efforts, even though Jordan's total GHG emissions are very small in absolute terms compared to other countries as indicated above. Climate change is expected to affect sustainable development, economic growth and society in Jordan. Based on outcomes from the latest TNC Report to UNFCCC (2014), serious vulnerability and impacts results are expected based on modeling and projections analyses. Predicted trends indicated that the annual precipitation tends to decrease significantly with time. Simultaneously, the mean, maximum and minimum air temperature tends to increase significantly by 0.02, 0.01, and 0.03 °C/year, respectively. On the other hand, the relative humidity tends to increase significantly by an average of 0.08%/year. In addition, the dynamic projections predicted more extremely likely heat waves and likely drought events, dry days, and potential evaporation among other potential impacts (TNC 2014).

With regard to mitigation of GHGs and adaptation to climate change in Jordan, the currently operational master plan is the *National Climate Change Policy 2013-2020*. The Policy advanced concrete strategic objectives, measures, and instruments to both cut the levels of GHGs in most polluting sectors (Energy, Transport, Waste, Industries, and Agriculture/LULUCF) and to adapt the country to climate change impacts in each vulnerable sector (Water, Coastal Areas, Agriculture/Food Security, Health, Tourism, Biodiversity, and Socioeconomic/Poverty).

The TNC 2014 report fully assessed the GHG emissions levels and predicted trends for mitigation sectors as well as the vulnerability of Jordan to climate change and proposed adaptation measures. Thus, this TNA Report will present here only the summary of results of the vulnerability assessment and proposed adaptation measures for the whole group of sectors vulnerable to climate change. The TNC 2014 report applied a robust methodological framework that relied on two main pillars (i) a qualitative and quantitative climate change impact and vulnerability assessment (CCIVA) and (ii) identification and prioritization of adaptation for all the prioritized regions and sectors. For example, based on the climate trends analysis conducted in the TNC assessments, the main climate hazards that the water sector faces in Jordan are temperature increases, precipitation decreases, increased incidents of drought and increased evaporation. Climate sensitivity indicators in water sector were determined as reduced groundwater recharge, groundwater quality deterioration, stream flow reduction and increased water demand.

In the context of assessing the two main mitigations sectors (energy and transport), it is worth mentioning that the demographic characteristics of the Jordanian population show that the Jordanian development process faces a challenge in providing basic needs in such a developing country. The high annual growth rates of demand for energy for the period 2015-2025 remains one of the highest in the world and thus is considered one of the Kingdom’s most significant development challenges. In 2013, total primary energy consumed in Jordan was about 8.2 million tons of oil equivalent, 82% of which were crude oil and oil derivatives, 11% natural gas, 3% renewable energy and imported electricity and 4% petroleum coke and coal. The national energy sector’s main concern is the provision of adequate energy for development with the least possible cost and best quality. The energy sector still suffers from extreme fluctuations of oil prices and the ability to secure constant and sustainable energy supply for the country. The running policy of the GoJ in the field of energy was shaped through the adoption of the *Updated Master Strategy of Energy Sector in Jordan for the period 2007-2020*. The main goals of the Strategy are to secure reliable energy supply through increasing the share of local energy resources such as oil shale, natural gas in the energy mix, expanding the development of renewable energy projects, promoting energy conservation and energy efficiency and awareness and generating electricity from nuclear energy. The running energy strategy is to transform the energy mix from one heavily reliant on oil and natural gas to one more balanced with a higher proportion of energy supplied by oil shale and renewable sources. The 2012 *Energy Efficiency and Renewable Energy Law* no. 13 is also a key enabler, providing incentives for sustainable energy solutions as Jordan seeks to increase renewable energy from 2% of overall energy in 2013 to 10 % in 2020, and to improve energy efficiency by 20 % by 2020. However, the influx of Syrian refugees into Jordan has increased the demand for energy and electricity. In addition to long-standing structural challenges in the energy sector in terms of supply, demand as well as management, Jordan also faces exacerbating factors resulting from the increase of Syrian refugees, who comprise nearly 13 % of Jordan’s 9.5 million population. Although Syrian refugees and forced migrants fall within the lower-income bracket and average energy consumptions remain less impactful on the broad energy challenges in Jordan relative to core energy users in the Country, total residential energy consumption has risen significantly.

From another perspective, the development of industrial and services sectors in Jordan, accompanied with the increase of Jordanian population and the increase of numbers of vehicles has resulted in an increase in the GHG emissions and pollution emitted to the ambient air in the last decades. Transport sector in Jordan is a major contributor to increasing emissions of greenhouse gases. With a percentage of 16% of emissions share to the bulk GHG emissions of Jordan, transport sector is the second source (after energy sector emitting 28%) of GHG emissions in the country. The Ministry of Transport (MoT) launched a long-term national strategy 2014 in which the sustainable transport is one of its pillars. Mobility of people and freight is a widely shared goal amongst transport policy makers in Jordan; therefore, the MoT is obliged to form its policies in line with sustainable transport trend. One of the major objectives of the long-term transport strategy at MoT is to increase the total number of commuters using public transport. MoT believes it is important to reduce all emissions from transport sector (i.e. CO_2, CO, PMx, NOx expressed in tons per day). On the other hand, serious measures are being taken to implement the national railway system, which would be a cornerstone of the planned multimodal network that would play a major role in the ease of the transport of goods within the country and the surrounding region. With such system in place, the reductions of emissions from these activities are obvious.

Water resources in Jordan are vulnerable to climate change. Previous studies, strategic documents (i.e. Jordan's SNC report (2009), National Climate Change Policy of Jordan (2013) and the TNC (2014) report have all identified scarcity of water resources as one of the major barriers facing sustainable development in Jordan; a situation that will be magnified by climate change. Expected reduced precipitation, maximum temperature increase, drought/dry days and evaporation are the main expected impacts of climate change hazards. The impact of the increased evaporation and decreased rainfall will result in less recharge and therefore less replenishment of surface water and groundwater reserves. In the long term, this impact will extend to cause serious soil degradation that could lead to desertification, exacerbating future conditions and worsening the situation of the agricultural sector due to the lack of sufficient water. This will affect the income of the agriculture sectors to the national economy. Low income will ultimately reduce the ability to the adaptation to climate change with families unable to respond to the pressing needs for replacing traditional water supplies with new methods that require more spending (purchasing drinking water from tanks). In addition to climate change the increased demand for water in Jordan during the last decade has contributed significantly to reducing per capita shares.

With regard to agriculture on the other hand, the Jordanian agricultural sector is established along three major climatic regions: the lowlands (Jordan Valley) that thinly stretches from the northwest to the southwest, the highlands and Marginal steppe where most of the rain-fed farming is practiced, and Badia (or desert) mostly livestock systems and some cultivation in watershed and from deep bore irrigation. Agriculture (animal and crop farming) is mostly influenced by water availability and the ability to adopt advanced water harvesting and to use technologies and interventions to mitigate the impact of the climate change.The contribution of agriculture to GDP has declined in relative terms from 20% in 1974 to less than 2.9% in 2011 while its contribution in absolute terms has increased (e.g. from JD 57 million in 1974 to JD 598.3 million in 2011. The importance of the agricultural sector stems from the fact that it is not only the major source of food items especially dairy products, fruits and vegetables, but also one of the sources of hard currencies originated from exports. About 25% of the total poor in Jordan live in the rural areas depending mostly on agriculture (livestock keepers, smallholder farm households and landless former agriculturalists), and in spite of poor motivation of the rural youth, agriculture is an important employer of the rural communities. The poor in rural areas in Jordan are expected to face the most severe consequences of climate change through disruption of livelihood options that depend on natural resource management. The expected impacts of climate change, particularly reduced agricultural productivity and water availability, threaten livelihoods and keeps vulnerable people insecure. Poor families and households are the most vulnerable group to the potential impacts of climate change.

The agricultural area in Jordan varies from one year to another depending on the rainfall amounts and available water resources. In view of the increasingly competitive demand for water magnified by the impact of the impeding climate change, there is a pressing need to develop and adopt innovative approaches and technologies that would address such challenges. Some of the approaches include the maximization of water use efficiency; crop diversification and cultivation of high value crops that promote competitive local and international markets while replacing crops that use proportionately higher amounts of water; development of food and feed crop varieties that are tolerant and adaptive to climate change; and enhancement of the integration and complementarity between crop and livestock production systems.

Areas under marginal rain-fed production will have less adaptive capacity than areas that are more productive and categorized as irrigated agricultural land. In addition, financial resources are one of the key factors in determining adaptive capacity, as most planned adaptations require investments. By that measure, Jordan ranks relatively low in overall adaptive capacity in the agriculture sector. Finally, agricultural systems that are poorly adapted to current climate conditions are indicative of low adaptive capacity to future changes in climate conditions.

Having all of this in mind, The TNA Project advanced by United Nations Environment Program (UNEP) and implemented through a partnership between UNEP and Technical University of Denmark (DTU), the UNEP-DTU activity comes at the right time to the Country to facilitate assessing mitigation and adaptation technology needs in a systematic approach. With regard to the TNA Project in Jordan and the national team structure, the *National Committee on Climate Change (NCCC)* will serve as the *Steering Committee* of the Project. All relevant national institutions involved in climate change policy development in Jordan are forming together the NCCC. However, to support the objectives of the TNA Project and to enrich the discussion about climate change technology needs and be involved in baseline assessments, two *Technical Working Groups* (one for mitigation and the other for adaptation) were established to complement the TNA Team. The TNA activity was systematically conducted through a country-driven process, involving all relevant stakeholders and taking national sustainable development priorities into consideration. This criterion was further subdivided into sub-criteria such as sector's national priority in the general sustainable development context of the country (persistent position of the sector); national priority in particular national sustainable development and planning documents. Thus, the TNA Team in Jordan made sure that in addition to taking all relevant sustainable development priorities into consideration that the TNA is also conducted based on extensive participatory process involving all relevant stakeholders, with emphasis on involving the two *Technical Working Groups*. Thus a very wide rainbow of stakeholders were involved spanning governmental agencies, academia and research centers, NGOs, (mainly institutions members of the NCCC) as well as another pool of relevant stockholders from business, customs, tax, standards, etc.

The national stakeholders were involved so far in two phases of consultation. In the first phase, the launching of the TNA project in Jordan took place (Nov 17th, 2015) where the workplan of the assignment was presented and discussed to obtain feedback from stakeholders on methodology and stakeholders groups to involve. In the same day, three exercises were conducted involving all attendees. The first exercise was for selection of priority mitigation and adaptation sectors for TNA, which was based on conducting another dedicated multi criteria analysis (MCA) exercise prepared purposely for this step utilized in addition to the standard MCA form proposed by UNEP-DTU for priority technologies selection. This sector selection MCA exercise executed during the Inception/Launching Workshop of the TNA Project in Jordan created serious and fruitful discussions lead to rational and fair selection to top priority sectors. The Launching Workshop was patronaged by H.E. Secretary General of Ministry of Environment who bestowed a gesture of political commitment and buy-in of provisions and outcomes of the project from the highest political position in the chain of command in the Ministry of Environment (MoEnv). During the Launching Workshop, the priority mitigation as well as adaptation sectors for technology needs assessment were concurrently determined in a dedicated national exercise in coordination with MoEnv to determine most important sectors in terms of the highest GHGs mitigation potential as well as the sectors of most vulnerability and impact due to climate change. The Sector Selection MCA in terms of criteria used for national stakeholders' discussions and structure of the exercise sheets as well as scoring system were brainstormed and prepared carefully by the team of consultants of this study in a dedicated meeting set specifically for this purpose in advance of meeting with stakeholders.

The MCA for selection of priority mitigation sectors was based on key criteria such as levels of greenhouse gas emission and mitigation actions viable while on the other hand MCA for selection of priority adaptation sectors was based on main criteria relevant to urgency of technology needs and risk of delay of action as relevant to vulnerability. The common criteria between the two MCAs were: the position of the targeted sector with regard to national priority to sustainable development; economic aspects, social impact, readiness of sector and level of current planning, implementation experience, sustainability potential, and financing factors.

The two MCA exercises revealed that the two top mitigation priority sectors with regard to technology needs are *Energy* and *Transport,* while on the other hand the two top adaptation sectors selected were *Water* and *Agriculture* based on the selection process by stakeholders representing all mitigation and adaptation sectors in the country. This conclusion was not unexpected in light of the current status of the energy and transport sectors as the two most emitters of GHGs as indicted in the beginning of this section and their critical implications with regard to sustainable development. The same conclusion is valid for water and agriculture sectors as they are the two sectors most vulnerable to climate change as shown in the extensive assessments conducted in the national studies, mainly the TNA study (2014) as mentioned above.

After the two top priority sectors for TNA were identified for mitigation (Energy and Transport) and adaptation (Water and Agriculture), the second exercise conducted on the Inception Workshop day was Stakeholder Identification and Involvement/Engagement Plan. In this context, the stakeholder pools who should be involved in the next phase of the project (technology prioritization) were brainstormed and discussed, taking into consideration that stakeholders are different in nature since they represent different interest groups. Thus, the different roles of stakeholders along the various steps of the implementation in the TNA project were discussed. Stakeholders participated in this exercise agreed that identifying and distinguishing all relevant stakeholders of the project at a very early stage of the TNA process is very important for successful involvement and engagement during the crucial steps of barrier analysis and the development of a technology action plan that is feasible and action-oriented.

In the third exercise conducted on the Inception Workshop day involving all national stakeholders, a random listing of potential technologies under each selected sector was conducted. This was done to initially identify the long list of technologies, which need in the consequent steps further investigation and description as well as developing a mechanism to select the top (6 to 15) priority technologies for each selected sector based on a robust approach. After this, the consultants embarked on assessing the potential focused list of technologies and started preparing a fact sheet for each priority technology to facilitate the stakeholder consultation for technology selection. The technology factsheets included the basic information about the technology options, including brief description of the technology, application potential in the country, costs (capital and operation), technical aspects (geographical applicability range, maturity), and the environmental, social, and economic impacts/benefits of their application in the country. Most importantly, the fact sheets encompassed specific sector-related criteria such as contribution to sustainable development by minimizing GHG emissions from the sector (for mitigation sectors) and maximizing the resilience and adaptation of the sector to climate change impacts (for adaptation sectors). Such information was provided to the stakeholders prior to the Adaptation Technical Working Group Meeting and the Mitigation Technical Working Group Meeting held on 24th and 25th of November 2015 respectively so that stakeholders were able to compare the different options using multi-criteria analysis in their next meeting.

In phase two of the stakeholders' involvement, Mitigation and Adaptation Technical Working Groups were invited in the two-day workshop mentioned above to discuss and prioritize technologies based on the set criteria for each sector. Results of the four MCA exercises revealed the following order for technologies in terms of priority. The top three mitigation technologies for energy sector are (1) Solar Thermal; (2) PV for Water Pumping; and (3) PV for Electrification. The three top-ranked technologies for Transport Sector were (1) Bus Rapid Transport; (2) Promoting Bikes; and (3) Ticketing System for Public Transport. However, due to the dissatisfaction the team of the study felt all the time later on after preparing this report over the weak participation of directly involved transport experts in the workshop held for transport sector on the 25th of November 2015 due to their busy schedules, it was decided later on to remove this guilt feeling and re-do the transport sector's technology prioritization activity after emphasizing the invitation and confirmed attendance of highly involved transport sector experts. Thus, this transport sector's technology re-prioritization workshop was re-organized on Sunday 27th of March 2016 at Land Transport Regulatory Commission and a big group of directly involved transport sector attended and successfully conducted the re-prioritization exercise. This time the following transport mitigation technologies came as top three: (1) Bus Rapid Transit; (2) Improving pedestrian infrastructure; and (3) Ticketing System.

The final results for water sector adaptation technologies of top three priorities are (1) Rainwater Harvesting; (2) Water Users Association; and (3) Desalination/Brackish Water Treatment and Re-use. Finally, the final results for agriculture sector adaptation technologies of top three priorities were (1) Support of Water Saving Technologies, such as Drip or Subsurface Irrigation, (2) Water Harvesting, and (3) Promoting Plant Varieties Resistant to Climate Change.

It is clear that water harvesting, for example, was a joint priority adaptation technology in both water and agriculture sectors, which reveals the critical importance of this technology to Jordan and indicates in the same time the robustness of perceiving a holistic approach for rainwater harvesting at the watershed level and the farm-level. We believe national stakeholders will keep the same level of effective involvement and enthusiasm bestowed in this phase of the project in the coming phase of the project to carry on barrier analysis and enabling framework (BA & EF) to assess obstacles and limitation to maximize and enhancing deploying such technologies effectively and systematically to deal with climate change.

CHAPTER 1 INTRODUCTION

1.1 About the TNA Project

It is clear that since the entry of the UNFCCC into force in 1994, Jordan took serious steps to fulfil its obligations to the convention. The fulfilment of the national obligation to UNFCCC implies that Jordan should have the human, organizational, institutional, technological, and financial resources for developing the required tasks and functions on a permanent basis. However, the lack of dedicated and best industry-based studies to assess, in particular, climate change technology needs in the sectors of most high levels of GHG emissions and those most vulnerable to impact of climate change is obvious. There is big need for conducting a systematic assessment of the country's needs for efficient and environmentally friendly technologies to backstopping Jordan's capacities in identifying and deploying the appropriate mitigation and adaptation technologies. Thus, this project in hands, the TNA Project of Jordan, sponsored by GEF and implemented by UNEP-DTU Partnership and executed by MoEnv in Jordan, comes at the right time to fill the technology gap and to complement the integrated approach Jordan is following to address the impacts of climate change.

Jordan, regardless of its relatively small amount of greenhouse gas (GHG) emissions (estimated to be 28.7 Mt CO_2 eq. in 2006), which amount to less than 0.1% of global emissions, and despite of the country's significant socio-economic challenges, the country is yet a regional pioneer in its climate change combat efforts. Jordan is embarked on an integrated approach to address the issue of climate change. As matter of fact, Jordan has made significant contribution to the global climate change mitigation and adaptation priorities agenda. Jordan was among the very first countries in the region to ratify (in November 1993) the UNFCCC before entering into force in March 1994. In 1996 Jordan, supported by the GEF project "*Building Capacity for Inventory and Action Plans in the Hashemite Kingdom of Jordan in Response to UNFCCC Communications*," developed the 1st National Communication Report to UNFCCC and the submission of the report took place in January 1998. At that time, Jordan was the first non-annex 1 country that submitted its first national communication report to UNFCCC. The major output of the 1st communication report to UNFCCC was the collation of the inventory of all GHGs sources and sinks for the first time in the country.

After completion of the 1st National Communication Report to UNFCCC, the pioneering study "*Vulnerability and Adaptation to Climate Change*[1]" was carried out concerning the potential effects of climate change on water resources. Few years later, Jordan formed the National Committee on Climate Change (NCCC) as early as 2001 by a decree of the Cabinet. In January 2003, Jordan made an accession to the Kyoto Protocol. Thus, a national entity, Designated National Authority (DNA), was formed to develop project proposals and initiatives for the Clean Development Mechanism (CDM) with accordance to a DNA. However, only four projects were implemented due to many reasons, which are beyond the context of this report.

In 2004, Jordan has started the second phase of the GEF project "*Building Capacity for Inventory and Action Plans in the Hashemite Kingdom of Jordan in Response to UNFCCC Communications*." The main objective of the enabling activity project was to build Jordan's capacity in the following areas: (i) **technology transfer**, (ii) define baseline parameters, and (iii) national legislations. The technology report produced out of this 2004 project was simple but weak and did not follow a systematic perspective based on best practice methodologies for such type of activities. It was mainly based on requesting stakeholders to filling out a a simple questionnaire targeting decision makers and technical people at industrial establishments to address the local needs and conditions with the objectives of raising the capacities for suitable technology transfer. The stakeholders surveyed included facilities of economic activities related to mining, transforming, and electrical supply and the focus of questions was on machines used, their age, intent to replace and search for newer technologies, alternative materials, amounts of wastes and pollution to air produced by the interviewed personnel in charge at such facilities and methods of handling the wastes. The study encompassed methods of energy saving (such as thermal insulator for walls).Thus, sectors that thought to have greatly contributed to consumption of energy were determined, which were Industrial Sector, Waste Sector, Energy Sector, and Transportation Sector. The report suggested a random list of recommendation-style actions to be taken to limit the contribution of such sectors to GHG emissions. The

[1] Date of this study is unknown as no proper documentation was kept.

perspective focused on technology changes in work places and diversifying energy sources such as using renewables and also improving primary and raw materials. In summary, the identification of technologies in the said study did not follow any criteria-based analyses and was based on the judgment of interviewed stakeholders. The report addressed training needs and staff existing level of qualifications, governing legislations, which might increase transfer of technology and potential of partnership between public and private sectors in this regard. The report mentioned some difficulties facing technology transfer. The report ended up with a general conclusion concerning the importance of technology to production and that, in order to benefit from such technology, it is important to seek technology that suits the Country's conditions and capabilities in terms of using local resources, suits available capital, and that suits the behavior of local individuals. According to the said report, even if suitable technology was transferred, it still requires the availability of enough scientists, scientific knowledge, and trained employees who are ready to use this technology. Moreover, the report stated that it will also require the availability of suitable, efficient and scientific administration to achieve objectives of the initiative. Finally, the said report concluded with the general statement that it became an urgent need to use science and technology in limiting greenhouse gases emissions by using industrial technologies that are environmentally friendly, clean, produce small amounts of waste and recycles produced wastes[2].

However, a major step in its path of dealing with climate change, Jordan in 2007 prepared the *National Capacity Self Assessment (NCSA) for Global Environmental Management* study with emphasis on identifying constrains for implementing Rio Conventions. The NCSA process was conducted in a participatory way and facilitated a national dialogue that resulted in a robust package of suggested strategic capacity building activities in the form of the NCSA capacity building action plan. The constraints were classified at the institutional, legislative, financial and technical (including technology) levels. Proposed projects were formulated within a logical frame analysis (LFA) to alleviate these constraints. However, from the NCSA, almost only one project has seen the light namely the project "*Developing Policy-relevant Capacity for Implementation of the Global Environmental Conventions in Jordan"* (shortly known as the *CB-2 Project*) executed from 2010-2013. The *CB-2 Project* exerted distinguished efforts to link climate change research with policy making. The *CB-2 Project* also supported re-establishing (re-structuring and diversifying) and most importantly re-energizing the NCCC, which was formed, as indicated above, back in 2001 but was inactive all that time period. The NCCC now has a mandate and is effectively involved in all climate change initiatives and activities in the country.

Parallel with that, (2009-2013) a joint program titled "*Adaptation to Climate Change to Sustain Jordan's MDG Achievements*" was implemented. The Programme's main goals were (i) developing sustained access to improved water supply sources, despite increasing water scarcity due to climate change and (ii) strengthening the capacity for health protection and food security under conditions of water scarcity. The 2010 as well witnessed the advancement of some other important actions and studies when Jordan associated itself to Copenhagen Accord and prepared the "*National Environmental and Economic Development Study* (NEEDS) *for Climate Change*[3]" which was submitted to UNFCCC in that year. The association to Copenhagen Accord was subject to the availability of funds, technology transfer and capacity building. Also, a number of projects were identified and listed in the letter of association.

In November 2011, the Adaptation Fund Board decided to accredit the Ministry of Planning and International Cooperation (MoPIC) as the National Implementing Entity in Jordan for the Fund. The Executing Entities for the Fund are: Jordan Valley Authority (JVA)/Ministry of Water and Irrigation (MWI); Jordan Hashemite Fund for Development of Jordan Badia (HFDB); National Center for Agricultural Research & Extension Center (NCARE); Ministry of Environment (MoEnv); and Ministry of Agriculture (MoA). These institutions are in the process of developing their own climate change adaptation actions, which will require taking their technology needs into consideration as such technical aspects are expected to develop in line with implementation plans.

In April 2012, the World Bank started the Partnership for Market Readiness (PMR) exercise in Jordan. The project aims at developing Jordan's market-based instruments (MBIs). The latest action of the project was

[2] Jordan Ministry of Environment, 2004, Building Capacity for Inventory and Action Plans in the Hashemite Kingdom of Jordan in Response to UNFCCC Communications Project (MoEnv, 2004).

[3] Jordan Ministry of Environment (2010), National Environmental and Economic Development Study for Climate Change: Jordan National Report, Submitted to the United Nation Framework Convention on Climate Change, (MoEnv, October 2010)

developing a Market Readiness Proposal (MRP) to request fund (usually in the scale of 3 millions) from the PMR's Assembly. The submitted (in Oct. 2015) MRP of Jordan revealed that the country is at an early stage of market readiness to implement any kind of a market-based instrument, particularly when compared to major emitters and PMR peer countries. This low level of readiness includes institutional and technical (including technological) readiness, mainly among the key public sector bodies, and lack of institutional frameworks. Equally, however, these readiness challenges also exist within the private sector, which is endeavoring to deliver a pipeline of low carbon activities in renewable energy and energy efficiency. The key challenges include lack of financial, technical and human resources. However, a major outcome of the PMR Project in Jordan will be the development of Jordan's' first *Monitoring, Reporting and Verification (MRV)* system for GHG emissions. Jordan still lacks a national system to guarantee and facilitate the production, exchange and analysis of such data. There is still no sector-level source for MRV of GHG emissions. The various features of CDM, NAMAs, LEDs, PMRs, INDCs[4] and other mitigation tools make it difficult for a holistic planning perspective in climate change mitigation. Thus, there is still big need for "a central hub for collecting, processing, archiving and reporting of GHG inventories[5]".

Most importantly in its path to combating climate change, Jordan has developed and launched in 2013 as one activity of the CB-2 Project featured above the holistic ***Climate Change Policy of the Hashemite Kingdom of Jordan (2013-2020)***; the first of its kind in the Arab Region and the Middle East. The Climate Change Policy of Jordan is considered the first national-level comprehensive planning document to deal with the global phenomenon of climate change in a holistic and integrated approach in the country. The National Climate Change Policy for Jordan is a road map for the 2013-2020 period. Parallel with the Policy development, in December 2014, Jordan finalized and submitted its *Third National Communication (TNC) Report to UNFCCC* and started preparation for first biennial update report (BUR), which is expected to start in late 2015/early 2016. In addition, Jordan has recently (May 2015) launched a new country-level vision and strategy (*Jordan Strategy and Vision 2025*), which sets out long term policy goals for economic and social development addressing indirectly some climate change adaptation and mitigation-related targets mostly in the energy, water and agriculture sectors. Finally, in September 2015, Jordan demonstrated a good example of its commitment to making a contribution to global efforts to combat climate change and reducing GHG emissions by submitting its ambitious *Intended Nationally Determined Contribution (INDC),* which sets a determined target of reducing its GHG emissions by 14% in 2030 compared to its baseline scenario. Although this pledge is considered conditional (12.5% of the target) on international support and availability of implementation means including technology transfer, it is believed the country can still present more if means of implementation, with emphasis on finance and facilitation of technology transfer, are made available to the country.

The TNA is a global activity of UNEP and UNEP-DTU Partnership (UDP) is the main entity involved in the implementation of this a global project funded by the Global Environment Facility (GEF). The TNA Phase I project was implemented between 2009 and 2013 in 36 countries. The TNA process is typically country driven and stakeholder consultations are highly emphasized in the approach of this activity. Therefore, UDP developed robust guidance documents and notes to guide the national institutional structure within the countries to support countries in Phase I. The note was based on the experiences of UDP experts who took part in discussions and missions to the countries of Phase I. The note has now been revised further for Phase II of the TNA, which started in November 2014, of which Jordan is a participatory country, on the basis of learning from Phase I.

The guidance prepared by UDP illustrates clearly the approaches and schemes to follow in building the institutional structure proposed for implementing TNA. The National TNA team will generally be responsible for conducting the TNA within the countries. The National TNA team comprises the National TNA Committee, National Consultants/Experts, Workgroups, and TNA Coordinator. In accordance with the said guidance materials, the suggested roles for each will be outlined below. Following the systematic approaches of the TNA, the national capacity on climate change technology needs assessment as related to mitigation of GHGs and adaptation to climate change will be strengthened, as the national TNA

[4] CDM (clean development mechanism); NAMAs (Nationally Appropriate Mitigation Action), LEDs (low-emission development strategies), PMR (Partnership for Market Readiness), INDCs (Intended Nationally Determined Contributions)

[5] Market Readiness Proposal (MRP) of Jordan to World Banks' Partnership for Market Readiness' PA, MoEnv, Oct 2015.

coordinators and consultants would receive training at the regional capacity building workshops on methodologies and tools for conducting TNA.

In Jordan, the agreement between UNEP-DTU Partnership and Jordan Ministry of Environment was signed in August 26th 2015. The structure of the national team proposed for implementing the TNA of Jordan was formulated afterward. This report will present the national climate change context of the country, the process followed in building the TNA team, selecting national consultants, conducting national stakeholders' involvement and consultation workshops, and results of sector as well as technology prioritization.

1.2 Existing National Policies related to Technological Innovation, Mitigation of Greenhouse Gases, Adaptation to Climate Change and Development Priorities

1.2.1 National sustainable development circumstances and challenges in Jordan

Jordan is classified as an upper middle-income country. It is affected by its geography, history, geopolitics and most importantly scarce natural resources. The government identified poverty and unemployment as two of the most important challenges the country faces in addition to energy demands and water scarcity. Before elaborating on the GHGs growth patterns and mitigation potential as well as vulnerability of the Country to potential impacts of climate change, it is important to present some information about Jordan especially in light of current development priorities and challenges impacted by economic and regional political situation.

Located in the Middle East (Figure 1), the overall population of the country is around 9.5 million (of which about 3 million are non-Jordanian) according to very latest census conduced at the end of 2015 and results released in Feb 2016. The population of Jordan was affected by political unrest in the region, thus the country witnessed numerous waves of refugees fleeing to the country from surrounding countries with civil strife. Most obviously since 2011, there has been a significant increase in the population due to Syrian crisis and resulting huge number of refugees, which are alone estimated in Jordan to be around 1.4 million[6]. This huge influx of refugees is placing additional strains on Jordan's already stressed scarce water and energy resources and has put additional pressure on resources and waste management, transport and other services.

Figure 1 Map of the Jordan and the surroundings

[6]Jordan's Intended Nationally Determined Contribution (INDCs) to UNFCCC, 2015

The Market Readiness Proposal for Jordan to the World Bank's Partnership for Market Readiness (PMR), October 2015, described two successive external shocks - the global recession and the regional turmoil that followed the Arab Spring –and highlighted that the two hard experiences have exacerbated Jordan's long-term structural vulnerabilities[7]. Following the global financial downturn of 2008, growth decelerated sharply. Turmoil throughout the region further undermined Jordan's outlook, which led to (i) slower growth and lower fiscal revenues, and (ii) initially, increased public spending to partly accommodate social pressures. This has resulted in an accumulation of a large public debt, the servicing of which, exacerbates fiscal pressures. In particular, interruptions started in 2011 in the Egyptian natural gas supply, which in 2009 fueled about 90 percent of Jordan's power generation, forced the country to increasingly rely on more expensive and less efficient diesel and heavy fuel oil (HFO) during a time of high oil prices. The Government's initial decision not to pass-through the higher fuel costs to final consumers resulted in a significant increase in the National Electricity Power Company's (NEPCO) operating losses. As a result, NEPCO has been running deficits equivalent to around 4-5 percent of gross domestic product (GDP) per year since 2011 and has accumulated total operating losses of about JD4.7 billion by end of 2014, for which debt servicing has until recently been directly covered by the budget. As a result, gross public debt has risen rapidly and is estimated to have reached around 90 percent of GDP at the end of 2014. The unsustainably high cost of energy subsidies has led the Government to embark on a major subsidy reform program supported by the International Monetary Fund Stand-By Arrangements (IMF-SBA) which, in November 2012, completely eliminated subsidies on petroleum products (except for Liquefied Petroleum Gas (LPG) cylinders mainly used for household cooking). The Government is also implementing a five year electricity tariff adjustment plan that aims at enabling NEPCO to reach full cost recovery by 2017. To promote energy security and reduce cost of electricity supply, the Government is also seeking to diversify its energy sources by scaling up renewable energy and developing a Liquefied Natural Gas (LNG) terminal in Aqaba, which became operational in July 2015.

The demographic characteristics of the Jordanian population show that the Jordanian development process faces a challenge in providing basic needs in such a developing country. The high annual growth rates of demand for energy (4-5% for primary energy and 5.3% for demand for electricity) for the period 2015-2025 remains one of the highest in the world and thus is considered one of the Kingdom's most significant development challenges. In 2013, total primary energy consumed in Jordan was about 8.2 million tons of oil equivalent, 82% of which were crude oil and oil derivatives, 11% natural gas, 3% renewable energy and imported electricity and 4% petroleum coke and coal. The national energy sector's main concern is the provision of adequate energy for development with the least possible cost and best quality. The energy sector still suffers from extreme fluctuations of oil prices and the ability to secure constant and sustainable energy supply for the country. While Jordan has achieved many sustainable development goals, sustaining these results and reducing the burden of the energy sector on economic and social development will increasingly depend on the transition to a sustainable energy future[8]. The high cost of importing energy puts a heavy burden on the public budget already constrained by running costs. Since the prices of energy imports have increased with high risk in constant supplies, this situation spurred governmental action to improve energy efficiency and provide additional energy resources.

The running policy of the GoJ in the field of energy was shaped through the adoption of the Updated Master Strategy of Energy Sector in Jordan for the period 2007-2020. The main goals of the Strategy are to secure reliable energy supply through increasing the share of local energy resources such as oil shale, natural gas in the energy mix, expanding the development of renewable energy projects, promoting energy conservation and energy efficiency and awareness and generating electricity from nuclear energy. The running energy strategy is to transform the energy mix from one heavily reliant on oil and natural gas to one more balanced with a higher proportion of energy supplied by oil shale and renewable sources. The energy strategy sought to increase reliance on local energy sources to 25 % by 2015, and up to 39 % by 2020 as set in 2020 Energy Strategy. Placing more emphasis on the utilization of renewable energies

[7]Market Readiness Proposal for Jordan to the World Bank's Partnership for Market Readiness (PMR), October 2015.
[8]Jordan's INDCs to UNFCCC 2015.

will alleviate the dependency on the traditional energy sources, especially oil, which is imported from neighboring countries. This will also be paralleled with the reduction of energy produced from oil from 82% in 2013 to reach 50% in 2020.

The 2013 Arab Future Energy Index (AFEX) showed that Jordan has made progress in this regard, ranking second in the Arab region for renewable energy trends and the second for energy efficiency. The 2012 Energy Efficiency and Renewable Energy Law no. 13 is also a key enabler, providing incentives for sustainable energy solutions as Jordan seeks to increase renewable energy from 2% of overall energy in 2013 to 10 % in 2020, and to improve energy efficiency by 20 % by 2020. However, the influx of Syrian refugees into Jordan has increased the demand for energy and electricity. In addition to long-standing structural challenges in the energy sector in terms of supply, demand as well as management, Jordan also faces exacerbating factors resulting from the increase of Syrian refugees, who comprise nearly 13 % of Jordan's 6.388 million population. Although Syrian refugees and forced migrants fall within the lower-income bracket and average energy consumptions remain less impactful on the broad energy challenges in Jordan relative to core energy users in the Country, total residential energy consumption has risen significantly.

From another perspective, the development of industrial and services sectors in Jordan, accompanied with the increase of Jordanian population and the increase of numbers of vehicles has resulted in an increase in the GHGs and pollution emitted to the ambient air in the last decades. Transport sector in Jordan is a major contributor to increasing emissions of greenhouse gases. With a percentage of 16% of emissions share to the bulk GHGs of Jordan, transport sector is the second source (after energy sector emitting 28%) of GHG emissions in the country. The Ministry of Transport (MoT) launched a long-term national strategy 2014 in which the sustainable transport is one of its pillars. Mobility of people and freight is a widely shared goal amongst transport policy makers in Jordan; therefore, the MoT is obliged to form its policies in line with sustainable transport trend. One of the major objectives of the long-term transport strategy at MoT is to increase the total number of commuters using public transport. In 2010 this percentage stood at 13 percent, of which 9% were public service taxies. It is anticipated that this percentage would increase by implementing programs and projects that will enhance the quality of service of the whole public transit network to 25 percent by 2025[9]. The environmental sustainability of Jordan's transport strategies are focused on three main aspects, namely *emissions*, *energy consumption*, and *traffic reduction*. MoT believes it is important to reduce all emissions from transport sector (i.e. CO_2, CO, PMx, NOx expressed in tons per day). MoT will also work on reducing percentage of fuel consumption which might be achieved through the implementation of the transport strategy. With regard to traffic reduction, Mot will work on this contribution in terms of reduction of vehicle kilometers traveled (V-km) at national level and in densely populated areas by type of vehicle (i.e. car, HGV, LGV and expressed in 1000v-km per day). MoT believes that introducing higher order public transit systems such as bus rapid transit (BRT) systems is key to improving the transport service in the country. MoT is already taking on the Zarqa-Amman project that would link to the Amman BRT system that is being implemented. Initial steps are being taken to tackle other probable viable routs including Salt- Sweileh-Baqa'a.

On the other hand, serious measures are being taken to implement the national railway system, which would be a cornerstone of the planned multimodal network that would play a major role in the ease of the transport of goods within the country and the surrounding region. With such system in place, the reductions of emissions from these activities are obvious. MoT believes that utilizing latest technology in the transit sector can add to the efficiency of operations; implementing applications that connect taxies to customers for instance can reduce idle time thus reducing energy usage thereby reducing emissions. Adopting and implementing policies related to fleet characteristics would also enhance efficiency and reduce emissions. Issues related to fleet service life, replacement incentives, and reconfiguration of technical elements will have a positive effect on energy consumptions and reducing CO_2 and other greenhouse gases emissions.

Recently, the GOJ launched in mid of 2015 Jordan's 2025 National Visions and Strategy, which charts a path for the future and determines the integrated economic and social framework that will govern the economic and social policies based on providing opportunities for all. Jordan 2025 includes more than 400 policies or procedures with performance indicators (including energy, water, waste, agriculture and other

[9] Jordan's INDCs to UNFCCC (2015)

mitigation-oriented sectoral policies, procedures and indicators) which will lead to reduction of GHGs that will be implemented through a participatory approach between the government, business sector and civil society. Most importantly, the 2025 National Vision and Strategy has set a 11% Key Performance Indicators (KPIs)-style "targets" for renewable energy share in the total energy mix in 2025 as well as increasing the percentage of the contribution of natural gas in the energy mix to 39%.

1.2.2 General Technological Innovation Plans in Jordan

Technology aspects of the development process in Jordan is covered in different sectors' planning documents. For example, one of the seven pillars of the *National Higher Education and Scientific Research Strategy* (2007-2012) was *Technical and Technological Education*. Among the many objectives of the said Strategy were: (1) Developing educational plans and programs and updating them according to requirements of national and Arab development taking into account latest scientific and technological developments and advancements at the international level, (2) upgrading the educational plans and programs of colleges and institutes of Intermediate University Education (community colleges) of high technical and vocational qualifications in line with national and Arab development agendas. Thus, under the *Technical and Technological Education* Axis, one of the three operational objectives was widening the *technological education at the bachelor level*. However, the National Research Priorities 2010-2020[10] of the country developed by *Higher Council for Science and Technology* and *Scientific Research Support Fund* did not bestow special attention to climate change technologies in particular under the research priorities of the *Water and Environemnt* area. Under "*Impacts of Climate Change on Water and Enviromemnt", the document* only focused on assessment of climate change impcts on water resources, adaptation and mitigationa measures, and simulation of dynamic statistical data. Recently, UNESCO assisted Jordan in formulating its Science, Technology and Innovation (STI) policies, strategies and plans, as well as the reform of science systems through the provision of guidelines, methodologies, technical advice on formulation, implementation and monitoring. Funded by the Japanese Fund in Trust, UNESCO supported the GoJ to develop the *National Policy & Strategy for Science Technology & Innovation* 2013-2017- a medium-term, needs-and-results-based Master Plan in STI. The Plan is supposed to serve as a guide for the Government, businesses and public organizations to join in the effort to develop the STI sector in Jordan[11].

It is obvious to observers in Jordan that the term "innovation" started to explicitly appear in recent planning documents concerned with education and technology in Jordan. Among the five focus elements of said STI *Policy* was element No. 3 concerning "*Infrastructure for Science, Technology, and Innovation*". Moreover, three of the five strategic objectives of the document encompassed the term "technology", namely Objective 2 "*Disseminating the culture of science, technology, and innovation in schools, colleges, institutes, public and private universities, and different productions sectors, including the general public so as a suitable environment for innovation is established*;" No. 3 "*Activation of the role of research and development (R&D), and technology applications in the social and economic development processes*," and No. 4 "*Establishing knowledge networks and partnerships in science, technology, and innovation fields at the national and international levels*". The said STI document highlighted some lessons learned of other countries in the region such as Egypt and Lebanon in STI regard. One of the weakness aspects of the technology system in Jordan, according to the document's SWOT analyses conducted was "*lack of skilled experts in some advanced science and technology fields*." And one threat identified was "*accelerated technology evolution and competition globally.*" The assessment and analyses conducted for the document revelaed that the status of sceince and etchnology in Jordan is fair but still needs a lot of efforts for advancment. However, the staus of innovation appeared to be weak specially its contribution to enhancing the economy with emphasis on the permanent challenges in water, food, and energy Jordan facing which all are impacting the national economy. This conclusion was emphasized by a World Bank mission assessment cited in the said document[12].The solutions presented to bridge such gaps were formulated into strategies in the said STI document. Among such strategies were the following: (1) "utilizing international experience and models in developing the intuitional framework for the advancement of the system of science, technology and innovation and identifying collaboration channels and mutual cooperation

[10]Defining Scientific Research Priorities in Jordan for the Years 2011-2020. Higher Council for Science and Technology and Scientific Research Support Fund, November 2010.
[11] UNESCO Press Release 13.05.2013 -http://www.unesco.org/new/en/amman/about-this-office/single-view/news/supporting_jordan_in_the_development_of_its_national_strategy_for_science_technology_and_innovation_2013_2017/#.Vjrt-fkrKUk
[12] National Policy & Strategy for Science, Technology & Innovation 2013-2017.

between elements of this system including coordinating relevant policies, regulations and their enforcement;" (2) "*Taking advantage of national companies, international networking, grants, and direct foreign investment in completing infrastructure and leveraging equipment, and training personnel in advanced technology areas*;" (3)" *entering into international technology transfer consortia;*" (4) "*attracting Foreign Direct Investment (FDI) that is based on research and technology evolution in developing new products/services*;"(5) "*Increasing direct governmental support to higher education and scientific institutions and raising awareness of the general public of the importance of science, technology, and innovation in the developmen*t;" (6) "*Integrating advanced technology in different development sectors*;" and (7) "*entering into developing technologies that are still in their early stages of evolution*."

1.2.3 Climate change mitigation and adaptation-related policies in Jordan

Based on the base year 2006, Jordan's share in global greenhouse gas emissions was 28,717 Gg of CO_2 eq., (detailed breakdown of emissions shares per surveyed sectors and covered gases is provided in the TNC Report to UNFCCC and the accompanying inventory submitted in late 2014). The Country's bulk share of GHGs represents only around 0.06% of global total according to a global GHGs analysis conducted in 2010[13].

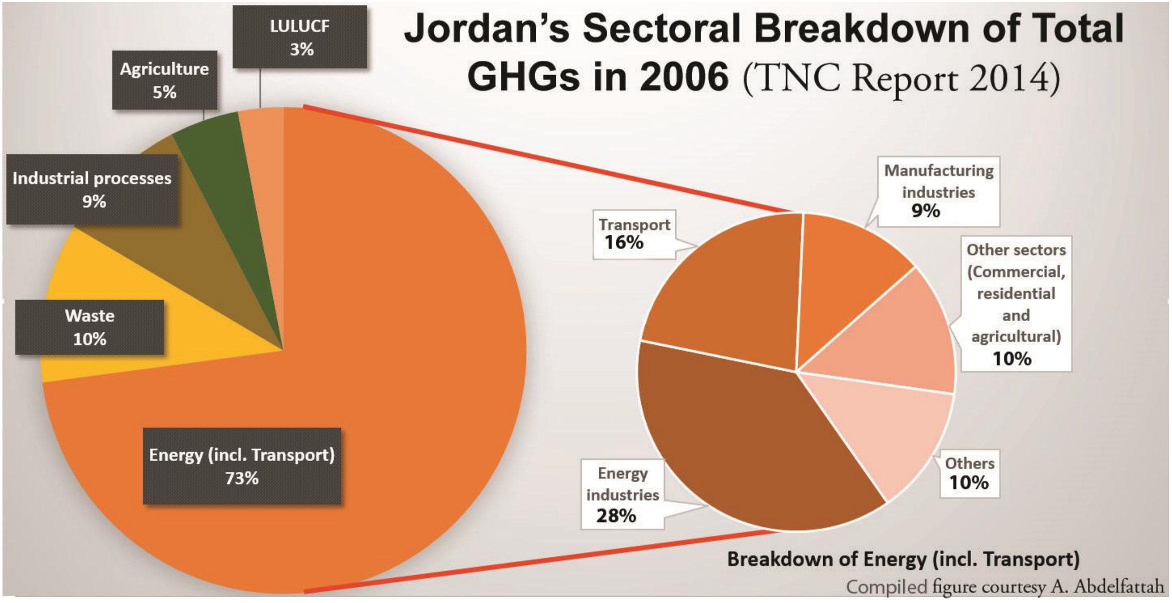

Figure 2 Jordan's greenhouse gas emissions by sectors in 2006 (TNC Report, 2014)

According to World Bank, the CO_2 metric tons per capita emission is 3.4 in 2010. As Figure 2 illustrates, energy (including transport)-related activities have the dominant share of GHG emissions in Jordan totaling 73% followed by almost close percentage for both waste and industrial activities totaling 10% and 9% respectively. Activities from Agriculture and LULUCF have the lowest, also close percentages of 5% and 3% respectively. These emissions are expected to grow according to the 2006 baseline scenario used in the TNC (2014) report to 38,15 Gg, 51,03 Gg and 61,57 Gg of CO_2 eq. in the years 2020, 2030 and 2040 respectively due to normal growth models. The baseline scenarios was based on 2014 conditions, which were deeply relying on imported fossil fuel and the delay in renewable and alternative energy projects as well as interruptions in gas supplies. Now, in 2015/2016, the conditions have changed with more emphasis on renewables and gas. It is believed when Jordan develops its Biennial update Report (BUR) to UNFCCC based on 2010 inventory the baseline scenario will lead to a peak year[14].

Even though historically Jordan was amongst the most active countries in the region with regard to involvement in international climate change efforts and response actions as elaborated above in Section 1.1, however, Jordan, as a non-Annex I country, has, so far, no commitments for GHG emission reduction

[13]*United States Department of Energy's Carbon Dioxide Information Analysis Center (CDIAC) for the United Nations, 2010*. The data only considers carbon dioxide emissions from the burning of fossil fuels and cement manufacture, but not emissions from land use, land-use change and forestry. Emissions from international shipping or bunker fuels are also not included in national figures.

14 Jordan's TNC to UNFCCC (2014)

targets. Nevertheless, Jordan believes that there is a large potential for mitigation, even though Jordan's total GHG emissions are very small in absolute terms compared to other countries as indicated above. Developing full-fledged NAMA projects and capacity building in establishing and running an effective MRV system both on macro level and on sectoral and activity levels are highly needed since MRV is looked at as prerequisite for developing NAMAs. More dedicated efforts are needed to provide institutional capacity strengthening for data collection and management particularly with regard to mitigation. There is good improvement in renewable energy policies, strategies, laws and by-laws formulation but improving robust implementations still needs further work. However, there is now a good number of activities (projects, legislative instruments, etc) under execution in renewable energy and energy efficiency in the country. Private sector engagement in climate change activities is still not at the expectation level but slowly improving and good progress is taking place in investment in renewable energy sector particularly. However, the overwhelming majority of climate initiatives and projects in Jordan are still donor-driven. Thus, the pledged reduction of emissions by 2030 of 14% compared to a BAU scenario levels still require substantial international financial support and a paradigm shift in national planning that includes the allocation of domestic resources for low carbon emission growth strategies.

Climate change is expected to affect sustainable development, economic growth and society in Jordan. Based on outcomes from the latest TNC Report to UNFCCC (2014), serious vulnerability and impacts results are expected based on modeling and projections analyses. Predicted trends indicated that the annual precipitation tends to decrease significantly with time. Simultaneously, the mean, maximum and minimum air temperature tends to increase significantly by 0.02, 0.01, and 0.03 °C/year, respectively. On the other hand, the relative humidity tends to increase significantly by an average of 0.08%/year. In addition, the dynamic projections predicted more extremely likely heat waves and likely drought events, dry days, and potential evaporation among other potential impacts (TNC 2014).

With regard to activities and plans related to mitigation of GHGs and adaptation to climate change in Jordan, the master plan currently operational is the ***National Climate Change Policy 2013-2020***, which advanced concrete strategic objectives, measures, and instruments to both cut the levels of GHGs in most polluting sectors (Energy, Transport, Waste, Industries, and Agriculture/LULUCF) and to adapt the country to climate change impacts in each vulnerable sector (Water, Coastal Areas, Agriculture/Food Security, Health, Tourism, Biodiversity, and Socioeconomic/Poverty). Before developing this holistic Policy, Jordan conducted (2009-2013) a major joint program of water and health sectors' adaptation namely "*Adaptation to Climate Change to Sustain Jordan's MDG Achievements*". The program's outcomes were to develop sustained access to improved water supply sources, despite increasing water scarcity due to climate change and to strengthen the capacity for health protection and food security under conditions of water scarcity. Moreover, and in continuation of national actions, Jordan mainstreamed climate change in its *National Strategy and Action Plan to Combat Desertification (2015-2020)* which was recently aligned with the global UNCCD 10 year Strategy. Jordan also mainstreamed climate change into the *National Biodiversity Strategy and Action Plan (2015-2020),* which was also recently aligned with the global CBD-10 year Strategy concurrently with aligning the desertification strategy. Finally, all sustainable development-oriented plans in the country have led to a crowning national effort, which will be the development of a national strategy and action plan for transitioning towards the green economy in Jordan (2016-2025) which is currently under development. All of such climate change-response actions demonstrate the extraordinary efforts and the size of involvement of such a small country in the fight against climate change.

According to the Market Readiness Proposal report of Jordan sponsored by the World Bank's Partnership for Market Readiness (PMR), Table 1 highlights the main policy and legislation relevant to the climate change mitigation in the country (as relevant to the PMR target sectors-energy and water) as well as the main national actors delivering these mitigation activities.

Table 1 Policy and actors delivering Jordan's GHG Mitigation Activities (ref.: PMR 2015)

Policy and legislation	Purpose and key actors
National climate change policy (NCCP) for 2013-2020	Coordinated by the *National Committee on Climate Change*, under the Ministry of Environment's Climate Change Directorate and Green Economy Unit, established the mitigation and adaption priority actions for Jordan, an implementation plan and the roles and responsibilities of key actors to deliver these actions. These have been

	re-enforced in in Jordan 2025-A National Vision and Strategy (launched June 2015).This draws on the National Agenda for Sustainable Development, 2006-2015.
Jordan Environmental Protection Fund (JEF) by-law 66 in 2009	A public financial institution, *Jordan Environmental Protection Fund* was created in 2009 for financing projects strengthening capacity of entities to comply with national environmental protection, under the MoEnv. Hitherto projects have focused on treatment of industrial wastewater, solid-waste management, energy conservation and renewable energy sources.
Renewable Energy and Energy Efficiency Law, 2012	Building on the *Energy Master Plan***,** created a centralized tender for Large RE projects run by the ministry of Energy and Mineral Resources, and tariff incentives for smaller scale projects with bonuses for Jordanian origin. Tax exemptions for IPP of RE, and RE and EE equipment Creation of a public financial institution, the *Jordanian RE and EE fund (JREEEF)* in 2012 under the MEMR, to fund and deliver large scale public RE and EE programmes (as per the NEEAP 2013), and support the capacity building of RE developers and EE service providers.
Energy Efficiency and Renewable Energy Policy for the Jordanian Water Sector (2015)	The Ministry of Water and Irrigation's *Energy Efficiency and Renewable Energy Policy for the Jordanian Water Sector (2015)* is aimed at the optimization of energy use in the water sector serves the objective of financial restructuring through improving cost recovery, tapping alternative energy sources, and decreasing inefficiencies.
National Energy Efficiency Action Plan, 2013	The NEEAP is an ambitious document establishing measures which will enable Jordan to meet its GHG mitigation and energy resilience aims, along three key themes: • Creating the economic incentives for energy efficiency • Delivering large scale national programmes for GHG mitigation. Namely, residential solar water heater programme, light replacement in SMSEs, public and residential buildings, and water pump energy efficiency. (For the water sector, MWI EE and RE Policy for the Jordanian Water Sector (2015)) • Developing supporting capacity and supply chain for the RE and EE industry There are a vast number of implementing actors, from Government Agencies (MoEnv, MEMR, GAM, MWI, MT, MoMA, MoT), PFIs (JEPF, JREEEF), private sector parties (JEPCO and distribution cos) and importantly, a large participation of the donor community, including Multilateral development Banks, (WB, EBRD), International organisations (UNDP), and foreign aid organisations (AFD, USAID, JICA, Europe Aid, Canadian Government)

1.3 Vulnerability assessments in the country and adaptation measures

The TNC report to UNFCCC released in 2014 fully assessed the vulnerability of Jordan to climate change and proposed adaptation measures. Thus, this TNA Report will display here only the summary of results of the vulnerability assessment and proposed adaptation measures for the whole group of sectors vulnerable to climate change. For full material and detailed results of the TNC Project with regard to vulnerability assessments, readers can refer to Jordan's TNC 2014[15].

1.3.1 Water resources vulnerability assessment

Based on the climate trends analysis using CORDEx[16] and RCP[17] 4.5 and 8.5 utilized in the TNC 2014, the main climate hazards that the water sector faces in Jordan are temperature increases, precipitation

[15] *Jordan's Third National Communicationon Climate Change, submitted to UNFCCC December 2014.*

[16] The Coordinated Regional Downscaling Experiment (CORDEX) was initiated by the World Climate Research Programme (WCRP) in 2009 in response to the need for a coordinated framework for evaluating and improving regional climate downscaling (RCD) techniques and producing a new generation of RCD-based fine-scale climate projections for identified regions worldwide. The CORDEX framework additionally offered the potential for better coordination of RCD-related research and modelling activities within the regional climate modelling and downscaling communities and further to bridge the gap between the climate modelling community and end users of climate information across the globe. (http://www.icrc-cordex2016.org/index.php/about/what-is-cordex).

[17] **Representative Concentration Pathways (RCPs)**: factors to be taken into account when trying to predict how future global warming will contribute to climate change. The amount of future greenhouse gas emissions is a key variable. Developments in technology, changes in energy generation and land use, global and

decreases, increased incidents of drought and increased evaporation. Climate sensitivity indicators in water sector were determined as reduced groundwater recharge, groundwater quality deterioration, stream flow reduction and increased water demand. Assessment of sensitivity showed that the average sensitivity level is 3.71 (out of 5) and can be classified as *high*. That indicates how the system can be adversely impacted by the investigated climate change hazards.

Adaptation strategies and measures suggested for the water sector are[18]:

- *Rainwater harvesting*
- *Waste water treatment*
- *Desalination*
- *Increasing efficiency of irrigation technologies*
- *Grey water reuse*
- *Public awareness*

1.3.2 Agriculture sector vulnerability assessment

According to assessments conducted by TNC 2014, the poor in rural areas in Jordan are expected to face the most severe consequences of climate change through disruption of livelihood options that depend on natural resource management. The expected impacts of climate change, particularly reduced agricultural productivity and water availability, threaten livelihoods and keeps vulnerable people insecure. Poor families and households are the most vulnerable group to the potential impacts of climate change and deserve the priority in the design of appropriate adaptive measures according to the experts conducted the TNC assessments. The major climate exposure risks associated with agriculture in Jordan were identified as: 1) Temperature increase, 2) Rainfall decrease 3) Droughts and 4) Shift in rainy season. The major sub-sectors of high climate sensitivities were 1) cropping systems, 2) livestock production and 3) livelihood and food security.

Adaptation measures vary horizontally according to the agricultural sub-sectors and their vulnerability to climate change. These measures vary vertically according to the different actors involved in the development and implementation of this policy.

Adaptation strategies and measures suggested for the agriculture sector in the TNC 2014 report

- *The key adaptation measure to climate change is setting and implementing a sustainable agriculture policy;*
- *Agronomic and crop strategies that are intended to offset either partially or completely the loss of productivity caused by climate change through the application of defense tools with different temporal scales, e.g. short term adjustments and long term adaptations, and spatial scales, e.g. farm, regional or national level adaptation; and*
- *Socio-economic strategies intended to meet the agricultural costs of climate change.*
- *Modification of cropping pattern, modification of crop calendar including planting and harvesting dates, implementation of supplemental irrigation and water harvesting techniques, improving water use efficiency, utilizing of different crops varieties and modification of policies and implementation of action plans;*
- *Most of the interventions to upgrade rain-fed agriculture can be cost-effective in farming systems, especially where irrigated agriculture is not feasible. For example, supplemental irrigation (the watering of rain-fed crops with small amounts when rainfall fails to provide sufficient moisture) has proven to be a drought-proof strategy in most areas. Increase of water available for supplementary irrigation can be achieved through on-farm rainwater harvesting and management system, i.e. small farm ponds for micro-irrigation using drip or sprinkler irrigation systems. Larger rainwater storage structures can also be constructed to provide supplementary irrigation water to a number of small farms or fields by using the micro-dams.*

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regional economic circumstances and population growth must also be considered. So that research between different groups is complementary and comparable, a standard set of ***scenarios*** are used to ensure that starting conditions, historical data and projections are employed consistently across the various branches of climate science. There are four pathways: RCP8.5, RCP6, RCP4.5 and RCP2.6. RCPs are referred to as pathways in order to emphasize that their primary purpose is to provide time-dependent projections of atmospheric greenhouse gas (GHG) concentrations. In addition, the term pathway is meant to emphasize that it is not only a specific long-term concentration or radiative forcing outcome, such as a stabilization level, that is of interest, but also the trajectory that is taken over time to reach that outcome. They are representative in that they are one of several different scenarios that have similar radiative forcing and emissions characteristics". *Source: IPCC Expert Meeting Report, Towards New Scenarios For Analysis Of Emissions, Climate Change, Impacts, And Response Strategies, IPCC 2007.*

[18] Jordan's TNC Report to UNFCCC (2014)

- *Conservation agriculture, on the other hand is very efficient, leading to increased crop yield. In this adaptation measure, several techniques are used to enhance soil water storage. Water conservation is usually enhanced through mulching and crop residue retention through zero or minimum tillage, stubble mulch tillage, strip tillage and crop rotation. Conservation agriculture, however, requires extension programs such as training and provision of equipment.*

1.3.3 Biodiversity and ecosystems vulnerability assessment

With regard to expected impacts of climate change on biological diversity and ecological systems, the expected impacts from climate change on such biospheres in Jordan according to climate exposure and sensitivity of ecosystems in the country conducted for the TNC 2014 are droughts, forest dieback, community composition change, expansion of drier biomes into marginal lands, habitat degradation and species loss. The highest exposure to climate change impacts is expected to be in the Eastern and Southern areas in Jordan and in the mountainous areas in the North. The highest sensitivity based on vegetation type is expected to be in the Northern Highlands and across the Middle areas in Jordan especially the Jordan Valley.

For water vegetation, the TNC impact analysis study expected reduced growth and reduced growth range due to lower soil moisture. For evergreen Oak forests and pine forests, it is expected to have lower regeneration rate, change in community composition and shrinkage in geographic range. For Mediterranean non-forest vegetation it is expected to have reduced growth in lower elevations and shift toward higher elevation with time. However, a higher adaptive capacity was noticed to be in desert vegetation, tropical vegetation and to lower extent in marginal vegetation types such as steppe vegetation. Overall it was noticed that the highest vulnerable ecosystems are forests (especially in the North) and fresh water ecosystems (especially in Jordan Rift Valley), which highlights that the priority is to perform adaptation interventions within these two ecosystems.

Adaptation strategies and measures suggested for Biodiversity and Ecosystems in the TNC 2014 report

- *Restoration of degraded forests and encouraging the establishment of community forests to control soil erosion, national wide, using diverse conservation governance forms including Protected Areas (PAs), Hima, and Special Conservation Areas (SCAs) that empower local communities to conserve their natural resources and improves their livelihoods;*
- *Protecting and enhancing ecosystem services in conservation areas and improving the access to ecosystem services and improving the quality of such services to empower local communities and increase the resistance/resilience of local communities to climate change impacts;*
- *Preserving water quality and flows in water catchment areas using buffer zones surrounding PAs and SCAs;*
- *Restoration and protection of rangelands to reduce the vulnerability of livestock to drought;*
- *Adopting water management procedures providing alternative water sources for fauna and avifauna such as retention dams.*

According to the prioritization done by the TNC's Team, it was found that enhancing ecosystem services provided by conservation areas and empowering local communities is the most important adaptation measure in Jordan followed by diversification of conservation methodologies and governance systems.

1.3.4 Coastal areas vulnerability assessment

Impacts on coastal areas in the coastal city of Aqaba from climate change are expected to occur through 1) sea level rise, 2) extreme rainfall events or droughts in upstream terrestrial areas which are connected to run off and flooding, 3) sea surface temperature increase and 4) CO_2 concentrations. Although changes in global mean sea-level could reflect changes in sea-level at the Gulf of Aqaba, the relationship between global mean sea level rise and local sea level rise will depend on a combination of factors, including changes in ocean circulation (which can alter sea-levels at local and regional scales), variations in oceanic levels due to thermal expansion and relative sea-level change associated with land movements. All this requires extensive in-depth research, which is currently lacking at the national level according to TNC 2014.

The northern parts of Aqaba are the most vulnerable regions for flashflood hazards since they are located downstream from areas of major wadis. In addition, they contain most of the town residential expansion areas. Despite the establishments of flood diversion channels at the northern parts of the Gulf of Aqaba, floods are still a threat, if rainfall events exceed the thresholds, based on the provision of regional climate projections using CORDEx and RCP 4.5 that predicted decreases of rainfall by 2050 reaching less than 50% of current rainfall in the North of Aqaba. Until 2100, the decrease of rainfall extends to the whole country, except the northeastern part. In addition, for the RCP 8.5, the precipitation decreases everywhere by 2050 except in two small areas in the mountains and in the Jordan Rift and the northern parts of Aqaba that are the most affected regions.

An increase in mean sea surface temperature will cause changes such as blooming in algal communities in the water as sea temperature and CO_2 concentration favor algal blooms in combination with increased nutrient run-off, which could lead to critical changes in ecosystems and species diversity. In addition, increases in temperature may intensify conditions of poor water oxygenation (lower solubility of O_2) and may promote the spread of diseases. However, rates of future warming in the Red Sea and Gulf of Aqaba are currently uncertain. The most likely climate change-related events at the Gulf of Aqaba are sea level rise, and the extreme rainfall or droughts from the upstream areas especially after analyzing the modeling data provided for precipitation rate. Based on the short coastline of the Gulf of Aqaba, the hazard impacts will have a tangible geographical magnitude. However, there is a low confidence in the results due to the current lack of a suitable model, in Jordan, that accurately simulate the possible impact of climate change on sea level. Ecosystem services in the Gulf of Aqaba area are very fragile and have low adaptive capacity due to the limited coastal areas at the Gulf of Aqaba with only about 27 kilometers and relatively short batches of major ecosystems. In addition, a moderate adaptive capacity is observed for both the economic and social capabilities and infrastructures at Aqaba.

The vulnerability assessment showed clearly that the geographically restricted coastline of the Gulf of Aqaba is vulnerable to climate change impact. This is true as the Gulf of Aqaba contains sensitive ecosystems and habitats, which are very vulnerable to any changes in sea composition. Despite that modeling showed that precipitation is anticipated to be very low at the upstream areas of Aqaba, but still moderate vulnerability results was obtained due to the high adaptive capacity expected.

Adaptation strategies and measures suggested for Coastal Areas in the TNC 2014 report

Under sea level rise

- *Awareness campaigns about potential impacts of climate change targeting both individuals and institutions are needed*
- *Prepare disaster reconstruction plans and develop local management plans and get technical expertise support*
- *Revise coastal zone management plan of the Gulf of Aqaba*
- *Training and individual development programs to enhance institutional capacity toward climate change*
- *Sustainable development measures at the coastal areas of the Gulf of Aqaba*
- *Retrofitting of buildings*
- *Increase public awareness of flooding and\ or drought and revise current flood management strategy*
- *Develop and revise current flooding design infrastructure for flood protection*
- *Maintenance of water infrastructures at Aqaba and enhance their capacity*
- *Water resources management at Aqaba and develop a warning system*

Under sea surface temperature and CO_2 concentration

- *Enhance the monitoring system of ecosystems and species at the Gulf of Aqaba*
- *Understanding fishing activities' impact and reduce its effects*
- *Develop a monitoring system for introduced, endemic and threatened species*

- *Increase awareness and knowledge toward the effects of climate change on ecosystems and biodiversity*
- *Strengthen expertise of individuals and institutions at Aqaba*
- *Information dissemination/education campaign on climate variability and change and its impacts for decision makers and the public*
- *Formulation of guidelines and legislation for the implementation of Integrated Coastal Zone Management (ICZM) for the entire coastal areas at Aqaba.*
- *Incorporation of climate change implications in the land-use planning of the coastal areas*

1.3.5 Urban sector vulnerability assessment

At the Kingdom's level, the overall exposure in RCP 4.5 is low and moderate in RCP 8.5. Although the exposure is low, the events concentrate in certain geographic areas and thus the Kingdom's exposure is not the best representation for specific urban areas as Amman and Salt. The main factor, which reduced the exposure score, is the confidence of occurrence due to the large geographic coverage, which is not uniform in exposure. For the purpose of better representation of climate change impact on communities, the exposure has been assessed for the pilot area specifically and for the Kingdom to cover the adjacent urban centers; Amman and Salt.

Adaptation strategies and measures suggested for the urban sector in the TNC include:

- *Introduce climate responsive building techniques and elements to reduce the effect of heat and reduce demand on energy for cooling;*
- *Promote the use of energy saving devices, and raise awareness on the long-term benefits of energy efficiency and saving devices;*
- *Amendments to sector policies and regulations, such as building codes, to reflect climate change risks and direct people towards insulating buildings to reduce energy demand;*
- *Construct proper storm water network to discharge storm water from built environment;*
- *Zoning and development changes to reflect increased vulnerability of specific locations and/or resources*

1.3.6 Health sector vulnerability assessment

It is believed that rising temperature due to climate change will increase microorganisms growth; leading to increase in water and food-borne diseases. In contrast, flooding which is a result of extreme rainfall through concentrating the annual rainfall in a small interval will lead to disruption of water purification and potential contamination with sewage disposal systems, leading to increase the probability of occurrence of epidemics due to vector borne "VBDs," water and food-borne diseases[19].

Moreover, it is believed that climate change may also have influence on the seasonal patterns for respiratory diseases, cardiovascular diseases and mortality. The most visible effect of climate change on respiratory diseases is on chronic respiratory diseases including bronchial asthma and chronic obstructive pulmonary diseases "COPD". However, acute infectious respiratory diseases seems that are not going to be directly encountered.

The TNC (2014) also considered the indirect impacts of climate change on health. Since one of the most important effects of climate change in Jordan is shortage of water, it is likely that some indirect health impact will take place due to applying the adaptation measures to cope with water shortage dilemma such as reusing of grey or treated wastewater in irrigation of trees or vegetables. This might increase the opportunity of transmission of several pathogens through crop contaminated with pathogens. This could also cause outbreaks like Typhoid fever or Hepatitis A if the water is not well treated.

In general, it was highlighted in the TNC (2014) report that the main climate change exposure issues for the public health in Jordan are drought, dust or sand storms, decreasing precipitation, rising temperatures, flooding due to extreme rainfall and shifting in the rainy season. The sensitivity of health sector in Jordan is directly or indirectly affected by climate change. The influence scale ranged from insignificant

[19] TNC 2014

(malnutrition) to catastrophic emerging epidemics (hemorrhagic[20] fevers). According to the TNC (2014) young children and elderly are the most sensitive group mainly to foodborne and waterborne diseases where the admission rates will be increased for such groups followed by respiratory diseases where the admission rate and mortality rate are expected to increase.

Adaptation strategies and measures suggested for public health in the TNC include:

- *Establishment of an early warning system for climate change-triggered diseases;*
- *Adopt healthy buildings, through formulation of building codes and guidelines which include instructions for advanced sanitary installation that separate grey water from black water;*
- *Sustaining and improving sanitary conditions*

1.3.7 Socio-economic vulnerability assessment

The TNC (2014) report has also developed socioeconomic analysis to determine expected impacts of climate change on local communities' socioeconomic settings and assessed their adaptive capacities by employing socioeconomic and adaptation analysis tools on the pilot area composed of four villages in the Amman-Zarqa basin. The study used the income assessment as a main critical indicator to the sensitivity of local community to climate change. The importance of these indicators are linked to the impacts of climate change on the agricultural yield or land productivity at the study site especially knowing that about 55% of the community income is based on agriculture which was considered the most sensitive sector to climate change.

Main results of the analysis included the following:

- Communities with less agricultural experiences such as Subeihi and Bayoudah will suffer severe effects due to climate change and it is expected that they will lose 10% to 20% of their income due to the decrease of their crop yields' productivity;
- It was well noticed that farmers above 60 years are less affected than others by external factors. This explains the importance of local knowledge and experience in agricultural practices;
- Seehan community will suffer an insignificant impact as the community scored the highest level in agricultural experiences. Because of diversification of their income sources, Seehan will not suffer major impacts on their livelihoods;
- Al-Irmemeen was an exception among the other communities where younger farmers (between 20-40 years) have reported higher income level from agriculture compared with older age groups. The reason behind this is that the dominant production system is irrigated agriculture and farmers used modern technology and protected agriculture.

Adaptation strategies and measures required for the socioeconomic settings

- *National governments must prioritize inclusive economic growth that, rather than excluding the rural poor, improves their well-being and reduces rural poverty.*
- *Increase women's skill-development and capacity building opportunities through training on community and political participation skills and link them to general literacy and education initiatives;*
- *Take measures to increase the labor productivity of rural women through improved access to training, extension services and technology;*
- *Mainstream the role of media in climate change and support NGOs and community-based organizations (CBOs), which are well placed to spearhead awareness raising efforts in different community segments, and in their climate change media-targeting activities;*
- *Conduct A pilot study on vulnerability to food security due to climate change using a multilevel approach, including an analytical and relatively comprehensive chain of logical events regarding the impacts of climate change for farm households is needed.*

[20] The viral hemorrhagic (or haemorrhagic) fevers (VHFs) are a diverse group of animal and human illnesses in which fever and hemorrhage are caused by a viral infection. VHFs may be caused by five distinct families of RNA viruses: the families Arenaviridae, Filoviridae, Bunyaviridae, Flaviviridae, and Rhabdoviridae.

1.4 Mitigation and Adaptation Sector Selection

1.4.1 An overview of mitigation sectors, projected climate change, and GHG emissions status and trends of the sectors

According to the TNC 2014 report based on year 2006 data, Jordan GHG emission reached 28.72 million tonnes (Mt) of CO_2 equivalent (CO_2 eq.) as highlighted above (Figure 2). As shown in Figure 2, a breakdown of GHG emissions contribution among major emission sectors in the country is as follows:

- Energy including subsectors: 20.94 Million tonnes (Mt) CO_2 eq, 72.9% distributed as:
  - Energy industries 7.92 Mt CO_2 eq (27.6%)
  - Transport 4.71 Mt CO_2 eq. (16.4%)
  - Other sectors (commercial, residential and agricultural) 2.88 Mt CO_2 eq. (10%)
  - Others 2.72 Mt CO_2 eq. (9.5%)
  - Manufacturing industries 2.68 Mt CO_2 eq. (9.3%)
- Industrial processes: about 2.55 Mt CO_2 eq., 8.9%;
- Agriculture : 1.32 Mt CO_2 eq., 4.6%;
- Waste : 3.05 Mt CO_2 eq., 10.6%, and
- LULU CF: 0.87 Mt CO_2 eq., 3.0 %

A breakdown of total emissions on a GHG basis is as follows :

- Carbon dioxide (about 24.00 Mt), 83.58%;
- Methane about (3.09 Mt CO_2 eq.), 10.75%; and
- Nitrous oxide (about 1.63 Mt CO_2 eq.), 5.67%.
- Emissions of the fluorinated gases of sulphur hexafluoride, perfluorocarbons and hydrofluorocarbons were negligible

1.4.1.1 Energy Sector

The total GHG emissions from this sector (including energy emissions from transport, commercial, residential, agricultural and manufacturing industry sources) were 20.94 Mt CO_2 eq., which represents 72.9% of the total GHG emission (Figure 2). Out of these GHG emission, CO_2 was the largest contributor and contributed alone 20.9 Mt at a percentage of 99.8 % of the total energy sector GHG emissions. On a per gas basis in the sector, energy sector contributed 87.5% of the total country CO_2 emissions. 1.4% of the total CH_4, 47.8% for total NMVOCs emissions and more than 99% of the total emissions of each of NO_x, CO and SO_2.

On a per sub-sector basis and as it can be seen from Figure 2, the largest contributor to emissions in the energy sector is the energy industries subsector, which accounted for 27.57 % of energy emissions, followed by the transport sector, which contributed 16 % of the energy emissions.

1.4.1.2 Transport subsector

The transport sub-sector is a major contributor to GHG emissions. It accounted for (4.71 Mt CO_2 eq.) at 22.5% and 16.4 % of the energy sector emissions and the total national GHG emissions in the year 2006; respectively. Conventional fossil fuels are mainly used in the following subcategories:

- Domestic aviation;
- Road transport;
- Rail transport;
- National Navigation; and
- Pipeline transport.

1.4.1.3 Industrial Processes Sector

Emissions from this sector reached 2.550 Mt CO_2 eq at 8.9% of total GHG emissions. Cement industries were the main contributor of 2.041 Mt CO_2 emissions , 91% of the sector emissions. The sector was the second largest source of NMVOC emissions and accounted for 0.062 Mt at around 39.5% of country total NMVOC emissions. NOx, CO, SO_2 and HFCs gases emissions were almost negligible.

1.4.1.4 Agriculture Sector

Agriculture activities accounted for 4.6 % (1.32 Mt CO_2 eq.) of country total GHG emissions. Methane and nitrous oxide were the main contributors with 0.02 Gg and 4.21 Gg (80 % of total N_2O emissions) respectively.

1.4.1.5 Land Use, Land Use Change and Forestry Sector (LULUCF)

With a net source of CO_2 emission, LULUCF sector contribution was estimated as 866 Gg of CO_2, 3.0 % of country emissions

1.4.1.6 Waste Sector

Waste sector contributed to around 10.6 % of the country emission with 3.05 Mt CO_2 eq. Most of the emissions originated from domestic solid waste, which accounted for 98.6 % (3.00 Mt CO_2 eq) of the total waste emissions, while wastewater handling accounted for 1.4 % (42 Gg CO_2 eq) of the total waste emissions.

It is obvious that Energy and Transport sectors are the dominate contributors to the bulk GHG emissions in Jordan. The role of the energy sector and sub-sectors (including transport) as the leading emitter of GHGs is expected to increase in the future from 73 % of total emissions in the year 2006 to 83 % in the year 2040 according to a BAU scenario. Therefore, it is anticipated to focus the mitigation efforts of the country on these two sectors[21]. Thus the Consultants Team of this study expects that these two sectors will be the focus of the national stakeholders with regard to TNA consideration.

1.4.2 An overview of expected climate change and its impacts in sectors vulnerable to climate change

1.4.2.1 General key messages from the TNC dynamic downscaling study as relevant to climate change vulnerability and impacts

Table 2 below shows the main messages that can be interpolated from the comprehensive climate change projections exercise conducted in the TNC (2014) report. The trends described below indicate the expected future of the climate in Jordan until 2100.

Table 2 key messages for climate projections in Jordan

Trend	Details
A warmer climate	All models converge that the temperature will increase. AFRICA CORDEX results are consistent with the IPCC projections. For the 2070-2100 period the average temperature could reach according to RCP 4.5 up to +2.1 °C [+1.7 °C to +3.2°C] and +4°C [3.8-5.5] according to RCP8.5
A drier Climate	Compared to the SNC that used CMPI3 results, CMPI5 results coupled with regional climate models in CORDEX give a more consistent trend towards a drier climate. In 2070-2100 the cumulated precipitation could decrease by 15% (- 6% to 25%) in RCP 4.5, by -21% (9% to - 35%) in RCP 8.5. The decrease would be more marked in the western part of the country.
Warmer summer, drier autumn and winter	The warming would be more important in summer. The reduction in precipitation would be more important in winter and autumn than in spring, as for instance median value for precipitation decrease reaching - 35% in autumn of 2100

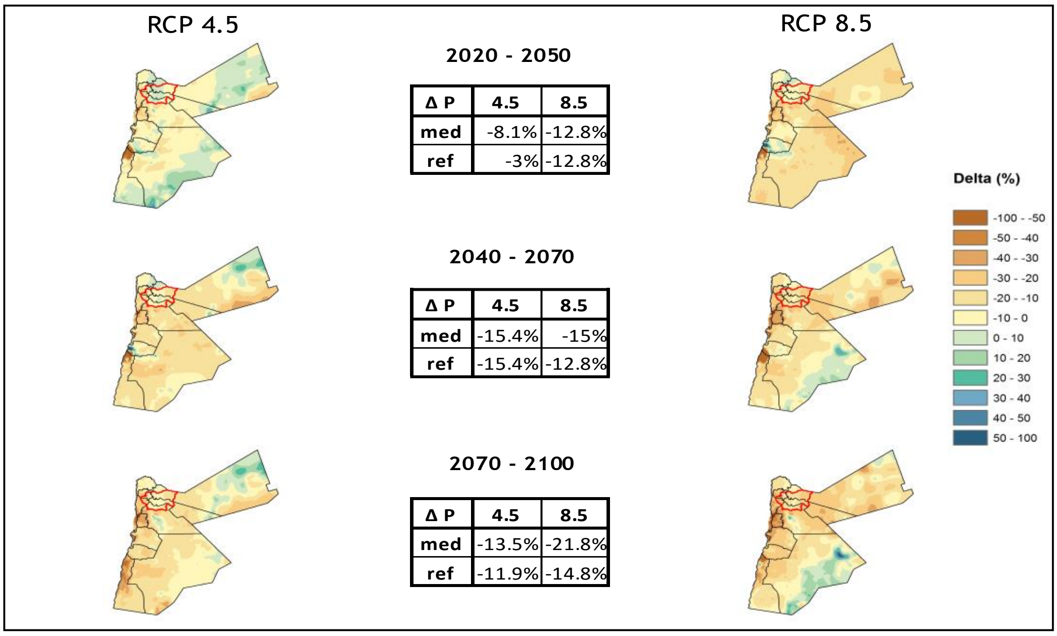
21 Jordan's INDC to UNFCCC (2015)

More heat waves	The analysis of summer temperatures monthly values and the inter-annual variability reveals that some thresholds could be exceeded. A pessimistic but possible projection for the summer months predicts that the average of maximum temperatures for the whole country could exceed 42-44° C
More drought, a contrasted water balance	The maximum number of consecutive dry days would increase in the reference model to more than 30 days for the 2070-2100 period. In contrast annual values still show possible heavy rainy years at the end of the century. More intense droughts would be (partly) compensated by rainy years in a context of a general decrease in precipitation. Evapotranspiration would increase. The occurrence of snow would strongly decrease. This will complicate water management.
No trend for intense precipitation or winds	The number of days with heavy rain (more than 10 mm) does not evolve significantly nor does the maximum wind speed or the direction of winds

1.4.2.2 An overview of expected climate change and its impacts on the water sector: vulnerability, impact assessments and adaptation of the water sector

Water resources in Jordan are vulnerable to climate change. Previous studies, strategic documents, i.e. Jordan's SNC (2009), National Climate Change Policy of Jordan (2013) and the TNC (2014) have all identified scarcity of water resources as one of the major barrier facing sustainable development in Jordan; a situation that will be magnified by climate change. Expected reduced precipitation, maximum temperature increase, drought/dry days and evaporation are the main determinants of climate change hazards. The impact of the increased evaporation and decreased rainfall will result in less recharge and therefore less replenishment of surface water and groundwater reserves. In the long term, this impact will extend to cause serious soil degradation that could lead to desertification, exacerbating future conditions and worsening the situation of the agricultural sector due to the lack of sufficient water that will affect the income of the agriculture sectors. Low income will ultimately reduce the ability to the adaptation to climate change with families unable to respond to the pressing needs for replacing traditional water supplies with new methods that require more spending (purchasing drinking water from tanks). In addition to climate change the increased demand for water in Jordan during the last decade has contributed significantly to reducing per capita shares. The natural growth of economic activities and population increase has been exacerbated by the continuous flow of refugees from Syria in particular and thus increase the demand for water (see Section 1.1).

The downscaled climate data on Jordan in general and on the study area selected for the TNC assessments (2014) in particular suggest that the long-term temperature and precipitation averages, for the periods 2020-2050; 2040-2070; 2060-2100 show a slight increase in temperature with slight decrease in precipitation (Figs. 3 and 4).



2020 - 2050

Δ P	4.5	8.5
med	-8.1%	-12.8%
ref	-3%	-12.8%

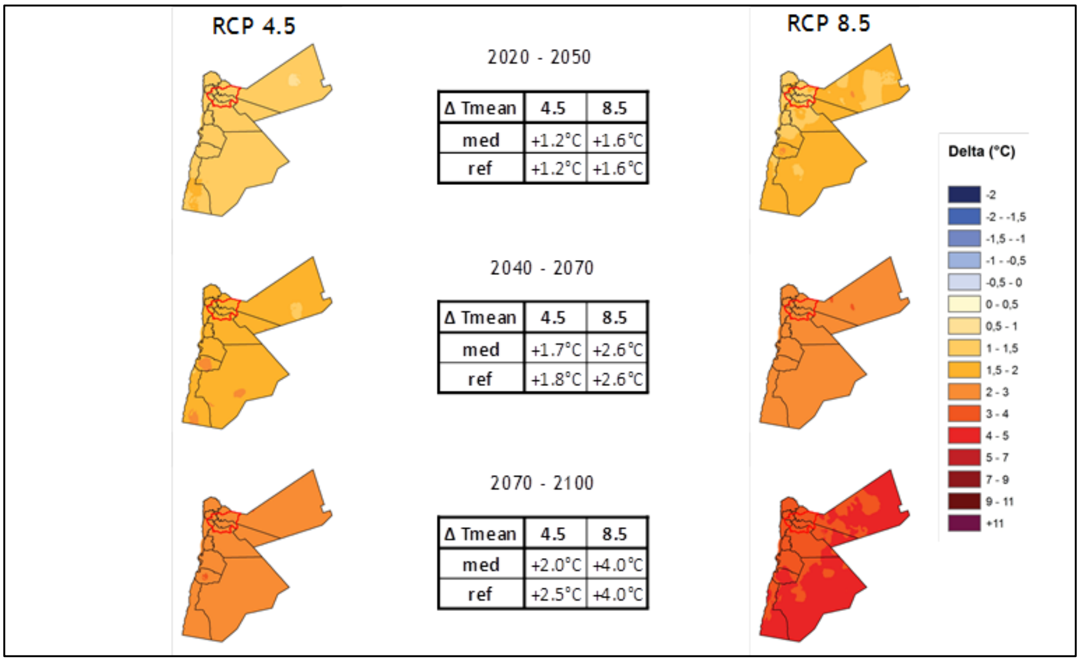
2040 - 2070

Δ P	4.5	8.5
med	-15.4%	-15%
ref	-15.4%	-12.8%

2070 - 2100

Δ P	4.5	8.5
med	-13.5%	-21.8%
ref	-11.9%	-14.8%

Figure 3 Projected annual precipitation using RCP 4.5 and RCP 8.5 over Jordan for the periods 2020-2050; 2040-2070; 2060-2100



2020 - 2050

Δ Tmean	4.5	8.5
med	+1.2°C	+1.6°C
ref	+1.2°C	+1.6°C

2040 - 2070

Δ Tmean	4.5	8.5
med	+1.7°C	+2.6°C
ref	+1.8°C	+2.6°C

2070 - 2100

Δ Tmean	4.5	8.5
med	+2.0°C	+4.0°C
ref	+2.5°C	+4.0°C

Figure 4 Annual mean temperature over Jordan for the periods 2020-2050; 2040-2070; 2060-2100

1.4.2.2.1 Assessment of water sector exposure and vulnerability to climate change

Table 3 shows the average exposure values based on the three components (likelihood, geographical magnitude and confidence level) for the two RCPs used in TNC study, which shows that the main climate hazard on water resources is the increase in temperature. The methodology for determining the final results of the average exposure is fully explained in the sectoral report on water vulnerability & Adaptation in the CD of resources attached to the TNC report.

Table 3 Average exposure in water sector scoring results

Climate change hazards	RCPs	Average assessment of hazard exposure	Total exposure score
Precipitation decreased	**RCP 4.5**	3.67	4
	RCP 8.5	4.33	
Temperature increased	**RCP 4.5**	5	5
	RCP 8.5	5	
Drought	**RCP 4.5**	3.67	4
	RCP 8.5	4.33	
Evaporation	**RCP 4.5**	3.67	4
	RCP 8.5	4.33	
Average		**4.5**	

Climate data pooled from eight models for three periods (2020–2050, 2040–2070, and 2070–2100) suggest that there is significant increase in temperature and hence in evaporation. Also, the data suggests reduced precipitation and hence, drought. Therefore, the TNC (2014) study focused on the four parameters mentioned above. Figure 5 shows a pictorial representation for evaporation's minimum, maximum and median values as well as for the reference model for RCP 4.5 and RCP 8.5. This significant change in the potential evaporation will apply further stress in the availability and distribution of the water resources in Jordan as well as in the study area. In conclusion, Jordan's water sector is extremely vulnerable to climate change, especially to temperature increase, decrease in precipitation and increase of evapo-transpiration in the area of study.

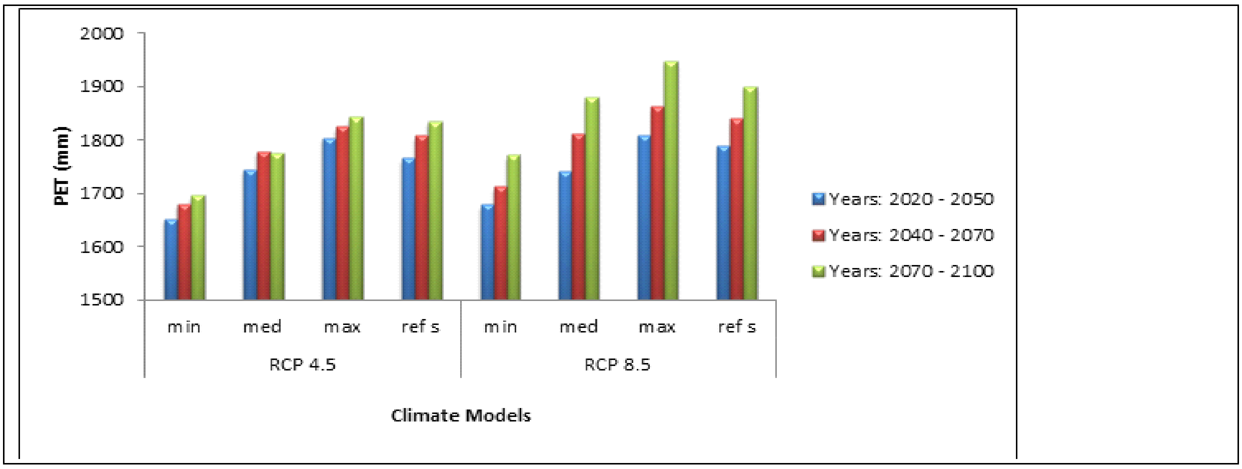


Figure 5 Predicted Potential Evaporation (PET)

Similarly, the changes in precipitation predicted by the same models indicate significant reduction in the rainfall amounts during the three periods (Fig 6).

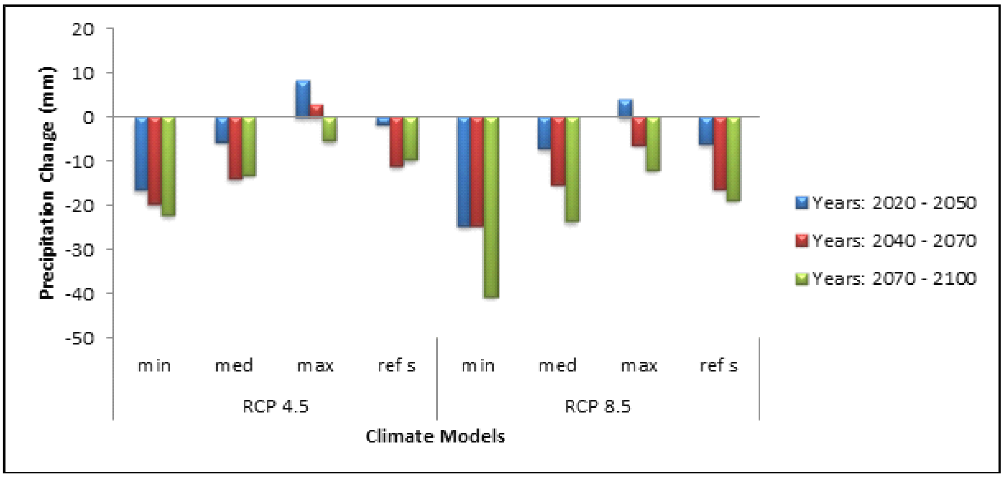


Figure 6 Predicted changes in precipitation

Based on assessments of sensitivity and impact levels, the TNA report (2014) presented the following summary results (Table 5).

Table 4 Results of the impacts level assessment on water sector

Climate Change Hazards	Sensitivity Factors Indicators	Exposure level		Sensitivity level	Impact level	
		RCP 4.5	RCP 8.5		RCP 4.5	RCP 8.5
Precipitation decrease	Groundwater level decline Groundwater quality deterioration Stream flow reduction	High (average score = 3.67)	Very High (average score = 4.33)	High (average score = 3.67)	High (average score = 3.67)	High (average score = 4.0)
Temperature increase	Groundwater recharge decrease Stream flow reduction	Very High (average score = 5)	Very High (average score = 5)	High (average score = 3.50)	Very High (average score = 4.75)	Very High (average score = 4.75)
Drought	Increased water demand	High (average score = 3.67)	Very High (average score = 4.33)	High (average score = 4.0)	High (average score = 3.83)	High (average score = 4.0)
Evaporation	Stream flow reduction	High (average score = 3.67)	Very High (average score = 4.33)	High (average score = 4.0)	High (average score = 3.83)	High (average score = 4.0)

The potential impacts of climate change, evaluated based on the above four climate hazards, seems to be serious ranging from high to very high especially the ones related to temperature increase. Also, the impact seems serious for both RCP 4.5 and RCP 8.5

1.4.2.2.2 Assessment of adaptive capacity of the water sector

Provision of drinking water is the responsibility of the government. Based on the statistics and on frequent interviews with local people in the study area conducted by the TNC (2104) Team, there is little to no stress on drinking water resources during most of the year, and there is adequate level of satisfaction. However, tremendous pressure on water supply occurs during the summer. This pressure is represented by intermittent water supply, which results in water shortage and in contamination due to corrosion of pipes. During the summer, a significant number of residents tend to buy potable water to meet their household need. Current adaptive capacities to the shortages in the study area include the installation of additional storage media such as tanks on top of houses to minimize the risk of running out of water between water supply cycles. To avoid water quality problems a significant number of people either buy filtered water or use water purification systems. Moreover, another aspect of adaptive capacity is rainwater harvesting (RWH). RWH is a common practice with over 50% of the houses has underground tanks or cisterns with a capacity of 30 cubic meters or more. This particular adaptive capacity is inherited and is socially very acceptable. For irrigation, current adaptive capacities include the application of drip irrigation to reduce the amount of water required, storing water during winter to be used in summer, planting crops that require less water and developing existing springs. Overall, the adaptive capacity levels to various climate hazards are determined based on social surveys that were conducted in the socio-economic section and expert judgment.

1.4.2.3 An overview of expected climate change and its impacts on agriculture sector

The Jordanian agricultural sector is established along three major climatic regions: the lowlands (Jordan Valley) that thinly stretches from the northwest to the southwest, the highlands and Marginal steppe where most of the rain-fed farming is practiced, and Badia (or desert) mostly livestock systems and some cultivation in watershed and from deep bore irrigation. Agriculture (animal and crop farming) is mostly influenced by water availability and the ability to adopt advanced water harvesting and to use technologies and interventions to mitigate the impact of the climate change.The contribution of agriculture to GDP has declined in relative terms from 20% in 1974 to less than 2.9% in 2011 while its contribution in absolute terms has increased (e.g. from JD 57 million in 1974 to JD 598.3 million in 2011 as shown in Table 5 (source: MoA and Central Bank of Jordan periodic reports).

The importance of the agricultural sector stems from the fact that it is not only the major source of food items especially dairy products, fruits and vegetables, but also one of the sources of hard currencies originated from exports. About 25% of the total poor in Jordan live in the rural areas depending mostly on agriculture (livestock keepers, smallholder farm households and landless former agriculturalists), and in spite of poor motivation of the rural youth, agriculture is an important employer of the rural communities.

The country's total yield in 2008 was 212,000 tons of field crops, 349,000 tons of fruits, and 1.4 million tons of vegetables. Data analysis indicated that 95% of the area of vegetables was irrigated, 93% of field crops area was rain-fed and 62% of the fruit tree area was rain-fed. These figures demonstrated that most of agricultural areas in Jordan were rain-fed, which made agriculture in Jordan more susceptible to climate change. The percentage of harvested to cultivated areas in 2008 was 45%, which indicated a high risk associated with rain-fed agriculture in Jordan.

Generally, rainfall amounts and climatic conditions of the country do not support good rain-fed agriculture, except for few areas in the northern and western highlands. The rain-fed agricultural zone is lying in areas where rainfall exceeds 250 millimeters although significant production of cereals does occur in some areas where rainfall is between 200 and 250 millimeters. There are three main sub-divisions within the rain-fed sector, namely fruit trees, field crops and to less extent the vegetables. Fruit tree crops dominate the hilly and steep sloping lands of the western part of the highland plateau (e.g. western parts of both Yarmouk and Zarqa basins). Slopes are generally too steep for cereal and other annual crop production even with soil conservation measures. However, wheat is grown on inappropriately steep slopes in some places. The main threat to rain-fed cultivation in Jordan is urban expansion and land fragmentation, in addition to the frequent droughts.

Irrigated agriculture is taking place in the Jordan Valley and the highlands. The main source for irrigation in highlands is the ground water. In northern Jordan Valley (JV), the area under cultivation is served by surface water supplies transported via the King Abdullah Canal (KAC) from Yarmouk River while the irrigation water to the middle and southern parts of Jordan Valley are mainly served by water coming from KTD on Zarqa River after mixing with that coming from KAC.

The total area under irrigation in Jordan Valley and the southern Ghors is estimated to be about 33,000 hectares. The major crops are vegetables and trees including citrus and bananas. Important irrigated agriculture is also taking place on the basalt plateau soils of northern Jordan, in Mafraq governorate. In these areas, the utilization of groundwater resources was expanded rapidly into the steppe zone, often for the production of fruit crops. The agricultural area in Jordan varies from one year to another depending on the rainfall amounts and available water resources.

In view of the increasingly competitive demand for water magnified by the impact of the impeding climate change, there is a pressing need to develop and adopt innovative approaches and technologies that would address such challenges. Some of the approaches include the maximization of water use efficiency; crop diversification and cultivation of high value crops that fetch competitive local and international markets while replacing crops that use proportionately higher amounts of water; development of food and feed crop varieties that are tolerant and adaptive to climate change; and enhancement of the integration and complementarity between crop and livestock production systems.

In the Poverty Reduction Strategy 2013 – 2020, Jordan emphasizes the strong linkage between agriculture, rural development and environment. The key policy and technical issues related to the design of the pro-poor agriculture, environment and rural development component of this strategy include creating productive employment and income generation opportunities for the rural poor, especially small holders who need support in farming their land by microfinance and extension services, development of agro-processing value chain that will create new jobs and increase local food production for consumption by rural residents and for food supplies to Jordan's urban population and for its tourism industry (Ref: PRS, 2013). Agricultural production is closely tied to climate, making agriculture one of the most climate-sensitive of all economic sectors. In the study area assessed in the TNC (2014) report, the climate risks to the agricultural sector are immediate and an important problem because the majority of the rural population depend either directly or indirectly on agriculture for their livelihoods. The rural poor will be disproportionately affected because of their greater dependence on agriculture, their relatively lower ability to adapt, and the high share of income they spend on food. Climate impacts could therefore undermine progress that has been made in poverty reduction and adversely impact food security and economic growth in vulnerable rural areas. Poor in rural areas in Jordan are expected to face the most severe consequences of climate change through disruption of livelihood options that depend on natural resource management. The expected impacts of climate change, particularly reduced agricultural productivity and water availability threatens livelihoods and keeps vulnerable people insecure. Poor families and households are the most vulnerable group to the impacts of climate change and deserve the priority in the design of appropriate adaptive measures.

1.4.2.3.1 Assessment of agriculture sector exposure and vulnerability to climate change

The major determinants identified are: 1) temperature increase, 2) rainfall decrease 3) droughts and 4) shift in rainy season. A detailed description of each is shown below:

1- *Temperature increase:*

Higher growing season temperatures can significantly impact agricultural productivity, farm incomes and food security. Changes in short-term temperature extremes can be critical, especially if they coincide with key stages of development. Only a few days of higher temperature at the flowering stage of many crops can drastically reduce yield.

Crop physiological processes related to growth such as photosynthesis and respiration show continuous and nonlinear responses to temperature, while rates of crop development often show a linear response to temperature up to a certain level. Both growth and developmental processes, however, exhibit temperature optima conditions.

Higher temperatures may be more immediately detrimental, increasing the heat stress on crops and water loss by evaporation. A 2°C local warming could decrease wheat production by nearly 10%. Different crops show different sensitivities to warming. It is important to note the large uncertainties in crop yield changes for a given level of warming because agriculture in many parts of Jordan is already marginal.

2- *Precipitation decrease:*

Water is vital to plant growth, so varying precipitation patterns have a significant impact on agriculture. As over 70% of total agriculture in Jordan is rain-fed, potential future precipitation changes will influence the magnitude and direction of climate impacts on crop production. The impact of global warming on regional precipitation is difficult to predict owing to strong dependencies on changes in atmospheric circulation, although there is increasing confidence in projections of a general decrease over the next 50 years. Precipitation is not the only influence on water availability. Increasing evaporative demand owing to rising temperatures could increase crop irrigation requirements by between 5 to 20%, or possibly more, by the 2070s.

Low rainfall causes poor pasture growth and may also lead to a decline in fodder supplies from crop residues.

3- *Droughts:*

The most immediate consequence of drought is a fall in crop production, due to inadequate and poorly distributed rainfall. Farmers are faced with harvests that are too small to both feed their families and fulfill their other commitments. Where crops have been badly affected by drought, pasture production is also likely to be reduced although output from natural pastures tends to be less vulnerable to drought than crop production.

4- *Shift in rainy season:*

The timing of rain, and intra-seasonal rainfall patterns are critical to smallholder farmers in Jordan. Seasonality influences farmers' decisions about when to cultivate, sow and harvest. It ultimately contributes to the success or failure of their crops. Delays and below-average rainfall will likely have a negative impact on agricultural production. A successive month of water stress for crops has increased the possibility of below average harvest and a reduction in the planting of cereal and winter crops. Usually shifts or delays in rainfall have caused irregular crop development.

Assessment of exposure

The score for climatic hazards for the exposure components were as follows (Table 6):

Table 5 Hazards' exposure average in Agriculture for the two RCPs 4.5 and 8.5

Climatic indices	Likelihood		Geographical magnitude		Confidence	
	4.5	8.5	4.5	8.5	4.5	8.5
Precipitation decrease	3	4	5	5	3	4
Temperature Increase	5	5	5	5	4	5
Shift in rain season	3	4	4	4	2	3
Drought	3	4	4	5	4	4

The average exposure level score for each projection is calculated and plotted in the vulnerability matrix shown later.

Assessment of climate sensitivity

The major determinants identified are: 1) cropping systems, 2) livestock production and 3) livelihood and food security. A detailed description of each is shown below:

1. *Cropping systems:*

Climate change impacts on crop yield are different or vary according to the geographic position or kind of crop. There is a general trend toward a yield decrease that ranges from 5%-20% for different crops. The crop yield is more sensitive to the precipitation than temperature. If water availability is reduced in the future, soil of high water holding capacity will be better to reduce the frequency of drought and improve the crop yield. According to the projected climate change scenarios, the growing period will be reduced, and the planting dates needs to be changed to ensure higher crop production.

Climate change can decrease the crop rotation period, so farmers need to consider crop varieties, sowing dates, crop densities and fertilization levels when planting crops.

2. *Livestock production:*

An increased environmental temperature, decreased precipitation, increased frequency of extreme weather conditions and summer season length has negative impact on productive and reproductive performance of livestock such as increased incidence of livestock diseases and parasitic infestation, decreasing trend of feed and fodder resources.

3. *Food security and livelihood:*

Food security is defined by the Food and Agriculture Organization (FAO) as a, "situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." The definition involves four aspects of food security, namely, food availability, food stability, food access and food utilization.

Climate change could affect food quality because of the increasing temperature and decreasing crop growth period. Also, it will affect the food quantity and the accessibility to food leading to food insecure communities. Food security is increasingly important for the livelihood of rural communities, where food availability and food quality are major concerns because of climate change impacts.

The sensitivity scale shown below (Table 7) was used to assess the sensitivity of the agriculture sector to climate change in the study area.

Table 6 Assessment of sensitivity in Agriculture: Sensitivity (consequence) scale (risk case)

Score	5	4	3	2	1
Qualitative measure	**Catastrophic**	**Major**	**Moderate**	**Minor**	**Insignificant**
Description	•Catastrophic losses of more than 50% of production and/or livestock. •Livelihood: Near complete collapse. •Phase 5: Catastrophe Food Insecurity	Major losses of between 25% and 50% of annual production and/or livestock. •Livelihood: Irreversible depletion. •Phase 4: Emergency Food Insecurity.	Moderate losses of between 10% and 25% of annual production and/ or livestock. •Livelihood: Accelerated depletion. •Phase 3: Crisis Food Insecurity.	•Minor losses of between 2% and %10of annual production and/or livestock. •Livelihood: Stressed. Phase 2: Stressed Food Insecurity.	•Slight losses of annual production and/or livestock covered by normal contingency allocations. •Livelihood: Non-stressed. •Phase 1: No Acute Food

The sensitivity level of the agricultural sectors was minor to moderate (2+3)/2= 2.5. This was calculated based on average impact score for multiple climatic hazards (TNC 2014). The exposure average and the total impact scores are shown below in Table 8. These were calculated for the different climatic hazards under RCP 4.5 and RCP 8.5.

Table 7 Exposure average in Agriculture under RCP 4.5 and RCP 8.5 and total impact score for the different climatic hazards

Indices	RCP 4.5 exposure average	RCP 8.5 exposure average	Total impact RCP 4.5	Total impact RCP 8.5
Precipitation decrease	3.7	4.3	3.1	3.4
Temperature Increase	4.7	5	3.6	3.75
Shift in rainy season	3	3.7	2.75	3.1
Drought	3.7	4.3	3.1	3.4

Impacts of climate change on agriculture

Rain-fed agriculture

Field crops such as wheat and barley are important crops in Jordan. Barley was found to be more susceptible to climate change impacts than wheat because warmer temperatures tend to hasten development more, thus reducing the time available for assimilation of dry matter. According to Al-Bakri et al. (2010), assessments show that a 1°C increase in temperature and 10% decrease in precipitation will decrease yield by 7% for wheat and 18% for barley. While a 2°C increase in temperature and 20% decrease in precipitation will decrease yield by 21% for wheat and 35% for barley due to shorter duration of crop growth and lower water availability.

Olives: It is anticipated that a 1°C increase in temperature and 10% decrease in precipitation will decrease yield by 5%, while a 2°C increase in temperature and 20% decrease in precipitation will decrease yield by 10% due to lower water availability.

Irrigated crops

Climate change will affect growth and production of tuber and root crops, but the possible impact levels of climate change has not yet been studied for most species of this crop group. Potato yields are particularly sensitive to high-temperature stress because tuber induction and development can be directly inhibited by even moderately high temperature. It is anticipated that a 1°C or 2°C increase in temperature will decrease yield by 5 and 10%, respectively. (Al-Bakri et al. 2010)

Vegetables: For many vegetable crops, high temperatures may decrease quality parameters, such as size, soluble solids and tenderness. It is anticipated that a 1°C or 2°C increase in temperature will decrease vegetables yield by 5 and 10%, respectively.

Orchards: Using the appropriate varieties could help avoid the adverse impacts of temperature increase such as less flower bud induction, higher fruit drop, faster volume growth of fruit, earlier maturation, less total soluble solids and fruit reaches insipid and dry states earlier. Also, planting trees that have high tolerance to higher temperatures such as dates would prevent loss of productivity due to global warming. On the one hand, it is anticipated that a 1°C or 2°C increase in temperature will not have a negative impact on an average year if the right varieties or tree types are used. On the other hand, however, extreme weather could have a rather severe impact.

Impacts of climate change on rangelands

Vegetation change will probably be more closely coupled to changes in soil resources than to immediate physiological responses of plants to CO_2 concentration or temperature.

The increase in evapotranspiration (ET) rate and decrease in precipitation in drier systems such as the arid and semi-arid rangelands of Jordan would reduce productivity.

1.4.2.3.2 Assessment of adaptive capacity of agriculture sector

The assessment of adaptive capacity was based on the following determinants:

- Economic capability
- Social capital
- Physical infrastructure
- Institutional capacity

Current Adaptive Capacity

Assessing adaptive capacity in Jordan's agricultural sector and in the study area is challenging, because adaptive capacity reflects a wide range of socioeconomic, policy and institutional factors at the farm, local and national levels. Considerations in determining the variation in adaptive capacity across the country include current climatic exposure, social structures, institutional capacity, knowledge and education and access to infrastructure. Specifically, areas under marginal rainfed production will have less adaptive capacity than areas that are more productive and irrigated agricultural land. In addition, financial resources are one of the key factors in determining adaptive capacity, as most planned adaptations require investments. By that measure, Jordan ranks relatively low in overall adaptive capacity in the agriculture sector. Finally, agricultural systems that are poorly adapted to current climate conditions are indicative of low adaptive capacity to future changes in climate conditions.

1.4.3 Process and results of sector selection for mitigation and adaptation sectors

1.4.3.1 Launching/inception workshop of the TNA Project in Jordan and national exercise for priority sector selection

This Section will elaborate on the Launching/Inception Workshop of the TNA Project in Jordan and the national exercises and discussions took place during the workshop to select priority mitigation and adaptation sectors. The launching of the TNA Project in Jordan (Figures 7, 8, and 9) took place on November 17th 2015. (Agenda of event is posted in Annex 1). The workshop was patronaged by H.E. Secretary General of Ministry of Environment Eng. Ahmad Al-Qatarneh. H.E. emphasized the importance of this project to the country and indicated that the GoJ through MoEnv is targeting on securing international support for climate change projects. H.E. thus stressed on the high need to coordinate efforts of all involved and relevant stakeholders to collaborate planning and actions to respond to climate change impacts in the country.

Figure 7 A photo from the Inception Workshop of TNA Project, Jordan (Nov. 17th, 2015)

The TNA Project Coordinator in Jordan, Eng. Hanadi Marie, presented the new project to the audience and explained the concept “Technology Needs Assessment (TNA).” She emphasized that it is a country – driven process, which needs effective involvement of relevant stakeholders. She also explained the main pillars of the process, milestones, and expected outcomes and deliverables. She then talked about the agreement between MoEnv and UNEP-DTU Partnership, which entered into force as of September 1st 2015, and highlighted the new opportunity this agreement will provide to the country. The TNA Coordinator underlined the fact that MoEnv will actively involve all relevant stakeholders and funding community in the TNA process from project inception throughout implementation and follow-up phase.

Figure 8 A photo from the Inception Workshop of TNA Project, Jordan (Nov. 17th, 2015).

At the end of her presentation, Eng. Hanadi presented some slides about the TNA-relevant ***Climate Technology Center & Network (CTCN)*** which will provide technical assistance at the request of developing countries to assist the transfer of climate technologies through the NDE as well as will create access to information and knowledge on climate technologies. She highlighted that the CTCN will foster collaboration among climate technology stakeholders via the *Climate Technology Network* of regional and sectoral experts from academia, the private sector, public and research institutions.

Figure 9 A photo from the Inception Workshop of TNA Project, Jordan (Nov. 17th, 2015)

In Jordan, the selection of priority mitigation and adaptation sectors for TNA took place during the Inception Workshop was based on conducting another dedicated multi criteria analysis (MCA) exercise prepared purposely for this step in addition to the standard MCA template proposed by UNEP-DTU for priority technology selection. During the Inception Workshop, the priority mitigation and adaptation sectors for technology needs assessment were concurrently determined in a dedicated national exercise in coordination with MoEnv to determine most important sectors in terms of the highest GHGs mitigation potential as well as the sectors of most vulnerability and impact because of climate change. The Sector Selection MCA in terms of criteria used for national stakeholders' discussions and structure of the sheet as well as scoring system were brainstormed and prepared carefully by the team of consultants of this study in a dedicated meeting set specifically for this purpose. The final set of criteria used and scoring system of the sheets discussed with national stakeholders during the project's Inception Workshop are illustrated in Annex 2 for Mitigation Sector Selection exercise and Annex 3 for Adaptation Sector Selection exercise.

It is clear that MCA for selection of priority ***mitigation*** sectors was based on key criteria such as levels of greenhouse gases emission and mitigation actions viable; the position of the targeted sector with regard to national priority to sustainable development; economic aspects, social impact, readiness of sector and level of current planning, implementation experience, sustainability potential, and financing factors. On the other hand, MCA for selection of priority ***adaptation*** sectors was based on main criteria relevant to urgency of technology needs and risk of delay of action as relevant to vulnerability; the position of the targeted sector with regard to national priority to sustainable development; economic aspects, social impact, readiness of sector and level of current planning, implementation experience, sustainability potential, and financing factors.

For ***mitigation***, the criteria have been given weight based on experience of the project consultants and stakeholders' representatives attended the workshop. A wide pool of representatives from relevant stakeholder institutions has participated in the two concurrent sector selection exercises (Figures 10 and 11 for mitigation and adaptation sector selection exercises, respectively). For the weighted averages, each criterion/sub-criterion has given a mark out of 100 and then multiplied by its weight and dividing the total by 100 to give results on scale of 0 to 100. Results are depicted in Table (9) graded on a scale of 0 to 100. As can be concluded from the results in the table below, Energy and Transport sectors are the most important sectors in terms of technology needs.

Table 8 Results of prioritizations of mitigation sectors: classifications of sectors contributed to GHG and their weight of importance ranked from 0 to 100

Energy	***Transport***	***Industry***	***Waste***	***LULUCF/Agriculture***
99	**54.5**	41.25	37.4	25.6

The same exercise was conducted for ***adaptation*** sector selection and results was as follows (Table 10)

Table 9 Results of prioritizations of adaptation sectors: Classifications of sectors most vulnerable to climate change and their weight of importance ranked from 0 to 100

Water	***Agriculture***	***Health***	***Biodiversity***	***Coastal Areas/Tourism***	***Urban and Cities Adaptation***
98	**96**	70	86	65	60

To conclude, the two MCA exercises revealed that the two top mitigation priority sectors in Jordan are *Energy* and *Transport* while on the other hand, the two top adaptation sectors selected were *Water* and *Agriculture* based on the selection process by stakeholders representing all mitigation and adaptation sectors in the country. This conclusion was not unexpected in light of the current status of the energy and transport sectors as the two most emitters of GHGs and their critical implications with regard to sustainable development. The same conclusion is valid for water and agriculture sectors as they are the most top two vulnerable sectors to climate change as shown above in the extensive assessments conducted in the national studies, mainly the TNC study (2014).

Figure 10 A Photo from MCA exercise for mitigation priority sectors selection on the Inception Workshop Day (Nov. 17th, 2015)

Figure 11 A Photo from MCA exercise for adaptation priority sectors selection on the Inception Workshop Day (Nov. 17th, 2015).

CHAPTER 2 INSTITUTIONAL ARRANGEMENT FOR THE TNA AND THE STAKEHOLDER INVOLVEMENT

2.1. The Climate Change Stakeholders in Jordan

All relevant national institutions involved in climate change policy development in Jordan are forming together the National Committee on Climate Change (NCCC), which was established after a decree (no. 23 C/9/1/4821) from the Prime Minster issued on April 3rd, 2001. The current structure of the NCCC is as follows:

1. Ministry of Environment (MoEnv)
2. Ministry of Energy and Mineral Resources (MEMR)
3. Ministry of Planning and International Cooperation (MoPIC)
4. Ministry of Agriculture (MoA)
5. Ministry of Industry and Commerce (MIC)
6. Ministry of Transport(MoT)
7. Ministry of Water and Irrigation (MWI)
8. Ministry of Health (MOH)
9. Ministry of Tourism and Antiques (MOTA)
10. Ministry of Social of Development (MoSD)
11. Jordan Meteorological Department (JMD)
12. General Security Directorate/Drivers & Vehicles License Department
13. Royal Scientific Society (RSS)
14. Jordanian National Forum for Women
15. Greater Amman Municipality (GAM)
16. Aqaba Special Economic Zone Authority (ASEZA)
17. National Center for Agricultural Research and Extension (NCARE)
18. The Jordanian National Commission for Women (JNCW), hosted by the Jordanian Hashemite Fund for Human Development (JOHUD), the former to represent both JOHUD and JNCW, which in turn represents all women organizations in Jordan (such as the General Federation of Jordanian Women [GFJW] and Jordanian National Forum for Women [JNFW]).
19. Two national universities selected based on criteria set by committee (for 2011/2012-and since now as no change took place- Hashemite University and Jordan University for Science and Technology, JUST, were selected to represent universities in the NCCC)
20. Two national environmental NGOs selected based on criteria set by committee (for 2011/2012- and since now as no change took place-, Royal Society for Conservation of Nature and Jordan Environment Society were selected)

One of the specificities of the NCCC is that it is composed of middle-level and top-level administrative correspondents from the official (line ministries) and non official institutions as well as a number of scientific and technical experts selected from academic and research institutions for their expertise in a wide range of related fields and for their standing in the local and international scientific community. Members were historically and currently being nominated by the main stakeholders as well as current members of Committee after endorsement of Prime Minster. The NCCC is headed by the Minister of Environment while the Ministry of Environment is considered the national administrative body for the secretariat of the UNFCCC. The Committee establishes its specialized thematic legal and technical groups on permanent and/or ad-hoc basis, according to the subject of the discussion theme on hands. Thematic groups function under the umbrella of the NCCC and are composed of principal country expertise on the needed topics of advice and can cooperate with other relevant local and international specialists and experts in the targeted issue. The overall responsibilities and mandate of the NCCC is the implementation of the UNFCCC in accordance with national interests and providing needed advice in response to national and international commitments and obligations. Duties also include supervising and ensuring the development and execution of needed legal, regulatory and institutional arrangements and frameworks for supporting implementation of the Convention. The committee also sets up national climate change mitigation and adaptation programs on regular basis to support the government’s sustainable development plans; leads climate change adaptation and mitigation efforts; ensures the integration of adaptation within other national development strategies and plans; enhances the integration of gender dimension in these strategies; promotes effective and sustainable management of climate change aspects in Jordan; provides needed coordination; follows up country's technical progress; and provides recommendations for its improvement.

With regard to the TNA Project in Jordan, the NCCC will serve as the *Steering Committee* of the Project. However, to support the objectives of the TNA Project and to enrich the discussion about climate change technology needs and be involved in baseline assessments, two *Technical Working Groups* (one for mitigation and the other for adaptation) were established to form the rest of the TNA Team elaborated in Section 2.2 below.

2.2. National TNA Team in Jordan

2.2.1. The TNA Steering Committee

As described above, the NCCC will serve as the *Steering Committee* of the Project. Thus, the whole Committee was invited to attend the Inception/Launching Workshop of the TNA Project held on Nov. 17th 2015 and the meeting was considered the first meeting of the *Screening Committee* of the Project. All members of the NCCC had the opportunity to be introduced to the project's concept and objectives as well as providing feedback on its planning and implementation strategy. Minutes of this meeting and outcomes of the workshop will be documented in a separate report as required by UNEP/DTU and ALMAKAN's agreement.

2.2.2. The National TNA Coordinator

The Head of the *Adaptation Division* at the newly established *Climate Change Directorate* at MoEnv is serving as the National TNA Coordinator. The TNA Coordinator is in charge of coordinating and facilitating the activities of the TNA in Jordan as relevant to involvement of MoEnv and NCCC. She participate in planning of all activities and consultation workshops and reviews deliverables and obtains necessary endorsement for actions and deliverables from high level entities in the chain of commands at MoEnv.

2.2.3. The National TNA Committee: Sectoral Technical Working Groups

To systematically support the objectives and contribute to the milestones of the TNA Project and to enrich the technical discussions about climate change technology needs as related to Jordan as well to be involved in baseline assessments, dedicated two *Technical Working Groups* (one for mitigation and the other for adaptation) were established as part of the National TNA Team. The two committees together will be considered as the ***National TNA Committee.*** The structures of the two Sectoral Technical Working Groups is posted below.

2.2.3.1. Mitigation Technical Working Group (MTWG)

1. Ministry of Environment (MoEnv)
2. Ministry of Energy and Mineral Resources (MEMR)
3. Energy and Minerals Regulatory Commission
4. Ministry of Planning and International Cooperation (MoPIC)
5. Ministry of Industry and Commerce (MIC)
6. Ministry of Transport(MoT)
7. Land Transport Regulatory Commission
8. Ministry of Municipalities (MoMA)
9. Ministry of Housing and Public Works (MOHPW)
10. "Together We Arrive" Initiative
11. Jordan Meteorological Department (JMD)
12. General Security Directorate/Drivers & Vehicles License Department
13. Royal Scientific Society (RSS)
14. Greater Amman Municipality (GAM)
15. Aqaba Special Economic Zone Authority (ASEZA)
16. Tafila Technical University
17. Princess Sumaya University for Technology

18. National Electric Company
19. Traffic Department
20. Customs Department
21. Jordan Standards and Metrology Organization (JSMO)
22. Jordan Investment Commission
23. Jordan Enterprise Development Corporation (JEDCO)
24. Jordan Green Building Council
25. National Energy Research Center
26. Izzat Marji Group
27. Philadelphia Solar
28. Al-Rajhi Cement Factory
29. Manaseer Cement Factory

2.2.3.2. Adaptation Technical Working Group (ATWG)

1. Ministry of Environment (MoEnv)
2. Ministry of Planning and International Cooperation (MoPIC)
3. Ministry of Agriculture (MoA)
4. Ministry of Industry and Commerce (MIC)
5. Ministry of Water and Irrigation (MWI)
6. Ministry of Health (MOH)
7. Ministry of Tourism and Antiques (MOTA)
8. Ministry of Social of Development (MoSD)
9. Jordan Meteorological Department (JMD)
10. Royal Scientific Society (RSS)
11. Jordanian National Forum for Women
12. Greater Amman Municipality (GAM)
13. Aqaba Special Economic Zone Authority (ASEZA)
14. National Center for Agricultural Research and Extension (NCARE)
15. The Jordanian National Commission for Women (JNCW),
16. Customs Department
17. Jordan Standards and Metrology Organization (JSMO)
18. Jordan Water Co Miyahuna
19. Aqaba Water Company
20. Yarmouk Water Company
21. IUCN

2.2.4. The Consultants Team

The consulting entity selected by UNEP-DTU for carrying out the TNA assignment in Jordan was *Water, Food & Energy for Environmental Resources Management Co. (ALMAKAN).* ALMAKAN provides consulting services in all potential areas of water, food, energy and the wide sustainable development spectrum with emphasis on impacts of climate change and desertification. The name ALMAKAN was aggregated from the first letters/segments of the Arabic words "*ALMA*'" for Water; "*KALA*' " for Grass or Pasture[22], which symbolizes FOOD and "*AN-NAR*" {means "fire" in Arabic}, which symbolizes ENERGY.. ALMAKAN pledged to form a competent team of consultants to execute the assignment. Thus, a team of well experienced experts was formed as explained below.

In formulating the TNA Team in Jordan, the following DTU reference was utilized as well: Appendix II to the Agreement between UNEP/DTU and MoEnv, entitled "*Organizing the National Technology Needs Assessment (TNA) Process: An Explanatory Note*[23]".

The national institutional setup for TNA Team in Jordan could be visualized in Fig 12.

22 in its narrow meaning but the scope of this Arabic word "KALA' " is much more wider

[23]*Subash Dhar, Jyoti Painuly, Ivan Nygaard and Jorge Rogat, revised Nov. 2014,* "Organising the National Technology Needs Assessment (TNA) Process: An Explanatory Note"

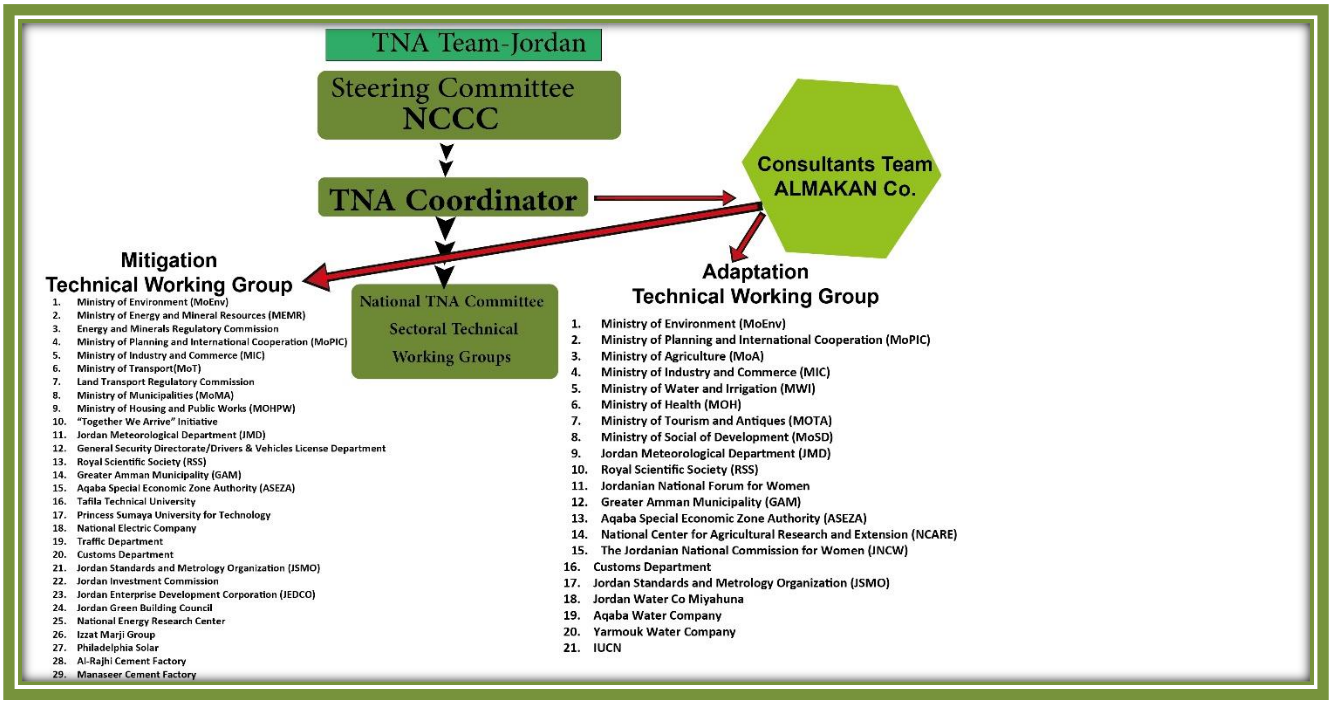


Figure 12 The national institutional setup for TNA Team in Jordan

2.3. Stakeholder engagement process followed in the TNA – overall assessment

In Jordan, the TNA activity was systematically conducted through a country-driven process, involving all relevant stakeholders and taking national sustainable development priorities into consideration, see for example the national exercises conducted to select priority sectors (Annexes 2 and 3). In the said exercises, all relevant national stakeholders were involved (Figures 12 and 13, which illustrating photos from MCA exercise for mitigation and adaptation priority sectors selection both conducted on the Inception Workshop Day(Nov. 17th, 2015)). The national sustainable development priorities were fully taken into consideration as the main criterion in the MCA to select priority sectors for TNA. This criterion was further subdivided into sub-criteria such as: sector's national priority in the general sustainable development context of the country (i.e., persistent position of the sector); national priority of the sector in particular national sustainable development and planning documents: example: (1) *Jordan 2025- National Vision and Strategy (2015-2025)*, (2) *Executive Development Programme (EDP) 2016-2018; and finally* national priority of the sector in particular climate change planning documents, *example: (1)* Climate Change Policy of Jordan 2013-2020 and (2) INDCs 2020-2030.

Thus, the TNA Team in Jordan made sure that in addition to taking all relevant sustainable development priorities into consideration that the TNA is also conducted based on extensive participatory process involving all relevant stakeholders, with emphasis on involving the two *Technical Working Groups*. Thus a very wide rainbow of stakeholders were involved spanning governmental agencies, academia and research centers, NGOs, (mainly institutions members of the NCCC) as well as another pool of relevant stakeholders from business, customs, tax, standards, etc. The details for the stakeholders consulted (including names, organisation, dates of consultation, and topics) are provided in Annex 4. Separate reports will documents the outcomes and discussions of such two workshop.

The national stakeholders were involved in two phases of consultation. In the first phase, the launching of the TNA project in Jordan took place (Nov 17th 2015) where the work plan of the assignment was presented and discussed to obtain feedback from stakeholders. In the same day, three exercises were conducted involving all attendees. The first exercise was for selection of priority mitigation and adaptation sectors for TNA, which was based on conducting another dedicated multi criteria analysis (MCA) exercise prepared purposely for this step utilized in addition to the standard MCA form proposed by UNEP-DTU for priority technology selection. This sector selection MCA exercise executed during the Inception/Launching Workshop of the TNA Project in Jordan created serious and fruitful discussions (Figures 10 and 11) which yielded the top priority sectors for mitigation (energy and transport) and adaptation (water and agriculture). The discussions of the mitigation sector selection group (Figures 10) focused on considering the level of GHG emissions as the main criterion of the highest weight of score to rank sectors. MCA for selection of priority mitigation sectors was based on key criteria such as levels of greenhouse gases emission levels and mitigation actions viable; the position of the targeted sector with regard to national priority to sustainable development; economic aspects, social impact, readiness of sector and level of current planning, implementation experience, sustainability potential, and financing factors. On the other hand, MCA for selection of priority adaptation sectors was based on main criteria relevant to urgency of technology needs and risk of delay of action as relevant to vulnerability; the position of the targeted sector with regard to national priority to sustainable development; economic aspects, social impact, readiness of sector and level of current planning, implementation experience, sustainability potential, and financing factors.

After the two top priority sectors for TNA were identified for mitigation (energy and transport) and adaptation (water and agriculture), the second exercise (Annex 5) conducted on the Inception Workshop day was *Stakeholders Identification and Involvement/Engagement Plan for additional key stakeholders that are to be invited to next activities of the assignment*. Stakeholders participated in this exercise agreed that identifying and distinguishing all relevant stakeholders of the project at a very early stage of the TNA process is very important for successful involvement and engagement during the crucial steps of barrier analysis and the development of a technology action plan that is feasible and action-oriented. In the third exercise conducted on the Inception Workshop day involving all national stakeholders, a random listing of potential technologies under each selected sector was conducted. This was done to initially identify the long list of technologies, which will be subjected in the consequent steps to further investigation and description as well as developing a mechanism to select the top (6 to 15) priority technologies for each selected sector based on a robust approach. The approach followed to come up with the top 6-15 priority technologies for mitigation and adaptation sectors and the process of putting them in order based on MCA exercise will be addressed in Chapters 3 to 6.

CHAPTER 3 TECHNOLOGY PRIORITIZATION FOR ENERGY SECTOR

3.1. GHG emissions and existing technologies of energy sector

According to the Jordan's TNC 2014 report, energy-related activities have been classified as the dominant source of GHG emissions in Jordan from either fuel combustion or non-combustion (fugitive) emissions. The total emissions has contributed to around 73% of total emissions with around 20.94 Mt CO2 eq. for the year 2006. The following is a summary of energy-related activities in the country as relevant to existing technologies, practices and potential emission sources.

Fuel oil: Jordan has no hydropower or nuclear power stations. Heavy fuel oil with high sulphur content of about 3-4% by weight was the main fuel used for public electricity generation in the year 2006. Thus the energy industries sub-sector contributed 70 Gg SO_2 out of the total 139 Gg SO_2 national emissions in the year 2006, representing more than 50% of the emissions for this gas.

Gas: In 2011, there was a significant decline in natural gas quantities imported from Egypt because of damages on natural gas pipeline occurred within the Egyptian territories, which led to the cutoff of natural gas supplies for large periods of the year, which in turn led to use alternatives for natural gas, such as diesel and heavy fuel oil to generate electricity (MEMR, 2011). In 2012, there was only 587 million cubic meters imported representing 22% of contractual quantities (MEMR, 2012). New quantities of gas were discovered in Risha field with the possibility of producing 100, 170 and 350 million cubic feet daily from Risha gas in planned progressive development phases. It is possible to realize a considerable saving in overall costs of the generation expansion plan through availability of additional quantities at Risha field and through consumption rationalization programs and loads management (MEMR, 2011).

Oil shale: As the fourth biggest world reserves, oil shale surface reserves in Jordan are more than 70 billion tons containing more than 7 billion tons of oil shale (MEMR, 2012). Oil Shale in Jordan can be utilized commercially by the direct incineration to produce electricity or by the retorting to produce crude oil; especially after the technological advancement in utilizing the oil shale, which achieve the environmental demands and the international success in this field. Esti Energia, an Estonian Company, is completing procedures to build a power plant using the technology of direct incineration of the Jordanian oil shale with a capacity of 430 MW. These procedures are submitting a final financial offer, providing finance to build the station, completing negotiation and reaching financial closure. It is expected that the station is opened in 2017 (MEMR, 2012). Key principles agreement was signed with the Chinese coalition HTG and Jordan Allajaun Company on 8/11/2012 to study the potential for building a station to generate 600-900 MW of electricity by using direct incineration of oil shale (MEMR, 2012).

Renewable Energy: Jordan is located within the Sunbelt with average solar insolation of 5-7 $Kwh/m^2 \cdot day \cdot$ Moreover, wind speed in specific regions ranges between 7-9 m/s. These figures are promising data for exploiting renewable energy for electricity generation in Jordan. Renewable Energy and Energy Efficiency Law was enacted as a permanent law under no. 13 for 2012. This law provides the legal, regulatory and legislative framework of investments in renewable energy, allows MEMR to deal with direct proposals submitted to it to invest in renewable energy projects without entering into long tender process, and grants tax and custom exemptions to renewable energy systems and equipment in addition to many privileges regarding investment in renewable energy. With respect to new and renewable energy resources, their share to the energy mix is not exceeding 2%. MEMR has adopted an ambitious program to increase renewable energy share to the energy mix to reach 7% by 2015 and 10% by 2020[24]. The Bio Gas Company continues working to process the organic waste in Alrosaifa Landfill. The amount of the solid and liquid waste that was processed in 2011 reached to 35 thousand tons, and the amount of electricity generated reached to 8005 MWh. The amount of the emissions reduced from biogas reached about 7.6 million cubic meters (MEMR, 2011). The amount of the liquid waste that was processed in 2012 reached to 770 m^3, and the amount of electricity generated reached up to 5.9 Mwh. The amount of the biogas that its emissions were reduced reached about 5.6 million cubic meters(MEMR, 2012).

[24]Updated Master Strategy ofEnergy Sector in Jordanfor the period (2007-2020), MEMR, Jordan December 2007.

Combined- Cycle Gas Turbines: Two gas units with a capacity of 142 MW was added in Al Samra electricity generation station in order to meet the demand of electricity in 2011. The first gas unit was commercially operated on 25/1/2011 and the second gas unit by the end of February 2011 (MEMR, 2011). Samra Electric Power Generation Company was assigned by the Council of Ministers to add a generation capacity of 145.9 MW to meet loads of summer 2013 (MEMR, 2012).

IPP: The project aims to contribute in cover electric loads with a capacity of 373 MW, by using the technology of the combined cycle that burns natural gas as a primary fuel and diesel as a secondary fuel according to the environmental standards applied in Jordan.

Combined Heat and PowerCHP: In Jordan, combined heat and power systems are non-existent. The government does not provide heating services, instead, heat is being provided on individual basis in the residential, commercial, industrial and service sectors mainly through the use of electricity, diesel oil, LPG and kerosene (MEMR, 2011).

3.2. An overview of possible mitigation technology options in Energy Sector and their mitigation potential and other co-benefits

This section will explain how the GHG emissions of Energy Sector can be reduced with different technology options. Nine technologies were assessed in terms of their potential and feasibility of GHGs reduction potential. The information was organized and tabulated in nine technologies factsheets, which have been finalized based on the mitigation consultant's deep experience in the industry and field experience and literatures. These factsheets contained information on the technology characteristics, potential of resources, potential of applications, financial appraisal, maturity, energy savings/GHG mitigation opportunities, economic benefits and social benefits (Annex 7).

3.3. Criteria and process of technology prioritisation for energy sector

The assessment of various technologies for the energy sector is based on their contribution to sustainable development by minimize GHG emissions from the sector, maximizing the resilience of the sector to climate change impacts, maximize development priority benefits in terms of environmental, social, and economic, and to minimize any negative consequences of the technology (UNDP, 2010). Accordingly, and in order to determine priority criteria and most important technologies within this context, an expert consultation workshop has been organized as mentioned above. Experts from all relevant energy stakeholders have attended to contribute in opinion, information provision, and experience required to achieve the tasks. Prioritization of technologies was performed using the Multi-Criteria Analysis (MCA) approach. Technologies were identified and analysed based on the project consultant experience, country reports, country policies and strategies, literature review, field experience and results of the expert workshop meeting held solely for this task. Results of criteria, weight and technologies are depicted in the tables below. Table 10 shows criteria and weight used to prioritize technologies. Final weights were allocated based on discussions and consultations with stakeholders after extensive discussion of initially-proposed criteria and weights by the consultants. As a matter of fact, stakeholders had the full freedom to thoroughly discuss and modify both the criteria and their weights as appropriate. This procedure was followed in the rest of exercises used for sectors' (transport, water and agriculture) technology selection.

Table 10 Criteria and weight used to prioritize technologies

	Criterion	Allocation of budget (total = 100)	Weight, %
Criterion 1	Potential of resources	25	25%
Criterion 2	Potential of applications	15	15%
Criterion 3	Financial appraisal	15	15%
Criterion 4	Maturity	10	10%
Criterion 5	GHG Emission Reduction	15	15%
Criterion 6	Economic benefit	10	10%
Criterion 7	Social benefit	10	10%

The following technologies were pre-selected for analysis (Table 11): Technologies selected

Table 11 energy technologies pre-selected for MCA

- PV Electrification
- PV Water Pumping
- Solar Street Lighting
- Solar Thermal
- Wind
- CSP
- Hydropower
- Green-building and passive design
- Replacing conventional lighting with LED and CFL Lighting

3.4. Results of technology prioritization for energy sector

Scoring was determined by stakeholders, facilitated by the energy consultant, for each technology and criteria and depicted in an Excel based worksheet designed using the Multi Criteria Analysis (MCA). During the exercise, several technologies were ruled out from the start by the stakeholders that judged them as unsuitable for the Jordan conditions. Accordingly, the MCA exercise was used to score and rank the remaining technologies. The tables below (Table 12) shows scores of the technologies that were used in the prioritization exercise and the results of evaluation, while Table 13 shows final technologies prioritization scores and ranking.

Table 12 Scores of selected criteria to technologies

Criteria **Options**	**Potential of resources**	**Potential of applications**	**Financial appraisal**	**Maturity**	**GHG Emission Reduction**	**Economic benefit**	**Social benefit**
Units	not given	not given	not given	not given	not given	not given	not given
Preferred value	High	High	High	High	High	High	High
Weight	25%	15%	15%	10%	15%	10%	10%
PV Electrification	100.00	100.00	75.00	66.67	100.00	75.00	75.00
PV Water Pumping	100.00	100.00	75.00	66.67	100.00	75.00	100.00
Solar Street Lighting	100.00	75.00	75.00	66.67	100.00	75.00	100.00

Solar Thermal	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Wind	50.00	50.00	50.00	33.33	100.00	75.00	0.00
CSP	100.00	25.00	0.00	0.00	100.00	75.00	25.00
Hydropower	0.00	0.00	25.00	66.67	100.00	0.00	25.00
Green building and passive design	75.00	75.00	50.00	100.00	66.67	50.00	100.00
Replacing conventional lighting with LED and CFL Lighting	50.00	100.00	100.00	33.33	0.00	50.00	100.00

Table 13 Results of energy sector technologies prioritization and ranking.

Option scores

Option	Weighted Score
PV Electrification	87.9
PV Water Pumping	90.4
Solar Street Lighting	86.7
Solar Thermal	100.0
Wind	53.3
CSP	53.8
Hydropower	27.9
Green-building and passive design	72.5
Replacing conventional lighting with LED and CFL Lighting	60.8

Ranking of options

Rank	Option	Weighted Score
1	**Solar Thermal**	**100.0**
2	**PV Water Pumping**	**90.4**
3	**PV Electrification**	**87.9**
4	Solar Street Lighting	86.7
5	Green-building and passive design	72.5
6	Replacing conventional lighting with LED and CFL Lighting	60.8
7	CSP	53.8
8	Wind	53.3
9	Hydropower	27.9

It is obvious that the top three mitigation technologies for energy sector are (1) Solar Thermal, (2) PV for Water Pumping, and (3) PV for Electrification.

CHAPTER 4 Technology Prioritisation for Transport Sector

4.1. GHG emissions and existing technologies of the Transportation Sector

GHG emissions from transport sector in Jordan are lumped with energy sector calculations (TNC, 2014). The transport sector was the second largest source of emissions, emitted in 2006 about 4706 Gg CO_2 eq. (16.4% of of total energy emissions (Figure 2) and 22.5 % of bulk country's emissions[25].

Transport is a major sector contributing to GHG emissions from fuel combustion for the passenger and freight. The following subcategories were included in the TNC (2014) assessments:

- Domestic aviation;
- Road transport;
- Rail transport;
- National Navigation; and
- Pipeline transport.

Among all energy sub-sectors, transport was the largest contributor to the emissions of N_2O, NO_x, CO and NMOVCs. Domestic aviation is limited to relatively small number of trips between Amman and Aqaba cities. Only around 1 % of jet fuel was used for domestic aviation in Jordan in the year 2006. Rail transport is also limited to one train transporting phosphate from Al Shadiya mine to the Jordanian port of Aqaba. Transport consumes about 39% of overall energy use (passenger cars accounting for around 57% of this) and to a large share of air emissions (estimated by World Bank's Country Environmental Assessment[26] at 80% for NOx; 20% for SOx, and 40% for TSP). The Transportation Regulatory Commission is regulating this sector by defining the routes and issuing permissions and controlling the whole sector operations. In addition, the internal transportation (inside cities) especially small cars (service and taxis) have their own regulations and are mostly controlled by Municipalities.

The emissions of the energy (including transport sector) baseline scenario by the Gas Carbon Dioxide Emissions (CO_2) was estimated in the TNC Report for three projected future years 2020, 2030, and 2040 (Figure 13).

When it comes to emissions, Jordanian quality standards for fuel and exhaust emissions do exist but with limited monitoring and enforcement. In relation to this, the national Transport Strategy has been recently launched (2014) with one of the sectorial objectives is focused on the reduction of environmental impacts from the transport sector. However, this has not developed into any projects in the implementation plan yet.

4.2. An overview of possible mitigation technology options in the transportation sector and their mitigation potential and other co-benefits

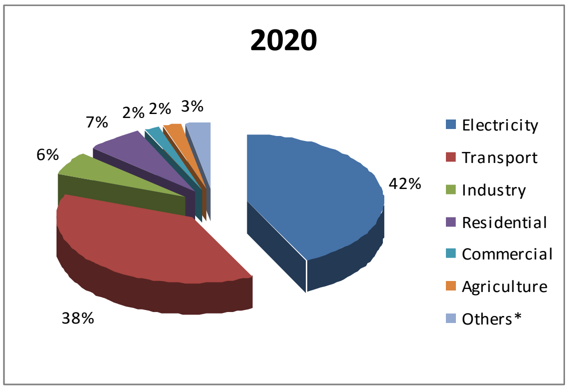
According to TNC (2014), the possible mitigation technology options in addition to the ones already under deployment or in planning phase in Jordan are as follows.

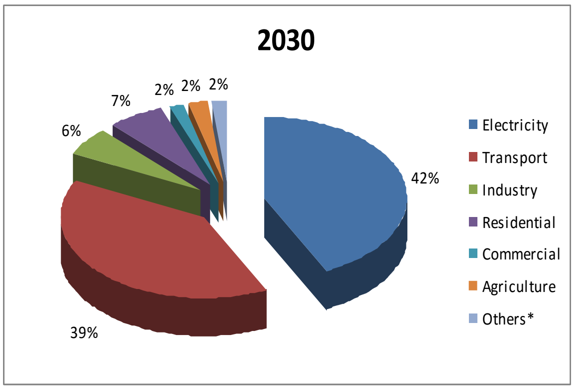
1. Introducing Amman – Zarqa BRT Project

This project/technology (Table 14) has the following assumptions (i) annual increase of reduction of fuel consumption and CO_2 emission after using BRT project equal to annual population growth which was 2% for the year (2008-2012), (ii) the project will start working in 2016.

[25] Jordan's TNC Report to UNFCCC (2014)

26 World Bank, 2009, Hashemite Kingdom of Jordan. Country Environmental Analysis, Sustainable Development Sector Department (MNSSD) Middle East and North Africa Regi





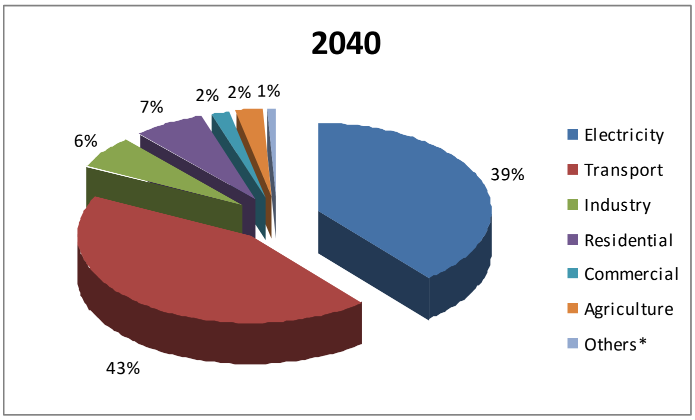


Figure 13 CO2 levels estimated in the TNC Report for three projected future years 2020, 2030, and 2040

Table 14 Reduction of CO2 by Introducing Amman – Zarqa BRT Project

	Emissions CO2 (g)/ passenger /km (*)	Distance (km)	No of Passengers	CO_2 Emissions 000 ton / day	CO_2(000) ton /300 day
Amman – Zarqa BRT	80				
Conventional bus	190				
Reduction form Amman- Zarqa BRT	110	26	100,000	0.286	85.8

2. Reduction Cost of CO_2 for Public Passenger Cars

This project/technology (Table 15) has the following assumptions (TNC Report, 2014)

- Replacing conventional small passenger public cars with Hybrid cars within 10 years staring from 2015.
- Fuel saving 38%, (Prioritizing Climate Change Mitigation Alternatives: Comparing Transportation Technologies to Options in Other Sectors June 2008, Nicholas Lutsey).
- Average annual growth for small passenger public cars is 1%.
- Cost of hybrid car is higher than conventional car about 4000 JD.
- Life time for hybrid public passenger car is (10) years.

Table 15 Reduction Cost of CO2 for Public Passenger Cars

Saving (*)	no of public passenger cars in year 2012 (**)	no. of hybrid cars replaced by conventional passengers cars yearly (10%)	gasoline consumption by public cars 2012 TOE (***)	average yearly gasoline consumption by each conventional public passenger car year 2012 TOE	Reduction of gasoline consumption for each car by using hybrid public passenger car TOE	Reduction of gasoline consumption by replacing 10% yearly of conventional passengers cars by hybrid cars (000) TOE	Reduction of CO2 emissions (000 ton) by using hybrid cars for public passenger cars
38%	23817	2381.7	180000	7.56	2.872 #	6.84	19.75

(*)Prioritizing Climate Change Mitigation Alternatives: Comparing Transportation Technologies to Options in Other Sectors June 2008, Nicholas Lutsey.

(**) MOT Annual Report 2012.

(***) MEMR Transport Sector Survey year 2012.

: Reduction of gasoline consumption for each car by using hybrid public passenger car TOE=no. of cars *7.56*38%

According to the MOT letter no 1/1/2/760 dated 5/2/2014, MOT will develop long term strategy (2015 - 2032) taking into consideration mitigation of GHG emissions through the following:

1. Grant incentives for renewing all road means of transport (public transport, trucks, private cars).
2. Set minimum criteria for cars specifications, and set maximum allowable limit for bus life.
3. Impose high fees on old fleet.
4. Develop regulation for fleet emissions and maintenance criteria.
5. Set programs for monitoring noise and emissions levels for aircraft with coordination with the operators and government agencies.

These steps are mainly focusing in reducing the GHG emissions by shifting the transport sector from using private vehicles toward the public transportation maximization. Table 16 shows the amount of GHG reduction for some proposed technologies, criteria and process of technology prioritization for the transportation sector

Table 16 Emission reduction and emission reduction unit cost for transport mitigation projects

Project Name	Total discounted cost (M JD)	Total Discounted Emission Reductions (KTons CO_2eq)	Mitigation Cost (JD/ton)
Reduction by using hybrid cars for public passengers	316.2	1575.0	200.8
Reduction by Amman – Zarqa Bus Rapid Transit (BRT)	302.5	1087.0	215.7
Total emission reductions for the sector		2662.0	

After reviewing these challenges with the stakeholders in the TNA Inception Workshop, the transport mitigation consultant got the consensus of the National TNA Committee on such challenges elaborated above and listed with them five main potential technologies. The Consultant then further investigated other potential mitigation technologies most appropriate for the transport sector in Jordan and the total came up to five.

- Bus Rapid Transport BRT
- Promoting Bikes
- E-Vehicles
- Public Transportation Maximization
- Fuel Efficiency

For each priority technology, the expert started to collect data about and prepared a fact sheet that includes: a brief technology description, the costs of the technology, the application potential in the country, the mitigation and other social, economic, and environmental benefits (Annex 8). The fact sheet were shared with transport sector's stakeholders prior to conducting final prioritization. Thus, the sector prioritization process was carried out by taking into consideration constraints and the national context that are illustrated by several criteria. A set of prioritization criteria were listed by the transport mitigation expert to be identified in the meeting of the TNA mitigation committee based on their social, economic, and environmental benefits. This meeting carried a Multi-Criteria Analysis (MCA) decision-making exercise, where transport experts and stakeholders assessed the identified mitigation technologies based on to their importance in meeting national mitigation goals.

However, during the Technical Working Group meeting on the 25th of Nov 2015 held to prioritize transport mitigation technologies, the list was screened to revised become four main priority technologies which are:

- Bus Rapid Transport BRT
- Promoting Bikes
- E-Vehicles
- Public Transportation Maximization
- Ticketing System for Public Transport

Summary of the pre-prioritized technologies for the transportation sector

- **Bus Rapid Transport**

The Ministry of Transportation in Jordan is planning to establish a bus rapid transit system (BRT) in a high-capacity transport system with its own right of way, which can be implemented inside Amman Roads and between Amman and Alzarqa Governorate. It is a key technology in cities in developing countries, which can change the trend of using private vehicles towards public transportation, thereby bringing about a range of benefits, including reduced congestion, air pollution and greenhouse gases and more cost efficient. Its main drawback compared to other urban transport systems is its demand for urban space. A BRT system can take in one direction approximately 10-20 thousand passengers per hour and can reach levels up to 40 thousand passengers. This is a much higher value than for conventional buses.

The main advantages of the technology is that the buses can move quickly and unimpeded by congestion. Dedicated lanes matter the most in heavily congested areas. Intersections should be set up in order to maximize the green signal time for the bus lane. Passing lanes at stations allow additional travel time savings. In addition, stations should be located at least forty meters from intersections to avoid delay. Also, having the bus station platform level with the bus floor is an important way to reduce boarding and alighting times per passenger. Also, it could be integrated with other public transport, which includes physical transfer points, an integrated fare system and integrated information. Also it could be a clean vehicle technology to reduce emissions in order to decrease greenhouse gas emissions as well as to improve the health of the passengers and the urban population at large.

- **Promote Cycling**

Cycling offers numerous advantages to its users and to society in general. These include affordability in terms of ownership and maintenance; health benefits; the need for very little space for movement and parking in comparison to motor vehicles; and minimal impact on the environment. The main advantages of the technology that it can make an important contribution, not only to the transport system, but also to the environment, the economy and the social fabric of communities.

- **Electric Vehicles (EV)**

An electric vehicle (EV) uses one or more electric motors for propulsion, powered by electricity generated off-board the vehicle. Electric vehicles can include electric bicycles, electric motorcycles and scooters, electric cars, electric trucks, electric buses. In the other hand we have a plug in hybrid electric vehicle (PHEV) which is a hybrid electric vehicle with the ability to recharge its energy storage with electricity from an off-board power source such as a grid. (Pesaran et.al, 2009) The PHEV can run either on its Internal Combustion Engine (ICE) or on its battery.

A full electric vehicle uses its energy far more efficiently than a vehicle with an Internal Combustion Engine (ICE) and can drive about 2.5 times further with the same energy. For this reason it is expected that the electric vehicle will replace the ICE vehicle in the long run. However, in the coming 20 years or so vehicles will probably still be equipped with IC engines, possibly in combination with electric engines, because per unit of weight an ICE vehicle can still drive about 40 times further. In this 20 year period the IC engine is expected to improve substantially (Sharpe et al. 2009).

- **Public Transportation Maximization**

Public Transportation Maximization could occur by developing the whole public transportation system with providing an integrated transport management systems include GPS based optimization of public transport, computerized traffic signalling, information systems such as e-ticketing, e-information etc. Such systems increase the reliability, safety, efficiency and quality of public transport systems. An increase in the efficiency of the transport system also leads to a reduction in associated GHG emissions.

- Improving road network management, including public transport pricing.
- Improving road safety, by reducing collisions, casualties and deaths.
- Better travel and traveller information, helping to match supply and demand by providing better information so that travellers can make informed choices on when and how to travel.
- Better public transport on the roads, supporting more reliable, more accessible, safer and more efficient services.
- Supporting the efficiency of the road freight industry.
- Reducing negative environmental impacts.

- **Ticketing System for Public Transport**

Ticketing System for Public Transport allows a person to make a journey that involves transfers within or between different transport modes with a single ticket that is valid for the complete journey, modes being buses, taxies, etc. The purpose of integrated ticketing is to encourage people to use public transport by simplifying switching between transport modes, saving time and increasing the efficiency of the services.

In most cases, ticketing System for Public Transport is made possible by electronic ticketing technologies such as magnetic stripe cards or smart cards. Some smart card systems are also used for paying for goods and other services. Some public transport systems also use paper cash tickets that allow transfers within a specified area, and in some cases allow unlimited travel during specified times.

4.3. Criteria and process of transport sector technology prioritisation

The transport mitigation consultant assessed each technology separately. The factsheets were further reviewed by a wide spectrum of researchers and experts from national institutions. These factsheets contained detailed information on technology characteristics, institutional and organization requirements, adequacy of use, capital and operational cost, advantages as well as barriers and challenges. During the consultation workshop, the initially proposed weights were further discussed with stakeholders and validated and the ranking was conducted through an open discussion among the experts. Scores were attributed based on consensus.

The criteria were selected based on two main objectives: minimizing the GHGs and pollutant emissions for the transport sector and maximizing the environmental, social, and economic development benefits. Accordingly, seven main criteria for technologies selection were identified: (1) potential of resources, (2) potential of application, (3) financial appraisal, (4) maturity (5) GHG emissions reduction (6) economic benefits and (7) social benefits. Each criterion was assigned a weight (Table 17) based on its significance in meeting the national goals. Results of technology prioritization of this sector are posted in the following section.

Table 17 Criteria and weights used to prioritize transport sector's mitigation technologies

	Criterion	Allocation of budget (total = 100)	Weight, %
Criterion 1	potential of energy resources	10	10%
Criterion 2	potential of application	10	10%
Criterion 3	financial appraisal	20	20%
Criterion 4	Maturity	10	10%
Criterion 5	GHG emissions reduction	25	25%
Criterion 6	Economic Benefits	10	10%
Criterion 7	Social Benefit	15	15%
	Total allocated	**100**	

4.4. Results of technology prioritisation for the Transportation Sector

At the end of the MCA exercise, each proposed technology was scored in terms of the set of the criteria. The scoring values attributed to each criterion were from 0 to 5, and determined by the following:

5: high relevance/ high impact
3: relevant/ moderate impact
1: less relevant/ less impact
0: not relevant/ no impact

The final results are shown in Tables 18 and 19.

Table 18 Final scoring distribution for the transport technologies

Option/Criterion	potential of resources	potential of application	financial appraisal	Maturity	GHG Emissions reduction	Economic Benefits	Social Benefit
Units	not given	not given	not given	not given	not given	not given	not given
Preferred value	High	High	High	High	High	High	High
Ticketing System for Public transport	3	5	5	4	2	5	5
Bus Rapid Transport BRT	5	4	5	5	5	5	5
Public Transportation Maximization	2	5	2	4	2	5	5
Electric Cars	2	4	3	4	5	3	4
Promoting Bikes	3	3	5	5	5	5	5

Table 19 Final prioritization list of transport mitigation technologies for Jordan

Rank	Option	Weighted Score
1	**Bus Rapid Transport BRT**	**95.0**
2	**Promoting Bikes**	**83.3**
3	**Ticketing System for Public transport**	**58.3**
4	Electric Cars	36.7
5	Public Transportation Maximization	35.0

As a result, the MCA exercise for the transport sector's priority mitigation technologies enabled the selection of top three priority technologies for the transport sector in Jordan. The top-ranked technologies are 1) Bus Rapid Transport, 2) Promoting Bikes and 3) Ticketing System for Public Transport.

However, due to the dissatisfaction the team of the study felt all the time later on after preparing this report over the weak participation of directly involved transport experts in the workshop held for transport sector on the 25th of November 2015 due to their busy schedules, it was decided later on to remove this guilt-feeling and re-do the transport sector's technology prioritization activity after emphasizing the invitation and confirmed attendance of highly involved transport sector experts. Thus, the transport sector's technology re-prioritization workshop was re-organized on Sunday 27th of March 2016 at Land Transport Regulatory Commission and a big group of directly involved transport sector attended and successfully conducted the re-prioritization exercise.

Prior to conducting the workshop, the long list of candidate transport technologies for prioritization was also revised where the following technologies were assessed:

1. Bus Rabid Transit;
2. RE Powered Electric Vehicles
3. Improving pedestrian infrastructure;
4. Promote Cycling
5. Ticketing System

This time the following transport mitigation technologies came as top three: (1) Bus Rapid Transit; (2) Improving pedestrian infrastructure; and (3) Ticketing System (Table 20)

Table 20 Final results of re-prioritization list of transport mitigation technologies for Jordan after redoing workshop for transport sector

Rank	Option	Weighted Score
1	**Bus Rapid Transit**	**75.8**
2	**Improving pedestrian infractructure**	**54.2**
3	**Ticketing System**	**50.0**
4	Promote Cycling	45.8
5	RE powerd Electronic Vehicals	43.3

CHAPTER 5 TECHNOLOGY PRIORITISATION FOR WATER SECTOR

5.1. Climate Change Vulnerability and Existing Technologies in the Water Sector

5.1.1. Key climate change vulnerabilities in the water sector

The overall key climate change vulnerability assessment for water sector obtained from assessments conducted in the TNC Report (2014) are summarized above in Table, which identifies increase in temperature as the main exposure risk affecting vulnerability.

The overall vulnerability falls in the categories of high and very high. These unpleasant findings are originated from severe level of impact due to high sensitivity and exposure levels. The low levels of adaptive capacities play a role as well.

5.1.2. Overview of Existing Technologies in Water Sector

The following description represents an overview of existing technologies (based on TNC 2014 Report) in the water sector within the identified key climate change vulnerabilities in Water Sector build on the existing efforts (projects, programmes, polies, etc) to reduce the identified climate change vulnerabilities and adaptation needs.

- **Use of treated/recycled wastewater**: wastewater treatment and reuse in the agricultural sector
- **Optimizing the development and use of surface water resources** through supply-enhancing measures, including surface and subsurface storage, minimizing losses by surface evaporation and seepage, soil and water programs, and protecting surface water supplies from pollution;
- **Drinking Water Safety Plans**: a pro-active and preventive water adaptation approaches aiming at protecting the country's limited water resources with emphasis in drinking water resources and upgrading drinking water quality management system and surveillance programs accordingly.
- **Development of sustainable management plans for surface water systems in Jordan Valley**: this is attempted through conversion of open canal systems to a pressurized pipe system, giving priority to modernizing and upgrading systems, and precedence to water projects which make significant contributions to meeting rising municipal and industrial demands;
- **IWRM**: the system is in good shape in Jordan but lack key performance indicators
- **Water allocation to sectors:** a very effective way in utilizing water resources efficiently
- **Economic Instruments**: water tariffs and incentives for water savings
- **Regulating irrigated agriculture in the highlands:** by establish high-land water forums
- **Mega water conveyance projects**: such as Disi water conveyance and the Red-Dead conveyance projects)
- **Micro-catchment water harvesting systems**. Example techniques include earth and stone bonds, terraces and pots. Observed storage media include soil, tanks, underground cisterns, small check dams and one large dam which is the King Talal Reservoir (KTD).
- **Increasing Efficiency of irrigation technologies:** sprinkler systems, drip irrigation, subsurface irrigation systems and plastic greenhouses
- **Grey water Reuse:** not widely utilized in Jordan.
- **Introduction of water saving technologies**
- **Adaptation of different cropping patterns**
- **Monitoring Systems:** Ground water monitoring system; surface water monitoring system; and climate monitoring system.

5.2. Adaptation Technology Options for the Water Sector and Their Main Adaptation Benefits

5.2.1. Climate change adaptation strategic objectives proposed for the water sector in the Climate Change Policy 2013-2020:

- To further increase the knowledge and insight of climate change impact on the water, which is necessary to confidently identify the priority adaptation measures. Make existing climate information, knowledge and tools available for supporting adaptation decisions and actions;
- To take climate change risks into account in national and regional water sector policies, strategies, action plans and investment frameworks;
- To implement the priority no-regret measures in the water sector (measures that are necessary to balance demand and supply regardless of climate change), because they will all greatly contribute to adaptation to climate change in the sector as well;
- To strengthen the link of water sector planning with adaptation planning in other sectors, especially the agricultural, health, and land-use and urban planning sectors; and
- To promote a pro-active, and preventive water adaptation approaches (such as but not limited to Drinking Water Safety Plans) in protecting the country's limited water resources with emphasis in drinking water resources and upgrading drinking water quality management system and surveillance programs accordingly.

Climate change priorities, main measures and instruments in the water sector in the Policy

- Incorporate the potential climate change impact on precipitation level and patterns into the mid and long term planning of water demand and supply in Jordan, and in the underlying research;
- Establish a structural institutional exchange and cooperation between sector planners in the water sector and others sector on climate change impact and adaptation. The NCCC to provide the suitable forum;
- Further mainstream climate change consideration in water sector strategies, policies, and planning documents on all levels. The institutional and regulatory framework can be further strengthened and reformed. This includes adopting legally binding principles for water sector management based on the National Water Master Plan. This includes principles for water allocation to sectors and appropriate water tariffs and incentives for water savings to be introduced to promote (economical) efficiency of water supply and use. The balance between drinking water needs and industrial and irrigation water demands to be further rationalized and regulated;
- Improve international transboundary management of water resources as far as possible within the difficult political conditions in the region;
- Introduce regulations/directives on water supply to prevent the unsustainable abstraction of groundwater and the depletion of aquifers. Enforcement of these regulations is equally important;
- Promote a pro-active, preventive, approach (such as but not limited to Drinking Water Safety Plans) in protecting the country's limited water resources with emphasis in drinking water resources and upgrading drinking water quality management system and surveillance programs accordingly;
- Cap and regulate irrigated agriculture in the highlands and reinforce the by-laws;
- Address the use of treated/recycled wastewater in the regulation/directives on the demand-side such as grey water as part of codes and regulations for buildings including, high-rise and high-density buildings;
- Pursue implementation of the Disi water conveyance and the Red-Dead conveyance projects with due consideration for the (environmental and social) sustainability of these projects. Construction of the this conduit that will convey seawater and/or reject brine after desalination, into the Dead Sea, might help reduce impact of climate change in the water resources in the Dead Sea area. Moreover, consider other Dead Sea policy options such as changing the regional water management practices whereby freshwater from the Jordan and the Yarmouk river systems shall be diverted back to the Dead Sea;
- Improve the domestic water distribution networks, including reducing water losses and energy efficiency in pumping; and

- Secure the financing of no-regret measures in the water sector, to which both national and international resources could contribute. Resources should be allocated in a balanced way to supply and demand measures; and
- Develop proposals for adaptation in the water sector for financing from international climate change adaptation funds

5.2.2. Climate change adaptation strategies and measures proposed for the water sector in the TNC Report (2014)

Nearly all the low cost options for the development of new water resources are challenging in Jordan. Since all rivers and aquifers are highly exploited, few options are left for developing new sources of water for drinking and irrigation. However, a long list of possible opportunities is presented and evaluated in the following table and a detailed description of six options is given.

- **Rainwater harvesting**

Rainwater is the prime source of water in Jordan. The quantities lost to evaporation from temporary open water bodies and soil represent a significant part of the water budget in Jordan. Rainwater is dispersed over a wide area and, if properly collected, could provide a significant addition to the water reserves of the country.

Rooftop water harvesting, simple model indicates that where the average design-rainfall is about 400 millimeters per year and the losses are about 20%. A rooftop of 100 square meters can easily harvest 32 cubic meters per year. On the other hand, flood water harvesting at macro-catchment can collect considerable amounts of water in small dams across intermittent rivers and Wadis. Further, micro-catchment water harvesting is widely implemented in the study area. Example techniques include earth and stone bonds, terraces and pots. Observed storage media include soil, tanks, underground cisterns, small check dams and one large dam which is the King Talal Reservoir (KTD).

At study area level, field visits and consultations with farmers indicate that about 50% of the households have functional rainwater harvesting systems. However, the existing rainwater harvesting techniques need modification/improvements to adapt to the changing climate conditions and to ensure proper water quality. For example, significant increase and improvement in the catchment area will enhance the efficiency of rainwater collection and will improve the quality of the harvested water. In addition, public safety should be improved. Open reservoirs could be dangerous, as they may attract people to swim there while some may not be skilled enough. Jordan has a high rate of mortality due to drowning in open water bodies.

- **Wastewater treatment**

Wastewater treatment and reuse in the agricultural sector is a feasible option and already in use. Reusage helps meet the demand for freshwater, but the cost of treatment need to be minimized considering water quality and quantity constraints. Centralized wastewater treatment such as As-Samra treatment plants requires technical expertise and massive operation and maintenance costs. Hence, decentralized wastewater treatment is a viable option for farmers. Nevertheless, due to knowledge and financial reasons, few households in the study area own and operate decentralized wastewater treatment units. The capacity of the suggested decentralized wastewater treatment units reaches 200 cubic meters per day.

- **Desalinization**

Currently, the economy of Jordan, a developing country, cannot support the full implementation of seawater desalination as a fresh water source due to lack of financial resources and low abundance of energy sources. However, using clean energy such as solar and wind can be used for brackish water desalinization at a local, small scale. Groundwater with high quantity of total dissolve solids and sulphur contents is common in the country. This unused groundwater source can be utilized by farms or cluster farms.

- **Increasing Efficiency of irrigation technologies**

Agriculture is the largest water-using sector in Jordan, making implementation of proper irrigation technologies like sprinkler systems, drip irrigation, subsurface irrigation systems and plastic greenhouses necessary to improve water savings during hot seasons.

- **Grey water Reuse:**

Grey water can be reused to partially replace fresh water to flush toilets. Using proper showerheads can reduce demand for fresh water. Moreover, capturing and storing rainwater from roofs can reduce the demand on fresh water for other domestic purposes for example gardening purposes.

- **Public Awareness**

Based on the stakeholder consultation conducted in the study area, frequent field visits and casual interviews, a comprehensive program of public educating regarding water issues could help gain their support and assistance in maintaining and best management of water resources for irrigation and domestic purposes as well.

A list of adaptation measures is prepared based on the analysis, stakeholder consultation and bilateral interviews with local people. Table 21 lists prioritized adaptation measures in the water sector according to TNC assessments (2014) in addition to the recommendation actions followings.

Recommendations for action

- ***Filling current knowledge and methodological gaps***

There are clear gaps related to levels of public awareness, participation in water protection programs, construction of a comprehensive legal framework for water management and sectoral priorities for water conservation. Additional methodologies for sustainable water solutions are required such as reliable data bank, proper research, funding support and training program.

- **Policy recommendations**

The utilization and careful use of water resources requires integrated management policies to ensure sustainability of water and the environment. The existing water policy and by-laws seem to be well focused on the issues. However, there is a lack of enforcement and sustainability.

- **Other recommendations**
    - Intensive rainwater harvesting and assessing the existing rainwater harvesting structures. This action will benefit the farmers, and raise national food security.
    - Desalinization of seawater and wastewater.
    - Employing proper treatment technologies to treat industrial wastewater containing heavy metals.
    - Treated wastewater should be the main source for irrigation. Otherwise, there will be a need to reduce the agriculture activity plans.
    - Maintenance of the water distribution network to reduce the losses of drinkable water and avoid water contamination
    - The involvement of the private sector in running water resources is one option to assist in developing Jordan's water infrastructure and thereby reduce water losses.

Table 21 List of Prioritized Adaptation Measures in water sector

Climate Change Hazards	Sensitivity Indicators Factors	Overall vulnerability assessment (Average for RPC 4.5 and RCP 8.5)	Adaptation measures	Priority level
Precipitation decreased	Groundwater level decline Groundwater quality deterioration Stream flow reduction	High	Rainwater harvesting Springs rehabilitation Increasing efficiency of irrigation Reduce abstraction Water saving devices Wastewater treatment Reduce irrigation Decentralized wastewater treatment Research programs	1 2 3 4 5 6 7 8 9
Temperature increased	Decline of groundwater recharge Stream flow reduction	Very High	Artificial recharge Conjunctive use Research programs	1 2 3
Drought	Increased water demand	High	Enhance water storage efficiency Plants with low water requirements Awareness programs Desalinization Develop tolerable prediction models Research programs	1 2 3 4 5 6
Evaporation	Stream flow reduction	High	Improve runoff - Catchment treatment Increasing efficiency of irrigation Enhance water storage efficiency Complimentary irrigation Grey water Desalinization Research programs	1 2 3 4 5 6 7

5.2.3. Climate change adaptation strategies and measures proposed for the water sector in the INDCs of Jordan (2015)

One of the major pre 2020 studies Jordan conducted in the field of water (and health) sectors' adaptation was from 2009 to 2013 namely "*Adaptation to Climate Change to Sustain Jordan's MDG Achievements*". The study's goals were to developing sustained access to improved water supply sources, despite increasing water scarcity due to climate change and to strengthening the capacity for health protection and food security under conditions of water scarcity. The main adaptation knowledge products of the said project were:

— Water Safety Plans (WSPs) as a risk management approach to protecting drinking water safety in five pilot areas;
— A model farm reusing treated wastewater was created for use as a training and demonstration center;
— Piloted interventions for showcasing, awareness campaigns targeting stakeholders at different levels, and training programmes enhanced the capacities of local communities, youths, decision makers and professionals in this regard. This included the establishment of the *International Center for Water and Environmental Research* at Al Balqa Applied University;
— Capacity to adapt to climate change was strengthened in the Zarqa River Basin (ZRB), where extensive studies were conducted to assess and model climate change impacts on water quality and availability as well as to identify adaptation measures addressing these impacts.

Other water adaptation projects implemented in Jordan in partnership with the MoEnv's key partners, mainly IUCN, were:

- The Regional Knowledge Network on Water (R-KNOW) implemented through Regional Knowledge Network on Systemic Approaches to Water Resources Management project (2011-2015). The project aspired to create a Regional Knowledge Network on Water that will assist in strengthening the application of systematic approaches to water management and structured around the following thematic areas:
  — Water and climate change.
  — Water governance.
  — Water, food and energy nexus.
  — Sustainable water technologies.
- SWIM-Sustain Water MED project: It is one of the demonstration projects within the SWIM umbrella and addressed sustainable wastewater and sanitation management in the MENA region. The project was implemented from 2012- 2015. It operated in four countries including Jordan. Each of the demonstration projects addressed a different aspect pertaining to wastewater treatment and reuse as well as rainwater management to demonstrate effective and cost- efficient wastewater treatment and reuse technologies through pilot projects.
- Water-DROP Project: aimed at developing an Integrated Water Resources Management (IWRM) approach at the Mediterranean Basin level for managing the related cross-sector issues through the enforcement of multi-stakeholder partnerships, in particular with public and private actors. The project as well implemented 35 rain water harvesting cisterns for the rural community and schools in Balqa Governorate in order to harvest the water from the roofs.

Adaptation measures and programs for the water sector in the INDCs of Jordan (2015) include the following:

Residential water supply:

— Reducing water losses in distribution pipes;
— Introducing water metering;
— Introducing water saving technologies such as low-flow toilets and showers, and efficient appliances;
— Collection of rainwater for gardens, toilets, and other applications;

— Promoting water saving by awareness campaigns.

Irrigation:

— Introducing water saving technologies in irrigation schemes such as drip, micro-spray, and night irrigation, etc;
— Introducing new varieties of crops that use less water and are salt-tolerant;
— Increasing the efficiency of irrigation systems;
— Reforming water pricing;
— Using groundwater more efficiently.

Water quality:

— Improving wastewater treatment plants (WWTP);
— Recycling wastewater;
— Developing river protection and sanitation zones;
— Improving chemical and biological monitoring.

Socio-economic issues:

— Training people of different ages and social statuses on water saving and sanitation methods;
— Increasing public awareness to water related issues;
— Introducing water cleaning and softening technology;
— Introducing policy measures to ensure the equity in access to water;
— Carrying out studies to estimate the impacts of hydrological disasters such as flash floods and thunderstorms;
— Improving the drought prediction and mitigation system.

The above measures can be grouped in the following programs:

1- Groundwater protection

Most groundwater aquifers are exploited at more than double of their safe yield. The sustainability of irrigation in the highlands and the Badia areas will be greatly endangered unless strict measures are taken to address this issue[27]. As such, the development and implementation of an action plan is needed in order to ensure that plans for groundwater protection, management, monitoring and restoration are defined, integrated and managed in a cost-effective manner. However, such action plan needs:

- A strong legal basis, given by laws and by-laws of the Water Authority, 2002;
- Guidelines and legal provisions;
- An administrative structure for implementation and survey;
- Public involvement;
- Measures will also continue to be taken to protect the groundwater resources from all sources of pollution.

In order to improve groundwater situation in Jordan, MWI is establishing an integrated program to assess the availability and exploitability of all resources at rates that can be sustained over long periods of time. The mining of renewable groundwater aquifers will be checked, controlled, and reduced to sustainable extraction rates. MWI will further encourage the application of applied research activities, including artificial recharge to increase groundwater supplies, and the employment of new technologies that will optimize operation and development of groundwater systems and promote more efficient and feasible uses.

2- Surface water development

In Jordan, direct runoff from heavy rainfall lasts from less than an hour to very few days. This makes the management of this type of resource difficult. Possible measures are:

[27] Ministry of Water and Irrigation, Water Policy of Jordan (http://www.mwi.gov.jo/sites/en-us/SitePages/Water%20Policies/Water%20Policy.aspx)

— Optimizing the development and use of this resource through supply-enhancing measures, including surface and subsurface storage, minimizing losses by surface evaporation and seepage, soil and water programs, and protecting surface water supplies from pollution;
— Development of sustainable management plans for surface water systems in Jordan Valley, conversion of open canal systems to a pressurized pipe system, giving priority to modernizing and upgrading systems, and precedence to water projects which make significant contributions to meeting rising municipal and industrial demands;
— Dams are required for storing flood waters during the wet winter seasons and releasing the water gradually during the summer seasons when the demand is high. Additionally, 'ordinary' reservoirs, so called desert dams (water harvesting) help increase groundwater recharge and provide water for pastoral use.

3- Demand management

Mobilization of additional water resources can be achieved through:

— Artificial groundwater recharge;
— Surface water reservoirs;
— Water harvesting;
— Increased re-use of treated wastewater;
— Use of non-conventional water resources;
— Desalination;
— Weather modification (cloud seeding); and
— Transfer of water among different basins in Jordan.

Various projects have been set up to reduce water consumption and to enhance water use efficiency by:
— Reduction of losses from the supply networks;
— Introduction of water saving technologies;
— Public awareness campaigns on water consumption;
— Adaptation of different cropping patterns.

4- Water resources monitoring system (quantity and quality)

— Ground water monitoring system;
— Surface water monitoring system; and
— Climate monitoring system.

5.3. Criteria and Process of Technology Prioritisation

After conducting exercise no. 3 on the Inception Workshop day involving all relevant adaptation stakeholders, an initial long list of the potential adaptation technologies for the water sector in Jordan was prepared. The long list is as follows (Table 22):

Table 22 Results of potential technologies exercise to prepare long random list of adaptation technologies for the water sector

Results of TNA Exercise to prepare long random list of adaptation technologies for the water Sector
1. Water Harvesting Techniques
2. Water Treatment Technology/Domestic & Industrial
3. Water Purification Technologies, chlorificaton, desalinization, etc
4. Water Convey and Distribution Technologies
5. Drinking Water Savings techniques
6. Greywater (treatment, use) technology
7. Water Monitoring, Telemetering, and Forecasting
8. Reuse of treated wastewater in agriculture, industry, urban, etc
9. Water Resources Protection technologies

10.Water data development and banking
11.Agricultural drainage water reuse
12.Flood control
13.Groundwater recharge
14.Rain Seeding
15.Brackish water treatment and re-use
16.Reduction & evaporation techniques
17.Soil water conservation and measures
18.Improving water use efficiency/ enhancing agricultural water productivity through irrigation technologies
19.Hydroponics/soilless agriculture
20.Water Productivity through selecting crops of high return

After conducting exercise no. 3 on the Inception Workshop day involving all relevant adaptation stakeholders, which aimed at creating an initial long list of the potential adaptation technologies for the water sector, the Water Sector Adaptation Consultant collated this long list and posted the list into a matrix (Annex 6) to compare the result of this exercise with outcomes and results of other national studies and initiatives attempted to prioritize adaptation measures/technologies for water sector. This step aimed at extracting the random top 10 priority adaptation technologies based on results and outcomes form available national studies and initiatives.

The top 10 disordered (in random order) water adaptation measures/technologies based on comparison of different climate change adaptation studies and initiatives in the country for water sectors are as follows:

1. **Rainwater harvesting**
2. **Maintenance and rehabilitation of the water distribution network to reduce the losses of drinkable water**
3. **Maintenance and rehabilitation of the irrigation water distribution network**
4. **Water saving devices-Zero Reject Household RO System**
5. **Water Resources Protection technologies/Reduce water abstraction/Use groundwater more efficiently for irrigation/IWRM**
6. **Greywater treatment and re-use**
7. **Improvement of wastewater treatment and reuse systems in the agricultural sector**
8. **Artificial groundwater recharge**
9. **Desalination/brackish water treatment and re-use**
10. **GIS Aided flood control modeling/management of flash floods**

The final results of top 10 technologies were subjected to MCA activity to put them in priority order utilizing information from the water adaptation technologies fact sheets (Annex 9) the consultant prepared for stakeholders discussion before their meeting in the Technical Working Group Meeting held on 24th November 2015. The Consultant prepared technology factsheets to facilitate the stakeholder consultation for technology selection. The technology factsheets included the basic information about the technology options, including brief description of the technology, application potential in the country, costs (capital and operation), technical aspects (geographical applicability range, maturity), and the environmental, social, and economic impacts/benefits of their application in the country. Such information was provided to the stakeholders prior to the Adaptation Technical Working Group Meeting held on 24th November 2015 so that stakeholders were able to compare the different options using multi-criteria analysis. Sources of information utilized on adaptation technologies: http://climatetechwiki.org/ and technology handbooks available at www.tech-action.org, under "Publications"; the 3 Technology guidebooks: Technology Guidebook for Coastal Zones, Technology Guidebook for Water Sector, and Technology Guidebook for Agriculture sector. Factsheet examples, as well as links to additional materials available at www.tech-action.org, under "Resources" were also utilized.

The water sector adaptation technologies were prioritized in order based on the following criteria:

Environmental

- Reduction of vulnerability to climate change/Resilience to Climate
- Technology Capability & Suitability/Technology Maturity

Economic Criteria:

- Economic Importance
- Capital, Operational and Maintenance costs

Social Criteria

- Social Suitability
- Human and Informational Requirements/Institutional and Organizational requirements

The importance of the technology's main uses to the society was included in social, economic, and environmental benefits analysis. Results of Technology prioritization is shown in the following section

5.4. Results of technology prioritisation for the water sector

The results of technology prioritization are presented below (Table 23). A brief description of each technology and its benefit could be found in the facts sheets. The final results for water sector adaptation technologies of top three priorities are (1) Rainwater Harvesting, (2) Water Users Association, and (3) Desalination/Brackish Water Treatment and Re-use.

Table 23 Water sector technology options scores and ranking

Water Sector Technology options scores and ranking

Option	Weighted Score
Rainwater Harvesting	87.5
Maintenance and rehabilitation of the drinking water network to reduce losses	60.0
Maintenance and rehabilitation of the irrigation water distribution network to reduce losses	60.0
IWRM	65.0
Greywater treatment and re-use	7.5
Improvement of wastewater treatment and reuse systems in the agricultural sector	65.0
Water saving devices-Zero Reject Household RO System	60.0
Water Users Associations	87.5
Desalination/brackish water treatment and re-use	67.5

Ranking of options

Rank	Option	Weighted Score
1	**Rainwater Harvesting**	**87.5**
2	**Water Users Associations**	**87.5**
3	**Desalination/brackish water treatment and re-use**	**67.5**
4	IWRM	65.0
5	Improvement of wastewater treatment and reuse systems in the agricultural sector	65.0
6	Maintenance and rehabilitation of the drinking water network to reduce losses	60.0
7	Maintenance and rehabilitation of the irrigation water distribution network to reduce losses	60.0
8	Water saving devices-Zero Reject Household RO System	60.0
9	Greywater treatment and re-use	7.5

CHAPTER 6 TECHNOLOGY PRIORITISATION FOR AGRICULTURE SECTOR

6.1. Climate Change Vulnerability and Existing Technologies in the Agriculture Sector

6.1.1. Key Climate Change Vulnerabilities in Agriculture Sector

The overall vulnerability resulting from impact and adaptive capacity is determined through the following vulnerability assessment matrix for the two climatic projection scenarios RCP 4.5 and RCP 8.5 (Tables 24 and 25 based on assessments of TNC (2104). The overall vulnerability assessment for increase of average annual temperature is *high* at RCP 4.5. However, at RCP 8.5 this hazard as well as shifting in rainfall season are both *high*.

Table 24 Overall vulnerability in Agriculture for RCP 4.5

Climate change hazards	Resulting impact	A. Exposure level	B. Sensitivity level	C. Total impact	D. Adaptive capacity level	E. Overall vulnerability assessment
Shift in rainfall season	Decrease in reliable cropping days and crop failure	Moderate (average score = 3)	Moderate (average score = 3)	Moderate (average score = 3)	Low - (average score= 2)	Moderate
Increase in average annual temperature	Increase in evapotranspiration causes decrease in agricultural productivity	High (average score = 4.7)	Moderate (ave. score = 3)	High (average score = 3.85)	Low- (average Score = 2.5)	High
Decrease in average annual precipitation	Decrease in agricultural productivity and revenue	Moderate (average score = 3.7)	Minor (average score 2)	Moderate average score = 2.85)	High (average score = 4)	Moderate
Increase frequency droughts		Moderate (average score = 3.7)	Moderate (average score = 3)	High (average score = 3.35)	Moderate (average score = 3.5)	Moderate

Table 25 Overall vulnerability in agriculture for RCP 8.5

Climate change hazards	Resulting impact	A. Exposure level	B. Sensitivity level	C. Total impact	D. Adaptive capacity level	E. Overall vulnerability assessment
Shift in rainfall season	Decrease in reliable cropping days and crop failure	Moderate (average score = 3.7)	Moderate (average score = 3)	Moderate (average score = 3.35)	Low - (average score= 2)	High
Increase in average annual temperature	Increase in evapotranspiration decreases agricultural productivity	High (average score = 5)	Moderate (average score = 3)	High (average score = 4)	Low- (average score = 2.5)	High
Decrease in average annual precipitation	Decrease in agricultural productivity and revenue	Moderate (average score = 4.3)	Minor (average score 2)	Moderate average score = 3.15)	High (average score = 4)	Moderate
Increase in frequency of droughts		Moderate (average score = 4.3)	Moderate (average score = 3)	High (average score = 3.65)	Moderate (average score = 3.5)	Moderate

6.1.2. Overview of Existing Technologies in Agriculture Sector

The following practices and technologies are predominant in the agriculture sector in Jordan

Water conservation measures:

- Use of plastic houses and tunnels that decrease water requirements for unit of production.
- Reducing need for water by choosing drought tolerant species and varieties especially in fruit trees.

Crop management:

- Modification of sowing dates through delaying seeding time in response to delayed winter rains.
- Use of crop varieties with greater drought tolerance and change of crop cultivars and adopt crop rotation systems in both rain fed and irrigated farming.
- Delaying planting date of field crops until the amount of soil moisture will be enough for seed emergence and development in early stages.
- Improving the effectiveness of pest, disease and weed management practices through wider use of integrated pest and pathogen management.

Land and Soil management:

- Adopting the "Conservation Agriculture (CA)" and other approaches such as no or minimum tillage or use of alternative fallow and tillage practices to address climate change-related moisture and nutrient deficiencies.
- Mixing plant residue with the top soil of continuous moisturizing to generate enough heat to eliminate or inhibit the growth of weeds, sterilizes the soil and improves the soil characteristics.

Effective water use:

- Use of irrigation practices to address the moisture deficiencies associated with climate change and to reduce the risk of income loss due to recurring drought.
- Adopting supplementary irrigation in dry seasons or during heat waves.

6.2. Adaptation Technology Options for the Agriculture Sector and Their Main Adaptation benefits

The main existing efforts (projects, programmes, policies, etc) to reduce the identified climate change vulnerabilities and adaptation needs in the key focus areas are mainly those presented in the Climate Change Policy of Jordan (2013-2020) and most importantly the measures proposed in the TNC Report (2014) and INDCs of Jordan (2015).

6.2.1. Climate Change Adaptation Strategies and Measures proposed for the Agriculture Sector in the Climate Change Policy 2013-2020

Climate change strategic objectives in the agriculture, food security/production, desertification, and land-use planning

- To further increase the knowledge and insight of climate change impact on agriculture/food productivity/food security, and desertification, which is necessary to identify the priority adaptation measures. This includes improving the understanding of climate change impacts on rural community livelihoods in the Jordan, and addressing food security in an international regional context;
- To integrate climate change impact considerations and the related adaptation priorities in the overall strategies and policies of the agricultural sector, currently under development.
- To increase the insight in the linkages between the adaptation strategies in the agricultural sector and in other sectors, particularly the water sector; to strengthen the link of agriculture sector planning with planning in other sectors, especially the water sector. Water planning should shift from supply-oriented to a balanced planning of supply and demand. This requires a cross-sector approach;
- To promote resource efficiency and sustainable agriculture.
- To engage local communities, farmers, farmer associations, local experts, and local and national government representatives in helping craft response options to climate change in agricultural ecosystems;
- To work with communities to integrate climate change concerns into sustainable rangeland and agricultural management practices, and work with local water users to integrate climatic change concerns into irrigation regime for sustainable agriculture;
- To incorporate climate change impact and adaptation consideration in the national policies, strategies and action plans against desertification; and
- To incorporate climate change adaptation considerations in land use planning

Climate change priorities, main measures and instruments in the agriculture, food security/production, desertification, and land-use planningper the Climate Change Policy

- Establish a structural institutional exchange and cooperation between sector planners in the agricultural sector and the water sector on climate change impact and adaptation. The NCCC to provide the suitable forum;

- Further strengthen the assessment and monitoring of vulnerability in agriculture (mapping and assessment of agro-ecological zones projects; early warning and risk management systems projects), and strengthen knowledge management and technology transfer;
- Strengthen Arab, Muslim, regional, and global cooperation to counter the challenges of drought and climate change by improving and adapting crop characteristics. This included common research aimed to creating regional strains and genetic qualities of crops more resilient to climate change;
- Identify and strengthen the community-based approach to adaptation accounting for gender issues. Vulnerabilities to climate change are mostly local and, thus, adaptation measures are highly location and community specific;[28]
- Concentrate the strategy for low rainfall areas on improving rangeland productivity and management to feed small ruminants, arrest desertification and promote conservation of agricultural natural resources;
- Emphasize dryland farming on water harvesting techniques, combating desertification, conservation of genetic resources, and preparation of legislation on preventing desertification;
- Improve farm production systems and productivity to compensate for limited arable land and to avoid expansion into fragile marginal lands;
- Promote water use efficiency in agriculture. This includes the necessary instruments to facilitate measurement of actual water consumption to promote efficient, high-productivity allocation of water in addition to drip irrigation, and other water and soil management techniques, and alternatives. Also, introduce appropriate water tariffs and incentives in order to promote economic water efficiency in agriculture. Other measures include: implement conservation agriculture, water harvesting, and supervised irrigation with treated wastewater;
- Reinforce early warning system for drought;
- Investigate and develop a comprehensive insurance system (weather insurance) for agriculture;[29]
- Establish a minimum amount that the Agricultural Credit Committee must lend to businesses in sectors of the green economy;
- Update the National Strategy and Action Plan to Combat Desertification to incorporate climate change impacts, in coordination with the adaptation strategies for biodiversity and agriculture
- Include climate change considerations in land-use and development planning. This includes reforming land use laws and promoting sustainable land use; and
- Develop proposals for adaptation for co-financing from international climate change adaptation funds

6.2.2. Climate Change Adaptation Strategies and Measures proposed for the Agriculture Sector in the TNC Report (2014)

The key adaptation measure to climate change is setting and implementing a sustainable agriculture policy. Adaptation measures vary horizontally according to the agricultural subsectors and their vulnerability to climate change. These measures vary vertically according to the different actors involved in the development and implementation of this policy.

The Adaptation strategies to a changing climate include:

- Agronomic and crop strategies that are intended to offset either partially or completely the loss of productivity caused by climate change through the application of defense tools with different temporal scales, e.g. short term adjustments and long term adaptations, and spatial scales, e.g. farm, regional or national level adaptation; and
- Socio-economic strategies intended to meet the agricultural costs of climate change.

[28]FAO, 2008
[29]Weather Index-based Insurance in Agricultural Development. A Technical Guide November 2011. World Food Program wfp.org

Generally, the most important adaptation measures for the study area are: modification of cropping pattern, modification of crop calendar including planting and harvesting dates, implementation of supplemental irrigation and water harvesting techniques, improve water use efficiency, use of different crops varieties and modification of policies and implementation of action plans**.**

a) List of measures

In the following sections, detailed description of adaptation strategies and measures will be discussed. Based on the main findings from this study, the most appropriate measures were proposed to reduce the impacts of climate change on agriculture in Jordan. A list of measures (per climate hazard) is shown below in the adaptation measures matrix.

In irrigated areas: The conversion to drip irrigation decreases water use anywhere between 30-70%, while increasing crop yields from 20-90%. Drip irrigation systems, especially low-head systems, use less energy than surface irrigation by emitting water at or near the root zone (increasing water use efficiency up to 90%).

In Jordan, irrigation efficiency and Water Use Efficiency (WUE) are relatively low. Therefore, shifting from surface irrigation to drip irrigation will increase irrigated areas, since drip irrigation uses less water and will promote more efficient use of fertilizers due to reduced nutrient leaching as well as improving yield and quality of crops such as vegetables.

Rainfed areas: In general, adaptation measures for rainfed agriculture include, but are not limited to, the following:

- ✓ Improving soil water storage to maximize plant water availability by maximizing infiltration of rainfall; minimizing unproductive water losses (evaporation, deep percolation and surface run-off); increasing soil-water holding capacity; and maximizing root depth.
- ✓ Application of conservation agriculture, which involves minimum soil disturbance and encompasses land preparation techniques that reduce labor, improve soil fertility, manage crop residue and tillage and conserve soil and water.
- ✓ Use of supplemental irrigation from harvested rainwater in the critical stages of crop growth.
- ✓ Modification of planting and harvesting dates for some crops.

Most of the interventions to upgrade rainfed agriculture can be cost-effective in farming systems, especially where irrigated agriculture is not feasible. For example, supplemental irrigation (the watering of rainfed crops with small amounts when rainfall fails to provide sufficient moisture) has proven to be a drought-proof strategy in most areas.

Increase of water available for supplementary irrigation can be achieved through on-farm rainwater harvesting and management system, i.e. small farm ponds for micro-irrigation using drip or sprinkler irrigation systems. Larger rainwater storage structures can also be constructed to provide supplementary irrigation water to a number of small farms or fields by using the micro-dams.

Conservation agriculture, on the other hand is very efficient, leading to increased crop yield. In this adaptation measure, several techniques are used to enhance soil water storage. Water conservation is usually enhanced through mulching and crop residue retention through zero or minimum tillage, stubble mulch tillage, strip tillage and crop rotation. Conservation agriculture, however, requires extension programs such as training and provision of equipment.

Modifications in planting and harvesting dates are very essential for field crops. Since temperature will increase with time, crop failure may increase. Therefore, early cultivation of field crops will reduce the risk of crop failure.

Other measures include:

<u>Selection of tolerant crop varieties-</u> Shift to cultivating crops that are more tolerant to droughts or lower water requirements, either as a long term change or as climate prediction information might suggest the likelihood of drier seasons. Farmers need to be linked to research institutions and centers such as NCARE

to get certified seeds or crop varieties to increase production under changing rainfall regimes. This is essential to improve farmer incomes and adaptation capacity.

Crop diversification- Crop diversification includes integration of different varieties of crops, both food and cash crops which will increase farmer's income. Because of changing rainfall amounts and temperatures, the existing cropping patterns are becoming less productive. Thus crop intensification, through mixed cropping and integration of high-value crops is needed. This can be achieved by adopting the following cropping patterns:

- Low-value to high-value crops (resulting in a price-risk benefit).
- Low-yielding to high-yielding crops (resulting in a yield-risk benefit).
- High water-use crops to water-saving crops with high nutritional values.

Prioritization of measures

The following matrix (Table 26) lists the adaptation measures per climate change hazard and the prioritization of the measures based on discussions and consultations held with the focus group during the results dissemination national workshop

Table 26 Adaptation measures per climate change hazard and the prioritization of the measures in Agriculture

Climate change hazards	Resulting impact	E. Overall vulnerability assessment	Adaptation measures	Priority
Shift in rainfall season	Decrease in reliable cropping days and crop failure	**High**	Application of conservation agriculture. Modification of planting and harvesting dates	2.0 2.0
Increase in average annual temperature	Increase in evapotranspiration decreases agricultural productivity	High	Conversion to drip irrigation and increase water use efficiency Use of supplemental irrigation	3.0 2.0
Decrease in average annual precipitation	Decrease in agricultural productivity and revenue	Moderate	Selection of tolerant crop varieties and crop diversification	3.0
Increased frequency of droughts		Moderate	Integrated watershed management	3.0

Recommendations for action

Actions needed at national level:

- Establishment of an integrated drought monitoring and early warning system at different levels.
- Development of policies and creation of institutions that support adaptation at different levels.
- Development and adoption of adaptive technologies and innovations.
- Agricultural agencies, particularly NCARE need to establish and support targeted research programs for agricultural adaptation to climate change.
- Communication about climate risk management and effective adaptation strategies need to be promoted and facilitated among researchers, extension agents, producers and policy makers.

- Researchers need to take advantage of the wealth of knowledge about climate risks and adaptation opportunities in their fields of specialties.

Policy recommendations

Climate change and management options need to be considered in government programs and policies. The question is how to integrate considerations of adaptation into policy and institutional systems at national and regional levels, in a consistent rather than in a fragmented way. This will ensure that government has proactive climate change adaptation strategies, and its initiatives contribute to the reduction of climate-related damages, and encourage timely and effective adaptations in the agribusiness sector.

Agribusiness investment, know-how and technology will be essential to respond to the challenge of adapting to climate change. Such action may not require creating new programs and policies focusing on climate change, but may simply entail having climate change risks and adaptations incorporated, where appropriate, in existing programs or program reviews. Thus, *there is a need to incorporate climate change adaptation into the Jordanian agricultural policy of 1999 when this document undergoes an updating process* Efficiency and cost-effectiveness of measures and win-win policies should be key considerations for policy makers.

Policy integration can be horizontal or vertical. Horizontal policy integration is coordination across sectors and involves responsibilities and actions across multiple agencies, and mainstreaming is an imperative. Many traditional structures exist—ministerial councils, cross-agency task forces, policy units in central agencies, national policies and plans for sustainable development, etc.

6.3. Criteria and process of technology prioritisation

After conducting the exercise to obtain the long list of initial potential technologies in the agriculture sector (exercise no. 3) on the Inception Workshop day involving all relevant adaptation stakeholders, a preliminary long list of the potential adaptation technologies for the agriculture sector was prepared. The long list is as follows. The stakeholders and through a consultation process identified the following list of possible adaptation technology options needed for Jordan agriculture sector.

1- Promoting plant varieties resistant to Climate change.
2- Conservative agriculture.
3- Improving water productivity.
4- Promoting Hydroponics.
5- Improving water use efficiency.
6- Water Harvesting techniques.
7- Organic Farming.
8- Diversification of crops/cropping pattern.
9- Changing sowing, planting and harvesting dates.
10- Soil and water conservation measures.
11- Precision farming.
12- Desalination and use of brackish water.
13- Fertilization programs/fertigation.
14- Early warning systems.
15- Afforestation programs/improvement of seedlings quality.
16- Promoting Integrated pest management programs.
17- Proper Land use planning.

After conducting exercise no. 3 on the Inception Workshop day involving all relevant adaptation stakeholders, which aimed at creating an initial long list of the potential adaptation technologies for the agriculture sector, the above list was revised by a larger group of specialized stakeholders that were identified during the inception workshop and was re-arranged into the following technology options.

1- Support of water saving technologies, such as drip or subsurface irrigation.
2- Conservative agriculture.
3- Promoting plant varieties resistant to Climate change.
4- Information and Knowledge Management.
5- Water Harvesting.
6- Promoting Integrated pest management programs.

The final results of top 6 technologies were subjected to MCA activity to put them in priority order utilizing information from the agriculture adaptation technologies fact sheets (Annex 10) the consultant prepared for stakeholders discussion before their meeting in the Technical Working Group Meeting held on 24th November 2015. The second consultation meeting was organized to share with stakeholders the inputs and addition of options (Technology Fact Sheets (TFS)) and to discuss and assess how the proposed technologies will meet specific development objectives, and influence key development policy goals. The meeting/workshop focused on: how to maximize development priority benefits in terms of environmental, social and economic benefits; and reduce climate change vulnerability.

The Consultant prepared technology factsheets to facilitate the stakeholder consultation for technology selection. The technology factsheets included the basic information about the technology options, including brief description of the technology, application potential in the country, costs (capital and operation), technical aspects (geographical applicability range, maturity), and the environmental, social, and economic impacts/benefits of their application in the country. Such information was provided to the stakeholders prior to the Adaptation Technical Working Group Meeting held on 24th November 2015 so that stakeholders were able to compare the different options using multi-criteria analysis. Sources of information utilized on adaptation technologies: http://climatetechwiki.org/ and technology handbooks available at www.tech-action.org, under “Publications”; the Technology Guidebook for Agriculture sector. Factsheet examples, as well as links to additional materials available at www.tech-action.org, under “Resources” were also utilized.

The agriculture sector adaptation technologies were prioritized in order based on the following criteria:

Environmental

- Reduction of Vulnerability of Agricultural Practices to Climate Change/Improving esilience to Climate
- Technology Capability & Suitability/Technology Maturity

Economic Criteria:

- Economic Importance
- Capital, Operational and Maintenance costs

Social Criteria

- Social Suitability
- Human and Informational Requirements/Institutional and Organizational requirements

The importance of the technology’s main uses to the society was included in social, economic, and environmental benefits analysis. Results of Technology prioritization is shown in the following section

6.4. Results of agriculture sector technology prioritisation

The results of technology prioritization are presented below (Table 27). A brief description of each technology and its benefit could be found in the facts sheets. The final results for agriculture sector adaptation technologies of top three priorities are (1) Support of water saving technologies, such as drip or subsurface irrigation, (2) Water Harvesting, and (3) Promoting plant varieties resistant to climate change.

Table 27 Agriculture Sector Technology options and ranking

Agriculture Sector Technology options scores and ranking

Option scores

Option	Weighted Score
Support of water saving technologies, such as drip or subsurface irrigation	77.5
Conservative agriculture	22.5
Promoting plant varieties resistant to Climate change	65.0
Information and Knowledge Management	42.5
Water Harvesting	70.0

Ranking of options

Rank	Option	Weighted Score
1	Support of water saving technologies, such as drip or subsurface irrigation	77.5
2	Water Harvesting	70.0
3	Promoting plant varieties resistant to Climate change	65.0
4	Information and Knowledge Management	42.5
5	Conservative agriculture	22.5

CHAPTER 7 SUMMARY AND CONCLUSIONS

This report elaborated on the TNA activity conducted in Jordan with emphasis on phase one of the Project-TNA Report (Sector and technology) Prioritizations Phase. It is clear that since the entry of the UNFCCC into force in 1994, Jordan took serious steps to fulfil its obligations to the convention. The fulfillment of the national obligation to UNFCCC implies that Jordan should have the human, organizational, institutional, technological, and financial resources for developing the required tasks and functions on a permanent basis. However, the lack of dedicated and best industry-based studies to assess climate change technology needs in the sectors of most levels of GHG emissions and those most vulnerable to impact of climate change is obvious. There is big need for conducting a systematic assessment of the country's needs for efficient and environmentally friendly technologies to backstopping Jordan's capacities in identifying and deploying the appropriate mitigation and adaptation technologies. Thus, this project, the TNA Project of Jordan, sponsored by GEF and implemented by UNEP-DTU Partnership and executed by MoEnv in Jordan, comes at the right time to fill the technology gap and to complement the integrated approach Jordan is following to address the impacts of climate change.

The national stakeholders were involved in two phases of consultation to identify mitigation and adaptations sectors as well as technologies of top priority. In the first phase, the launching of the TNA project in Jordan took place (Nov 17th, 2015) where the work plan of the assignment was presented and discussed to obtain feedback from stakeholders. In the same day, three exercises were conducted involving all attendees. The first exercise was for selection of priority mitigation and adaptation sectors for TNA, which was based on conducting another dedicated multi criteria analysis (MCA) exercise prepared purposely for this step utilized in addition to the standard MCA form proposed by UNEP-DTU for priority technology selection. This sector selection MCA exercise executed during the Inception/Launching Workshop of the TNA Project in Jordan created serious and fruitful discussions. The Launching Workshop was patronaged by H.E. Secretary General of Ministry of Environment which reflected high level of interest and buy-in of the concepts and outcomes of the project. During the Launching Workshop, the priority mitigation as well as adaptation sectors for technology needs assessment were concurrently determined in a dedicated national exercise in coordination with MoEnv to determine most important sectors in terms of the highest GHGs mitigation potential as well as the sectors of most vulnerability and impact because of climate change. The Sector Selection MCA in terms of criteria used for national stakeholders' discussions and structure of the sheet as well as scoring system were brainstormed and prepared carefully by the team of consultants of this study in a dedicated meeting set specifically for this purpose. The MCA for selection of priority mitigation sectors was based on key criteria such as levels of greenhouse gases emission and mitigation actions viable while on the other hand MCA for selection of priority adaptation sectors was based on main criteria relevant to urgency of technology needs and risk of delay of action as relevant to vulnerability. The common criteria between the two MCAs were: the position of the targeted sector with regard to national priority to sustainable development; economic aspects, social impact, readiness of sector and level of current planning, implementation experience, sustainability potential, and financing factors.

The two MCA exercises revealed that the two top mitigation priority sectors are *Energy* and *Transport* while on the other hand, the two top adaptation sectors selected were *Water* and *Agriculture* based on the selection process by stakeholders representing all mitigation and adaptation sectors in the country. This conclusion was not unexpected in light of the current status of the energy and transport sectors as the two most emitters of GHGs in Jordan and their critical implications with regard to sustainable development. The same conclusion is valid for water and agriculture sectors as they are the most top two vulnerable sectors to climate change as shown in the extensive assessments conducted in the national studies, mainly the TNC study (2014).

Results of assessing the potential focused list of technologies in light of information provided in the fact sheets prepared for each technology to facilitate the stakeholder consultation for technology selection during the Adaptation Technical Working Group Meeting and the Mitigation Technical Working Group Meeting held on 24th and 25th of November 2015 respectively revealed after conducting MCA for each sectors' technologies that the top three mitigation technologies for energy sector are as reveled in Table 28.

Table 28 The top three technologies ranked for TNA activities for each of assessed sectors in Jordan

Rank/TNA Sector	**Energy**	**Transport**[30]	**Water**	**Agriculture**
Rank 1	Solar Thermal	Bus Rapid Transit	Rainwater Harvesting	Support of Water Saving Technologies, such as Drip or Subsurface Irrigation
Rank 2	PV for Water Pumping	Improving pedestrian infrastructure	Water Users Association	Water Harvesting
Rank 3	PV for Electrification	Ticketing System	Desalination/Brackish Water Treatment and Re-use	Promoting Plant Varieties Resistant to Climate Change

It is obvious that there is there is big support in Jordan for solar energy-related technologies not just in sectors routinely known to engage in such technology such as energy industries but also sectors known to be more of adaptation response-nature, which revealed that such sectors are in high need of such technologies as the case of water sector. Bus Rapid Transport seems a viable option for Jordan in light of failure of the public transport system in the country. However, culture-cautious practices like biking seems now acceptable to replace reliance on private and public vehicles.

It is clear that water harvesting, for example, was a joint priority adaptation technology in both water and agriculture sectors, which reveals the critical importance of this technology and indicates in the same time the robustness of perceiving a holistic approach for rainwater harvesting at the watershed level and the farm-level.

We believe national stakeholders will keep the same level of effective involvement and enthusiasm bestowed in this phase of the project in the coming phase of the project to carry on barrier analysis and enabling framework (BA & EF) to assess obstacles and limitation to maximize and enhancing deploying such technologies effectively and systematically to deal with climate change.

[30] These results are after re-doing the transport sector workshop (See section 4.4)

ANNEXES

Annex 1 Agenda of Launching Workshop of TNA Project in Jordan

Climate Change Technology Need Assessment (TNA) Project
Jordan Ministry of Environment
Inception Workshop
Nov 17, 2015 (8:30 am) at GRAND MILLENNIUM HOTEL (Shmeisani) AMMAN

Agenda

Time	Event	Who
8:30-9:00	Registration	All
9:00 -9:15	• Opening Speech	H.E. Eng. Ahmad Al-Qatarneh, Secretary General, Ministry of Environment
9:15-9:30	• Introduction to TNA Project	Eng. Hanadi Marie, Head, Adaptation Division, Climate Change Directorate & TNA Project Coordinator
9:30-10:00	• Project Workplan, Deliverables & Milestones	Dr. Ahmad Abdel-Fattah, Consultants' Team Leader, *Water, Food & Energy for Env. Res. Mng. Co. (Almakan)*
10:00 -10:30	Coffee Break 1	
10:30-11:30	• Exercise 1: Priority Sectors Identification	All
11:30-12:30	• Exercise 2: Stakeholders Identification and Involvement/Engagement Plan	All
12:30-1:00	Coffee Break 2	
1:00-2:00	• Exercise 3: Preliminary Adaptation & Mitigation Technologies Identification and Brainstorming • Way forward and briefing of coming Technical Working Groups meetings	All
2:00-3:00	Lunch	

Annex 2 MCA Sheet developed by the consulting team for selection of mitigation priority sectors:

INCEPTION WORKSHOP EXERCISE 1: Table 1: Criteria proposed to prioritize the Sustainable Development Sectors in terms of need to MITIGATION climate change technology identification

Criteria	Weight	Sub-criteria	Proposed Sub-weight	*Energy*	*Transport*	*Industry*	*Waste*	*LULUCF/Agriculture*
Greenhouse Gases Emissions Levels and Mitigation Action Possible	**25**	**Greenhouse Gases Emissions Levels**	**15**					
		Mitigation Actions Possible (Feasibility, Viability, etc)	**10**					
National Priority to Sustainable Development	15	National priority in the general sustainable development context of the country (persistent position of the sector)	5					
		National priority in particular national sustainable Development and planning documents 1. *Jordan 2025- National Vision and Strategy (2015-2025)* 2. *Executive Development Programme (EDP) 2016-2018*						

		National priority in particular national climate change planning documents ***3. Climate Change Policy of Jordan 2013-2020*** ***4. INDCs 2020-2030***	5					
Contribution to Economy	15	General Economic Benefits	5					
		Contribution to GDP	5					
		Job creation potential; Potential for SMEs and Youth	5					
Social Factors	20	Equity	5					
		Involvement of Local Community	5					
		Role of end-users	5					
		Public Acceptability	5					
Planning, Implementation Experience, Sustainability, and Financing Factors	15	Cost Effectiveness of Technologies to be Transferred and Deployed	3					
		Competence and Capacity of Sectors' Stakeholders and Partners	3					
		Institutional Arrangements and Planning Experience of the Sector	3					
		Cooperation Potential mainly with Private Sector (PPP)	3					

		Financing Potential of Technologies and Projects	3					
Sector Experts' other Criteria of Choice -	10							
Total Score	**100**							
Sector final rank								

Annex 3 MCA Sheet developed by the consulting team for selection of Adaptation priority sectors:
INCEPTION WORKSHOP EXERCISE 1: Table 2: Criteria proposed to prioritize the Sustainable Development Sectors in terms of need to ADAPTATION climate change technology identification--(1.0-1.5 hours)

Criteria	Weight	Sub-criteria	Proposed Sub-weight	*Water*	*Agriculture/Food Security*	*Health*	*Biodiversity/Eco-systems*	*Coastal Areas/Tourism*	*Urban and Cities Adaptation*
Urgency of Technology Needs and Risk of Delay of Action	**25**	**Urgency of technology needs**	**10**						
		Risk of delay of action	**15**						
National Priority to Sustainable Development	15	National priority in the general sustainable development context of the country (persistent position of the sector)	5						
		National priority in particular national sustainable Development and planning documents 1. *Jordan 2025- National Vision and Strategy (2015-2025)* 2. *Executive Development Programme (EDP) 2016-2018*	5						

		National priority in particular national climate change planning documents ***1. Climate Change Policy of Jordan 2013-2020*** ***2. INDCs 2020-2030***	5						
Contribution to Economy	15	General Economic Benefits	5						
		Contribution to GDP	5						
		Job creation potential; Potential for SMEs and Youth	5						
Social Factors	20	Equity	5						
		Involvement of Local Community	5						
		Role of end-users	5						
		Public Acceptability	5						
Planning, Implementation Experience, Sustainability, and Financing Factors	15	Cost Effectiveness of Technologies to be Transferred and Deployed	3						
		Competence and Capacity of Sectors' Stakeholders and Partners	3						
		Institutional Arrangements and Planning Experience of the Sector	3						
		Cooperation Potential mainly with Private Sector (PPP)	3						

		Financing Potential of Technologies and Projects	3						
Sector Experts' other Criteria of Choice -	10								
Total Score	**100**								
Sector final rank									

Annex 4 Details for the stakeholders consulted (including names, organization, dates, and topics):

National Committee on Climate Change consulted in the Inception workshop (Nov. 17th 2015)

No.	Name	Organization	Email address
1	Ahmad Aqatarneh	Ministry of Environment/Secretary General	aqatarneh@moenv.gov.jo; aqatarneh@yahoo.com
2	Mohammad Alnsour	Ministry of Agriculture	mohammed_nsour@yahoo.com
3	Lubna Farouq Aqqad	Ministry of Industry and Commerce (MIC)	Lubna.aq@mit.gov.jo
4	Muawiyah Faydi	Ministry of Energy and Mineral Resources (MEMR)	Muawiyah.Faydi@MEMR.gov.jo
5	Abdullah Heyasat	Ministry of Health (MOH)	Abdullahheyasat@yahoo.com
6	Rasha Qadora	Ministry of Transport(MoT)	rasha.qadora@mot.gov.jo
7	Zaidoun Qasim Elnsour	Greater Amman Municipality (GAM)	zaidounqasem@yahoo.com
8	Saleh Alouran	Ministry of Water and Irrigation (MWI)	Salehalouran58@yahoo.com
9	Nasab Rawashdeh	National Center for Agricultural Research and Extension (NCARE)	nasab@ncare.gov.jo
10	Mohammad AlQinna	Hashemite University	qinna@hu.edu.jo

Rest of stakeholders consulted in the Inception workshop (Nov. 17th 2015)

No.	Name	Organization	Email address
1	Majd Alnubar	Higher Council for Sceince and Technology	Majd.Alnubarsrtd.hcst.gov.jo
2	Ilham Abu Eishoh	The Jordanian Society for Organic Farming	IlhamAbuEishoh@yahoo.com
3	Muntaser Majali	The Jordanian Society for Organic Farming	Muntaser.Majali@yahoo.com
4	Shatha Al Omari	The Jordanian Society for Organic Farming	ShathaAlOmari@yahoo.com
5	Anwar Al Adwan	Jordan Valley Authority	adwan_anwar@yahoo.com
6	Nadine Katkhuda	EDAMA	Nadine@edama.jo
7	Zuhair Hattar	Land Transport Regulatory Commission	zuhair.hattar@ltrc.gov.jo
8	Wesam Tuhtamouni	Land Transport Regulatory Commission	Wesam.tahtamouni@ltrc.gov.jo
9	Iyad Abu Qudoss	Royal Department for Protection of Environment (RANGERS)	IyadQuddoss@yahoo.com
10	Wafa Daibes	Ministry of Environment/Head of Mitigation Division	wafadabis@hotmail.com
11	Hanadi Marie	Ministry of Environment/Head of Adaptation Division	hanadi.marie@moenv.gov.jo
12	Abdelkarim Shalabi	Ministry of Environment/Head of EIA Division	shalabi3@hotmail.com

13	Maha Abu Mouis	Ministry of Environment	maha.abu-moes@moenv.gov.jo
14	Tawfiq Al-Zatari	ETA-Max	zatar@eta-max.com
15	Ali Almashni	Ministry of Environment/Monitoring and Evaluation Division	Mashniali73@gmail.com
16	Sayyed Saleh	Ministry of Environment/Monitoring and Evaluation Division	'Sayyed.saleh@moenv.gov.jo'
17	Belal Shaqarin	Ministry of Environment/Nature Protection Directoare	shqareen@yahoo.com
18	Ammar Mesmar	Ministry of Environment/Nature Protection Directoare	Ammar.mesmmar@moenv.gov.jo
19	Khaled Abukaf	Green Generation Foundation	KhaledAbukaf@gmail.com
20	Abed Alrahman Alzgoul	Green Generation Foundation	Abed_078@hotmail.com
21	Zein Almajed	GGGI	Zein al Majed <zein.almajed@gggi.org>

Annex 5 Exercise 2 on the Inception Workshop day: Stakeholders Identification Table for Priority Sector Identified from Exercise no.
Exercise 2 on the TNA Inception Workshop: Stakeholder Identification and Engagement (1.0-1.5 hours)
Identifying stakeholders: who do you need to successfully complete your TNA?
(+/- 30 mins)

1. Split based into components (Mitigation vs Adaptation) groups
2. Divide groups based on top priority sectors identified in Exercise no. 1
3. Identify and write down on a sheet of paper (enclosed) every stakeholder you feel needs to be engaged to complete your TNA. **Think broadly** to **all interested** parties
    a. These could be key sub-sectors, institutions, department, individuals, etcetera (that might not be directly representing your chosen sector but are interested parties nonetheless)
4. For each stakeholder, please identify their stake on the same sheet and note:
    a. What do they bring to the TNA?
    b. What technology-related information and experience they have

Recruiting (+/- 30 mins)

5. How would you effectively 'sell' your TNA to the stakeholders and engage them?
6. Identify what are the challenges you may run into?
7. How could you overcome some of these challenges?

Keeping stakeholders engaged (+/- 30 mins)

1. At what stage of the TNA do you engage them?
    a. Identify for each of your stakeholders at what stages of the TNA you would engage them
        I. <u>Initiation</u>
        II. <u>Planning of the TNA</u>
        III. <u>Execution of the TNA (the MCA process)</u>
        IV. <u>Implementation of the TNA's for climate change adaptation and mitigation</u>

Stakeholders Groups	List of stakeholders to involve	What do they bring to the TNA? And What technology-related information and experience they have	Identify what are the challenges you may run into to engage such stakeholder?	How could you overcome some of these challenges and effectively engage this stakeholder	At what stage of the TNA do you engage them? (put no.) ***1st.*** Technology identification and prioritisation ***2nd.*** Barrier analysis and enabling framework ***3rd.*** Technology Action Plan (TAP) and project ideas
1. Government and Regulatory Bodies	1.				
	2.				
	3.				
2. Research, Science/Academia & Technology Canters	1.				
	2.				
	3.				
	4.				
	5.				
3. NGOs/CBOs	1.				
	2.				
	3.				
	4.				
	5.				
4. Private Sector/Businesses	1.				
	2.				
	3.				
	4.				
	5.				
	6.				
	7.				

Annex 6 Results from exercise 3 (Initial Long List of Adaptation Technologies, the first column from the left) conducted on the day of Inception Workshop for TNA Project and comparison against results from other national studies and literature, the three column

TNA Exercise (MoEnv/UNEP-DTU Project, 2015-2017)	Reducing Vulnerability to Climate Change in Agricultural Systems (NCARE WB Project, 2010-2012)	Adaptation program of action relevant to climate change and integrated water resources management for the zarqa river basin, jordan (MoEnv-MWI-UNDP/MDG Fund, 2011) based on **Jordan's Second National Communications Report to UNFCCC (MoEnv, 2009)**	TNC 2014 (UNDP 2014)
1. Water Harvesting Techniques		Residential water supply: Collection of rainwater for garden, toilets, and other applications. **Water harvesting**	**rainwater harvesting**
2. Water Treatment Technology/Domestic & Industrial			**Employing proper treatment technologies to treat industrial wastewater containing heavy metals.**
3. Water Purification Technologies, chlorificaton, desalinization, etc			
4. Water Convey and Distribution Technologies		Residential water supply: Reduce water losses in distribution pipes. **Reduction of losses from the supply networks**	**Maintenance of the water distribution network to reduce the losses of drinkable water and avoid water contamination**
5. Drinking Water Savings techniques		Residential water supply: **Introduce water saving**	**Water saving devices**

		<u>technologies</u> such as low-flow toilets and showers, and efficient appliances. **<u>Use of water-efficient technology</u>** Promote water saving by awareness campaigns.	
6. Greywater (treatment, use) technology	Reuse of Greywater in Home Farming;	**Use of greywater**	**Grey water Reuse:**
7. Water Monitoring, Telemetering, and Forecasting		**Increase of monitoring systems** **Effective water quality monitoring and compliance**	
8. Reuse of treated wastewater in agriculture, industry, urban, etc	• Increase farm water efficiency, improve water management • ***Improve On-farm Water Use Efficiency and Integrated Water Resources Management*** through promotion of rainfall harvesting, **<u>use of treated wastewater for irrigation</u>**, improved use of brackish water, strict monitoring system for groundwater exploitation. (Advanced Wastewater Treatment Technology and Reuse for Selected Fodder and Cut Flower Crops; Reuse of Greywater in Home Farming; Deficit Irrigation for	**<u>Efficient utilization of treated wastewater</u>** **Implement water harvesting techniques at farm level** **Construction of small on-farm reservoirs**	**using treated waste water for crops** **Wastewater treatment and reuse in the agricultural sector (**decentralized wastewater treatment systems)

	Improving Water Productivity of Vegetable Crops; Sustainable Development of Potential areas of the Badia through Water Harvesting)		
9. Water Resources Protection technologies		Irrigation Water: Use groundwater more efficiently.	**Reduce water abstraction**
10.Water data development and banking			
11.Agricultural drainage water reuse	• Increase farm water efficiency, improve water management • ***Improve On-farm Water Use Efficiency and Integrated Water Resources Management*** through promotion of rainfall harvesting, use of treated wastewater for irrigation, improved use of brackish water, strict monitoring system for groundwater exploitation. (Advanced Wastewater Treatment Technology and Reuse for Selected Fodder and Cut Flower Crops; Reuse of Greywater in Home Farming; Deficit Irrigation for Improving Water Productivity of Vegetable Crops; Sustainable Development of Potential areas of the Badia through Water Harvesting)	Irrigation Water**: Improve farm management practices**	

12.Flood control		**Management of flash floods**	
13.Groundwater recharge		**Implementation of artificial groundwater recharge to sustain water demands**	**Artificial recharge**
14.Rain Seeding		**Weather modification (cloud seeding)**	
15.Brackish water treatment and re-use		**Desalination of brackish water at farm level** **Desalination of brackish groundwater**	**brackish water desalinization at a local, small scale**
16.Reduction & evaporation techniques			
17.Soil water conservation and measures			
18.Improving water use efficiency/ enhancing agricultural water productivity through **<u>irrigation technologies</u>**	• Increase farm water efficiency, improve water management • ***Improve On-farm Water Use Efficiency and Integrated Water Resources Management*** through promotion of rainfall harvesting, **<u>use of treated wastewater for irrigation</u>**, improved use of brackish water, strict monitoring system for groundwater exploitation. (Advanced Wastewater Treatment Technology and Reuse for Selected Fodder and Cut Flower Crops; Reuse of Greywater in Home Farming; Deficit Irrigation for Improving Water Productivity of Vegetable	Irrigation Water: Introduce water saving technologies in irrigation schemes such as drip, micro-spray, night irrigation, etc. Increase the efficiency of irrigation systems. **Construction of small on-farm reservoirs**	**Increasing Efficiency of irrigation technologies, such as sprinkler systems, drip irrigation techniques,** subsurface irrigation systems and plastic greenhouses necessary to improve water savings during hot seasons. **drip irrigation techniques** Reduce irrigation

	Crops; Sustainable Development of Potential areas of the Badia through Water Harvesting)		
19.Hydroponics/soilless agriculture			
20.Water Productivity through **<u>selecting crops of high return</u>**	• Increase farm water efficiency, improve water management • ***Improve On-farm Water Use Efficiency and Integrated Water Resources Management*** through promotion of rainfall harvesting, use of treated wastewater for irrigation, improved use of brackish water, strict monitoring system for groundwater exploitation. (Advanced Wastewater Treatment Technology and Reuse for Selected Fodder and Cut Flower Crops; Reuse of Greywater in Home Farming; Deficit Irrigation for Improving Water Productivity of Vegetable Crops; Sustainable Development of Potential areas of the Badia through Water Harvesting)	Irrigation Water: **<u>Introduce new varieties of crops that use less water and are salt-tolerant</u>**. **Use of drought-tolerant and salt-resistant crops** Irrigation Water**: Improve farm management practices**	**rotating or changing crops** **Plants with low water requirements**
21.		Irrigation Water: Reform irrigation water pricing.	

22.		**Development of drought management plan**	
23.		**Construction of desert dams**	
24.		**Public and stakeholder participation in groundwater management**	
25.		**Protection of groundwater from contamination**	
26.		**Improvement of existed wastewater treatment plants**	
27.		**Protecting surface water supplies from point and non-point pollution sources**	
28.			Enhance water storage efficiency
29.			**Public Awareness:** a comprehensive program of public educating regarding water issues for irrigation and domestic purposes
30.			Springs rehabilitation

Technology: Solar Thermal Systems

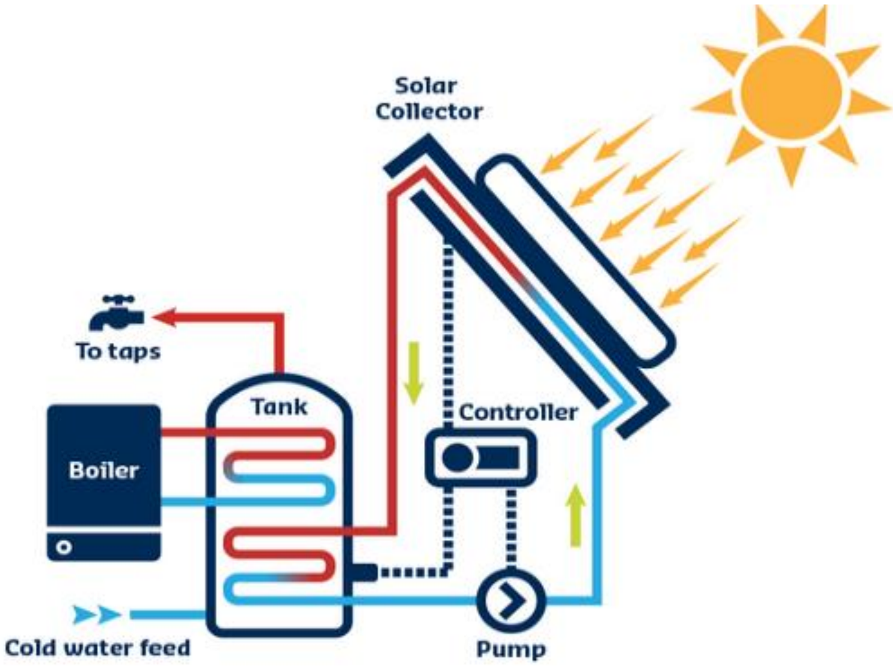
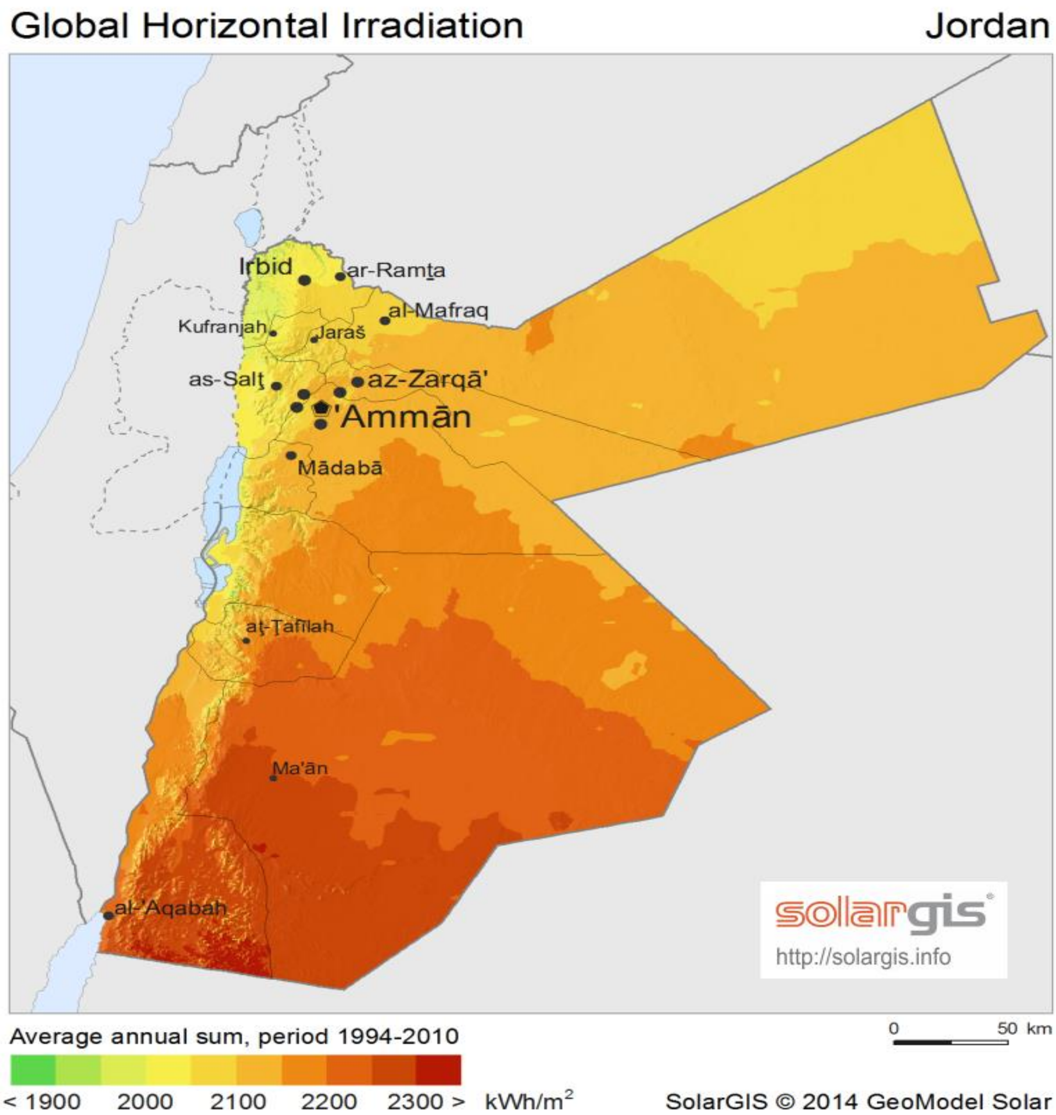
<table>
<tr><td colspan="2">Technology: Solar Thermal Systems</td></tr>
<tr><td colspan="2">Sector: Energy</td></tr>
<tr><td colspan="2">Subsector:</td></tr>
<tr><td colspan="2">Technology characteristics</td></tr>
<tr><td>Introduction</td><td>Solar thermal technology uses the sun’s energy, rather than fossil fuels, to generate low-cost, environmentally friendly thermal energy. This energy is used to heat water or other fluids, and can also power solar cooling.</td></tr>
<tr><td>Technology characteristics/ highlight</td><td>The two main types of collectors for low temperature applications are: Evacuated tube solar thermal system and Flat-plate solar system. As a system, other components are integrated with the collectors like storage tanks, piping systems, insulation and controllers.


Figure (): Schematic diagram of solar thermal system[31].
Main Advantages of the technology include on site, clean and safe generation, and rapid installation of the equipment. This technology provides an immediate and measurable reduction in fuel bills together with reduction in carbon dioxide emissions.</td></tr>
<tr><td>Institutional and Organizational requirements</td><td>In power generation applications, all regulations have been already endorsed by the government and implemented for all types of connections including net metering, power purchase agreements and direct proposals. Large projects require Environmental impact assessment and Grid impact studies which both are clearly outlined and implemented
In water heating applications, there is no regulations needed by the government apart</td></tr>
</table>

[31] http://www.markgroup.co.uk/homeowners/solar/solar-hot-water

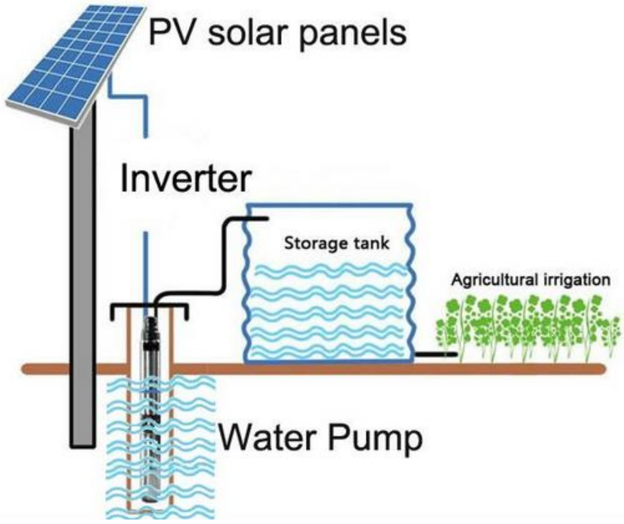
	from the quality of components. Many regulations have been endorsed to encourage such applications including exemption fro sales and custom taxes
Operation and maintenance	Solar thermal experience in Jordan dates back to early 1970s. Locally manufactured products can work for over 20 years with minimal maintenance
Endorsement by experts	Integrated approach to energy management on small and large scale applications. One advantage of solar thermal power station over PV is that it can be used during nigh times by means of using energy storage media
Adequacy for current climate	In terms of solar radiation potential and as can be seen in Figure ( ), Jordan enjoys high insolation ranges especially in the south which make solar energy project economically viable  **Figure (): Global Horizontal Insulation in Jordan [32]**

[32] http://www.solargis.info

Scale/Size of beneficiary group	Solarthermal can use technologies for gigawatt power generation. In water heating, it can be used for small houses to large industrial applications. So it can serve small houses to large buildings and industries to communities.
Disadvantages	• Needs frequent cleaning
Capital Cost	
Cost to implement adaptation technology	Although capital cost may be higher than conventional power station, economic indicators like NPV and IRR shows reasonable results compared to other alternatives but still higher than PV. For large scale applications, capital cost per kWp is around US$1500 to 3000 including installation. For water heating applications, a medium house may require a 3 m2 solar thermal system that costs around JD 600 in average.
Development impacts, direct and indirect benefits	
Direct benefits	• Reducing GHG emission and thus better health conditions • Creating jobs in different fields including installation, consultation and maintenance • Reducing energy bills • Less dependence on imported oil by using local free solar resources
Reduction of vulnerability to climate change/reduce d emissions, indirect	Many countries has already committed to increase the renewable energy contribution in their energy policies. This inturn will reduce GHG emissions considerably
Economic benefits, Indirect Employment	Solarthermal systems is the most feasible solar technology. This reduces burden of electricity bills of the consumers The average system cost nowadays ranges between 100 to 200 JD/m2 Pay back periods of such systems in Jordan ranges between 2 and 4 years.
Growth and Investment	Can create investment and service companies in training, installation, design and consultation fields
Social benefits (indirect benefits in Income, Education, and health)	• Communities living at areas of installations can benefit from creating local jobs • Improving health conditions due to improved comfort conditions • Training opportunities
Environmental benefits, indirect	Solar thermal systems enable to generate electricity without fuel consumption. Therefore, it is expected to provide 100% energy saving compared to conventional fossil fuel based electricity production. Greenhouse gas emissions is almost zero with few at the manufacturing stage of components
Local context	
Barriers	Main barriers that hinder the widespread application of this technology include: high investment cost in comparison to the conventional heaters, lack of expertise in design and installation of large scale systems, the high salinity levels of water in certain areas that decrease system lifetime, and the low quality products available in

	the market that adversely have affected reputation of this technology among users. However, increasing electricity tariffs has recently improved the economic viability of this technology.
Market potential	There is a large potential for solar water heater applications in both Commercial and Industrial sectors in Jordan. Many industries need hot water for processing such as food, textile, and chemical factories. Solar thermal technology comes in many shapes and sizes, and is used in a wide variety of commercial applications. Commonly seen types of solar thermal applications include: • Domestic Hot Water (DHW) systems: These include active and passive glycol systems (both closed and open loop), as well as drainback systems • Swimming Pool/Hot Tub-Heating Systems: There are closed loop glycol and drainback varieties • Space Heating Systems (radiant): Usually attached to a DHW system • Combined Systems: Combination of any of the above • In general, solar thermal technologies can be used in: • Space heating of commercial buildings, offices, greenhouses • Heating for commercial purposes such as dairies, sheltered housing etc. • Space heating in the service sector • Heating for indoor and outdoor swimming pools • Industrial process heating (low temperature heat up to 250°C) • Solar cooking • Desalination • Agricultural purpose (crop drying)
Status (National status of technology in Jordan)	Jordan is considered as a pioneer for renewable energy applications and regulation in the region. Some solarthermal power stations is currently under installations. For water heating, around in houses, penetration rate is around 11%
Timeframe	Large scale power stations can be ready in several months. Household water heating system can be installed and operated in the same day
Acceptability to local stakeholders	The technology is accepted and easily acceptable to stakeholders and users

Technology: Solar water Pumping System

Technology: Solar water Pumping System	
Sector: Energy	
Subsector:	
Technology characteristics	
Introduction	A solar water pumping system consists of photovoltaic (PV) solar panels converting sunlight directly into electricity, controller/inverter and the pump to transfer the water from one point to another. A storage tank or reservoirs may be used to store water during the day to be used at nights if needed. Solar water pumping systems are attractive solutions to provide water in remote regions where the grid connection is limited or not available.  **Figure (): Solar water pumping system[33].**
Technology characteristics/ highlight	Main Advantages: Solar water pumps are especially useful in small scale or community based irrigation. The operation of solar powered pumps is more economical mainly due to the lower operation and maintenance costs and has less environmental impact than pumps powered by grid electricity or diesel fuel. A great advantage of solar pumps is that demand for water matches with solar intensity
Institutional and Organizational requirements	In power generation applications, all regulations have been already endorsed by the government and implemented for all types of connections including net metering, power purchase agreements and direct proposals. For solar water pumping, systems needs no regulations
Operation and maintenance	Solar pumping system experience in Jordan dates back to early 1970s. Locally manufactured products can work for over 20 years with minimal maintenance
Endorsement by experts	Solar powered pumping systems are more reliable than diesel powered systems.

[33] http://solarsupplier.en.alibaba.com/

<table>
<tr><td>Adequacy for current climate</td><td>In terms of solar radiation potential and as can be seen in Figure ( ), Jordan enjoys high insolation ranges especially in the south which make solar energy project economically viable

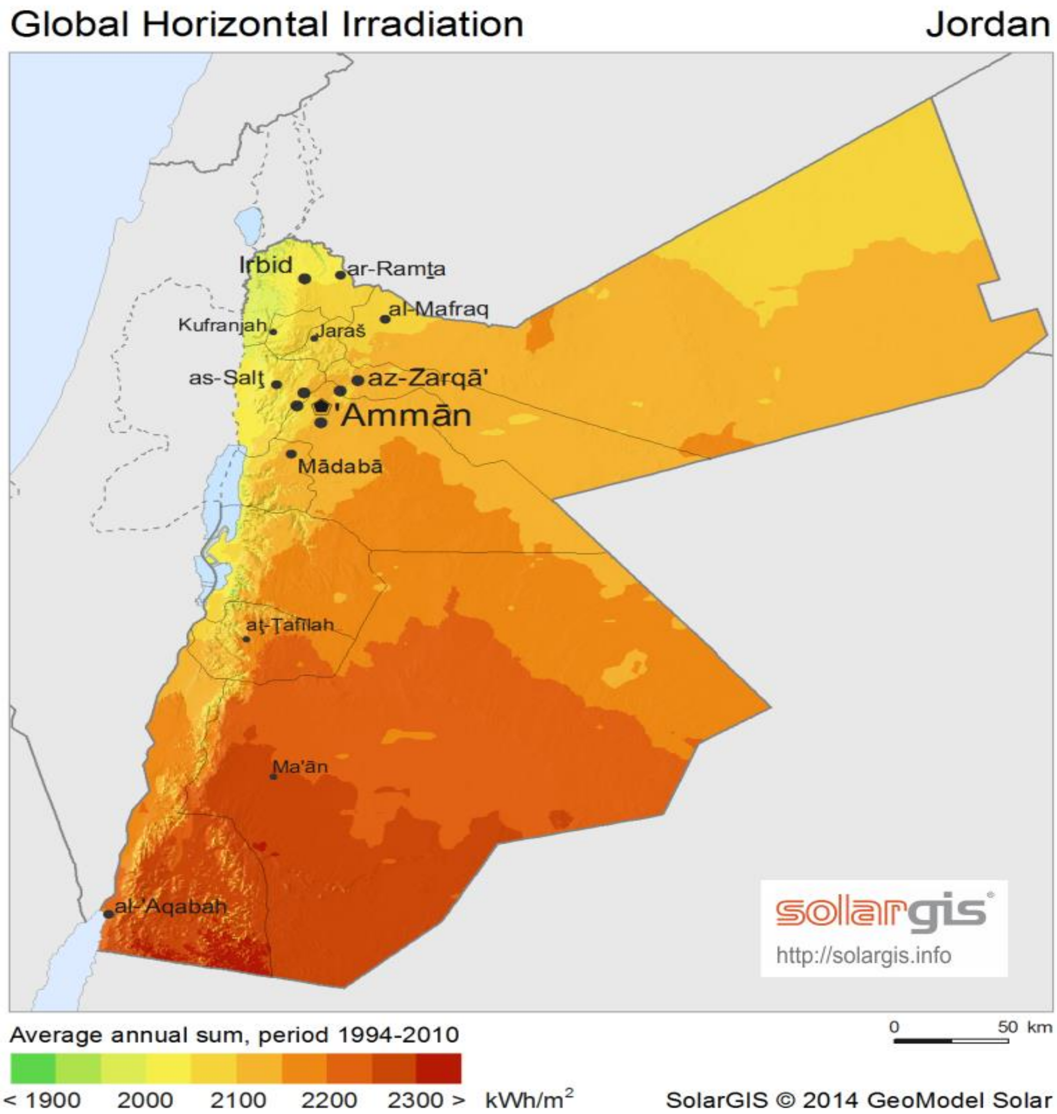


Figure (): Global Horizontal Insulation in Jordan [34]</td></tr>
<tr><td>Scale/Size of beneficiary group</td><td>Solar pumping systems can be installed in any size and can serve farmers and public sector.</td></tr>
<tr><td>Disadvantages</td><td>• Needs frequent cleaning</td></tr>
<tr><td colspan="2">Capital Cost</td></tr>
<tr><td>Cost to implement adaptation technology</td><td>capital cost per kWp is around US$1000 to 1500 including installation.</td></tr>
<tr><td colspan="2">Development impacts, direct and indirect benefits</td></tr>
</table>

[34] http://www.solargis.info

Direct benefits	• Reducing GHG emission and thus better health conditions • Creating jobs in different fields including installation, consultation and maintenance • Reducing energy bills • Less dependence on imported oil by using local free solar resources
Reduction of vulnerability to climate change/reduced emissions, indirect	Many countries has already committed to increase the renewable energy contribution in their energy policies. This in turn will reduce GHG emissions considerably
Economic benefits, Indirect Employment	Cost of pumping water by solar is almost half of that by diesel.
Growth and Investment	Can create investment and service companies in training, installation, design and consultation fields
Social benefits (indirect benefits in Income, Education, and health)	Communities living at areas of installations can benefit from creating local jobs and cheaper water. Agriculture sector can be one of the major beneficiary of such applications
Environmental benefits, indirect	Solar pumping systems enable to generate electricity without fuel consumption. Therefore, it is expected to provide 100% energy saving compared to conventional fossil fuel based electricity production. Greenhouse gas emissions is almost zero with few at the manufacturing stage of components
Local context	
Barriers	Main Barriers for this technology is the lack of experience in optimum design, selection of components and matching between them. High level qualified experts must be engaged in the design and installation. Moreover, availability of Inverters (that convert the DC current from the PV into AC required by the pump) is still limited by size. Maximum sizes for mature technologies is still below 20 kW. However, this can be solved by selecting standard PV inverters with some other accessories. More challenges are as follows • Securing financing for the high initial cost • Lack of maintenance experience • Lack of regulations for companies performing installations and offices doing design and supervision
Market potential	In accordance with the unavailability of Diesel fuel in rural area, complications of transport, frequent failures of diesel systems and the high records of maintenance requirements, all that will encourage farmers to switch into solar water pumping systems. On the public sector, Water Authority of Jordan consumes around one fifth of the total electricity production in Jordan almost goes for water pumping. It is considered the biggest consumer. The increased diesel fuel prices will bring PV technology as a strong competitive

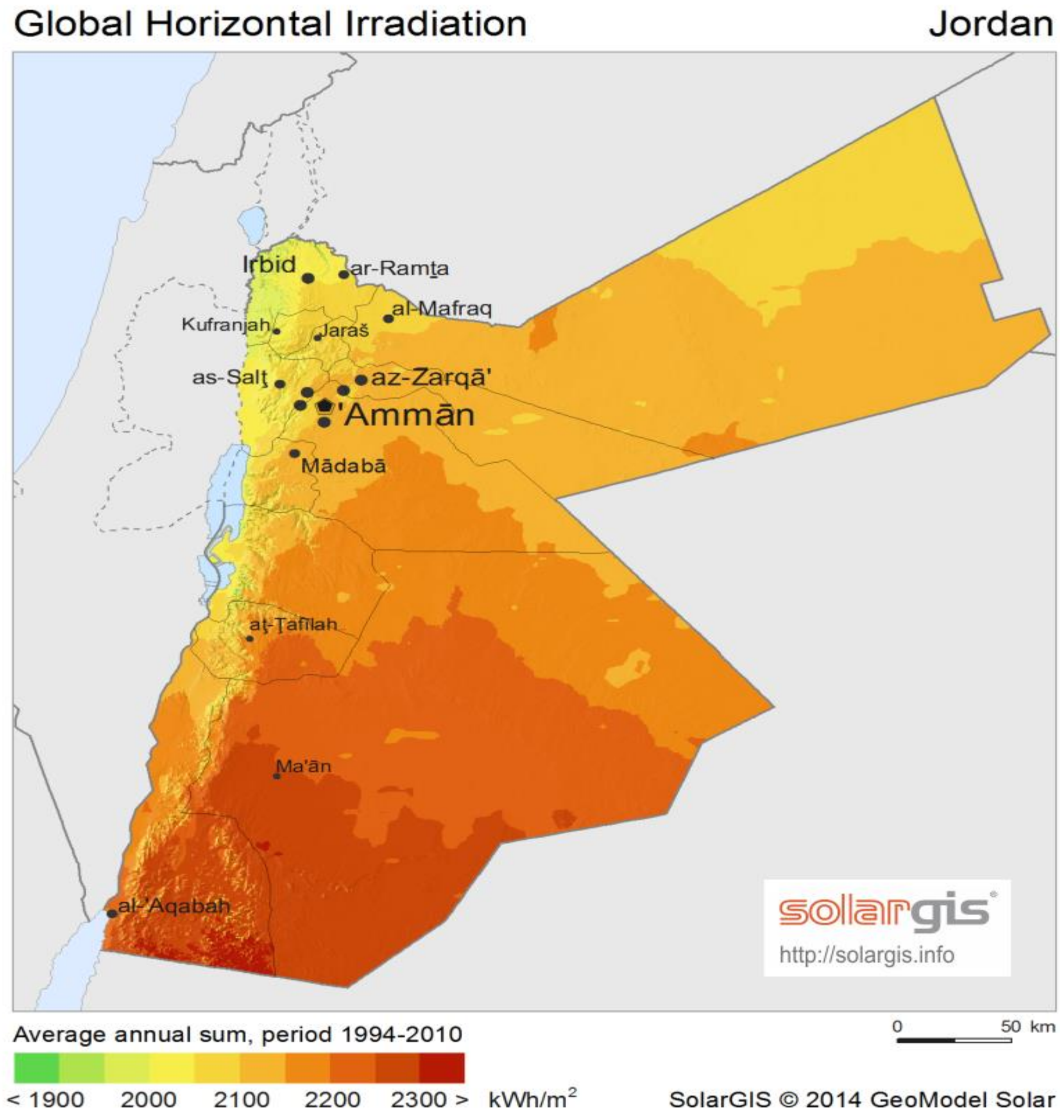
	alternative for diesel generators in remote areas. Moreover, the recent increase in electricity tariff and the sharp reduction in PV prices is significantly improving the economic viability of solar water pumping systems Field of applications are: • Delivery of drinking water • Delivery of water to livestock • Agricultural irrigation • Desalination systems • Wastewater treatment plants • Can be used for any industrial and commercial facility that needs water pumping and/or distribution
Status (National status of technology in Jordan)	Jordan is considered as a pioneer for renewable energy applications and regulation in the region. Many solar pumping stations have already been installed and many others are under construction
Timeframe	A solar pumping system can be installed and operated in few days
Acceptability to local stakeholders	The technology is accepted and easily acceptable to stakeholders and users

Technology: Solar Photovoltaic (PV) Electrification Systems

Technology: Solar Photovoltaic (PV) Electrification Systems	
Sector: Energy	
Subsector:	
Technology characteristics	
Introduction	Photovoltaic (PV) cells convert sunlight directly into electricity without causing air or water pollution.  **Figure ( ): Solar PV Panel[35].** Silicon is currently the most common material in PV cells. Cadmium telluride and copper indium (gallium) di-selenide Cells are also available. Each material has its own characteristics that determines the cell performance, manufacturing method and cost. In general PV cells can be classified as: Crystalline Silicon (c-Si): Modules are made from cells of either mono-crystalline or multi-crystalline silicon. Mono-crystalline silicon cells are generally more efficient, but are also more costly than multi-crystalline. Thin Film – Modules are made with a thin film deposition of a semiconductor onto a substrate. This class includes semiconductors made from: • Amorphous silicon (a-Si). • Cadmium telluride (CdTe). • Copper indium selenide (CIS). • Copper indium (gallium) di-selenide (CIGS)
Technology characteristics/ highlight	PV power systems can be classified into: • Off-grid domestic – Providing electricity to households and villages that are not connected to the grid. • Off-grid non-domestic – Providing electricity for a wide range of applications such as telecommunication, water pumping and navigational aids. • Grid-connected distributed PV – Providing electricity to a specific grid-connected facility. • Grid-connected centralised PV – Providing centralised power

[35] http://www.alternativasostenibile.it/articolo/gli-italiani-scelgono-l-energia-solare-1205.html
http://www.homepower.com/articles/image/691/1937?width=750&height=600&iframe=true&template=colorbox

	generation for the supply of bulk power into the grid. Concentrating photovoltaic Technology (CPV) uses optics, such as lenses and mirrors, to concentrate the sun onto solar cells. This dramatically reduces the amount of semiconductor needed and opens up the potential to cost-effectively use very high-performance multi-junction cells with efficiency levels greater than 40 percent. For proper operation, CPV modules must face the sun. Therefore, CPV modules uses high-performance trackers that intelligently and automatically follow the sun throughout the day. Other than this, CPV systems are built and operate much like traditional PV systems. PV systems consists of: PV modules, Supporting structure, DC cables, DC connectors, DC Junction boxes, DC Switches, , Inverter/s , AC cables, AC connectors, AC Switch gears, Transformer, Earthing system and Monitoring systems Main Advantages of the technology include on site, clean, safe generation, modular and quick installation of the equipment
Institutional and Organizational requirements	All regulations have been already endorsed by the government and implemented for all types of connections including net metering, power purchase agreements and direct proposals. Large projects require Environmental impact assessment and Grid impact studies which both are clearly outlined and implemented
Operation and maintenance	First installation in Jordan dates back to 1980's. Systems are still working with minimal maintenance. Downtime of systems was recorded at less than 1%.
Endorsement by experts	Integrated approach to energy management on small and large scale applications.
Adequacy for current climate	In terms of solar radiation potential and as can be seen in Figure ( ), Jordan enjoys high insolation ranges especially in the south which make solar energy project economically viable

	 **Figure (): Global Horizontal Insulation in Jordan [36]**
Scale/Size of beneficiary group	PV is a modular technology that can be installed from as low as few watts to giga-watts. So it can serve small houses to large buildings to communities.
Disadvantages	• Needs frequent cleaning • Can be stolen or broken when installed unprotected in remote areas
Capital Cost	
Cost to implement adaptation technology	Although capital cost may be higher than conventional power station, economic indicators like NPV and IRR shows better results than many other alternatives. For large scale applications, capital cost per kWp is around US$900 to 1400 including installation.
Development impacts, direct and indirect benefits	
Direct benefits	• Reducing GHG emission and thus better health conditions • Creating jobs in different fields including installation, consultation and

[36] http://www.solargis.info

	maintenance • Reducing energy bills • Less dependence on imported oil by using local free solar resources
Reduction of vulnerability to climate change/reduced emissions, indirect	Many countries has already committed to increase the solar PV contribution in their energy policies. This inturn will reduce GHG emissions considerably
Economic benefits, Indirect Employment	In Jordan, latest direct proposal has revealed a very encouraging prices of electricity which went down to lower than 5 piaster/kWh. This will mitigate the burden on the government that suffer a cost of almost double this figure
Growth and Investment	Can create investment and service companies in training, installation, design and consultation fields
Social benefits (indirect benefits in Income, Education, and health)	• Communities living at areas of installations can benefit from creating local jobs • Improving health conditions due to improved comfort conditions • Training opportunities
Environmental benefits, indirect	Solar PV panels enable to generate electricity without fuel consumption. Therefore, it is expected to provide 100% energy saving compared to conventional fossil fuel based electricity production. Greenhouse gas emissions is almost zero with few at the manufacturing stage of components
Local context	
Barriers	• Securing financing for the high initial cost • Lack of maintenance experience • Lack of regulations for companies performing installations and offices doing design and supervision • Intermittent power production in cloudy weather conditions
Market potential	The increased diesel fuel prices will bring PV technology as a strong competitive alternative for diesel generators in remote areas. Moreover, the recent increase in electricity tariff and the sharp reduction in PV prices is significantly improving the economic viability of grid connected PV applications. Sample applications are as follows • Electricity production to support the grid • Electricity supply in remote areas where the there is no access to grid connection • Energy efficient lighting and emergency call boxes • Water pumping and desalination • Solar Refrigeration • Rooftop applications (industrial and commercial facilities) • Any application needs electricity • Financial appraisal

	The average system cost nowadays went down to below JD1000/kWp. Pay back periods of such systems in Jordan nowadays ranges between 2 and 6 years depends on the application
Status (National status of technology in Jordan)	Jordan is considered as a pioneer for PV applications and regulation in the region. Many PV power stations is currently under installations and others in the tendering process
Timeframe	Large scale power stations can be ready in several months. Small scale applications can be installed in a week time or less
Acceptability to local stakeholders	The technology is accepted and easily acceptable to stakeholders and users

Technology: Efficient Solar Street Lighting

Sector: Energy

Subsector GHG emission (20.938 Million tonnes (Mt) CO2eq.)

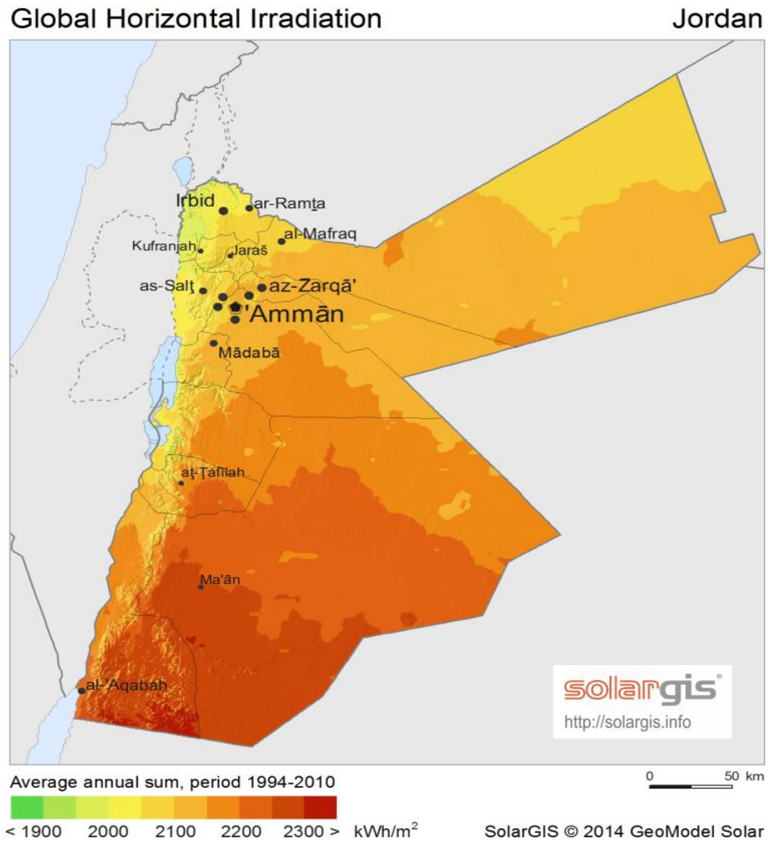
General Description

Efficient street lighting is aimed to provide a good visibility to users (pedestrians, cyclists, and drivers) during the darkness hours to support their safety and security. At the same time, it could be an attractive design element. High intensity discharge lamps (HID) are most common for street lighting. The most efficient HID lamp for such application is low pressure sodium type (80-150 Lumens/Watt), roughly three times more efficient than mercury vapour lamps. In recent times, also LED applications have been introduced. Even if LEDs are the most efficient source of lighting at the moment, they are still expensive and the maximum level of lighting is still low compared to conventional units.
Currently PV solar powered compact systems are becoming popular in street lighting applications where there is no possibility to connect to the grid.

Main advantages of the technology include lower operating costs, lower maintenance costs, more safety together with providing and improving human vision at the hours of darkness which is more beneficial than the traditional lamps.

Potential of Resources

In terms of solar radiation potential and as can be seen in Figure ( ), Jordan enjoys high insolation ranges especially in the south which make solar energy project economically viable



Annual Global Horizontal Insulation in Jordan [37]

Potential of Applications

- Public street lighting

[37]http://www.solargis.info

- Outdoor car park lighting
- Domestic and commercial outdoor lighting
- Lighting of sports fields.

Financial appraisal

The average system cost nowadays went down to below JD1500/kWp. Pay back periods of such systems in Jordan nowadays ranges between 4 and 6 years depends on the location and other alternatives.

Maturity (operation, Reliability and safety)

First installation of PV systems in Jordan dates back to 1980's,early 1990's. Systems are still working with minimal maintenance. Downtime of systems was recorded at less than 1%. Some components like batteries has a shorter lifetime of around 5 to 10 years.

Challenges/Barriers

Main barriers of the technology include complicated ownership schemes that reduce the potential of the private sector to offer solutions. Low pressure sodium lamps cannot be adopted if the colour rendering is a reason of concern. More are as follows

- Securing financing for the high initial cost
- Lack of maintenance experience
- Lack of regulations for companies performing installations and offices doing design and supervision

Energy Savings Opportunities/ Environmental/climate change mitigation Benefits

Energy efficient lamps can produce about 4 times more light than conventional ones at same power consumption. When using PV solar compact system, all power can be freely provided by the PV solar modules

Solar PV panels enable to generate electricity without fuel consumption. Therefore, it is expected to provide 100% energy saving compared to conventional fossil fuel based electricity production. Greenhouse gas emissions is almost zero with few at the manufacturing stage of components

Economic benefits

Cost of kWhr produced by PV is almost half of that produced by conventional power stations in Jordan.

Social benefit

Better environment and safer areas

Replacing conventional Lighting with CFL and LED

Sector: Energy

Subsector GHG emission

General Description

LED (Light Emitting Diodes)
Light-emitting Diodes (LEDs) are solid-state electronic devices that generate light via the transportation of electric energy to radiant energy within crystalline structure of a semiconductor metal. LEDs operate at low-voltage direct current and each LED produces around 10 lumens, therefore several LEDs must be assembled (dozens to hundreds) to provide sufficient illumination. LED is one of today's most energy-efficient and rapidly-developing lighting technologies. Quality LED light bulbs last longer, are more durable, and offer comparable or better light quality than other types of lighting.

LED Lighting is an environmental friendly technology because the LEDs contain no mercury, unlike fluorescent lamps. LEDs are extremely long lasting lamps with more than 25,000 operating hours. Colour shift over the time is minimal and several colours are available. Other advantages include durable quality (can withstand even the roughest conditions), little UV emissions infrared light (close to no UV emissions), design flexibility, operational in extremely cold or hot temperatures, low voltage operation, excellent colour rendering, no warm up period, low maintenance, and instantaneous switching on.

Fluorescent Lamps:
The central element in a fluorescent lamp is a sealed glass tube. The tube contains a small bit of mercury and an inert gas, typically argon, kept under very low pressure. The tube also contains a phosphor powder, coated along the inside of the glass. The tube has two electrodes, one at each end, which are wired to an electrical circuit which is hooked up to an alternating current (AC) supply. When the lamp is turned on, the current flows through the electrical circuit to the electrodes that has considerable voltage across, so electrons will migrate through the gas from one end of the tube to the other. This energy changes some of the mercury in the tube from a liquid to a gas. As electrons and charged atoms move through the tube, some of them will collide with the gaseous mercury atoms. These collisions excite the atoms, bumping electrons up to higher energy levels. When the electrons return to their original energy level, they release light photons.

Main advantages of the technology include long lamp lifetime between 7,500-24,000 hours, less heat emission compared to incandescent and halogen bulbs, availability in wide variety of styles, less energy consumption than the conventional bulbs which is resulting in higher Lumens output per electric watt input.

Potential of Applications

Due to its high efficiency rate (Lumens/W) and long lifetime, currently, LED and CFL lighting is used as an alternative for incandescent lamps, halogen lamps and other lighting sources. These technologies are becoming more and more popular in:

- Commercial buildings (Hotels, shopping malls, hospitals, leisure centres, warehouses, restaurants, swimming pools, universities, airports, offices, barracks, etc.)
- Industrial facilities (Pharmaceuticals, paper and board, brewing, ceramics, brick, cement, food, textile, minerals, wood etc.)

Financial appraisal

Sample prices CFL 0.1-0.2 JD/W, LED 0.4 to 1.0 JD/W
As average lifetime of LED is around 20000 hours and CFL is around 7000 hours payback period of both technologies when replacing incandescent lights is lower than 2 years.
Payback period of all above measures are normally below 3 years

Maturity (operation, Reliability and safety)

CFL has nowadays a provel lifetime of 6000 to 10000 hours. LED ligts can exceed 20000 hours. Both technologies have much higher lifetime than the conventional lightings

Challenges/Barriers

LED: Main Barriers: LEDs are more expensive than conventional lighting and LED performance largely depends on the ambient temperature of the operating environment. Heat sinks need to be installed to avoid excess heat.

CFL: Main barriers of the technology include safety precautions (in case of broken lamp, it can let out tiny amounts of mercury which can be extremely hazardous if exceeds the allowable limits), more expensive up-front when compared with incandescent bulbs. However, these barriers are eliminated when: 1) applying the standard regulations for the maximum allowable limits of Mercury and 2) conducting a feasibility study that considers long term operation cost not only initial capital investment cost.

Energy Savings Opportunities/ Environmental/climate change mitigation Benefits

LED has the potential to fundamentally change the future of lighting since it uses at least 75% less energy, and last 25 times longer than incandescent lighting.. Moreover, it reduces the cooling load demand.

Switching from High Intensity Discharge lamps to fluorescent can result in energy savings as high as 50 %.

Market Potential

Fluorescent lamps & Compact Fluorescent Lamps (CFL) are popular in Egypt. They are used in several facilities with estimated high potential in commercial building (hotels, offices, super markets, hospitals, universities, schools etc…).

Economic benefits

LED and CFL lightings are in general economically feasible and technically reliable. This reduces burden of electricity bills on the country economy.

Social benefit

Reducing electricity bills will have a great social benefits for householders.

Green Building and Passive Design

Sector: Energy

Subsector GHG emission (20.938 Million tonnes (Mt) CO2eq.)

General Description

Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by efficiently using energy and implementing other several measures. A variety of products are available to achieve this goal such as: renewable energy systems, super energy efficient appliances and HVAC systems, CFLs and now LED lighting, insulation, high-performance windows, shading devices and more.

Passive solar design refers to the use of the sun's energy for the heating and cooling of living spaces. In this approach, the building itself or some element of it takes advantage of natural energy characteristics in materials and air created by exposure to the sun. Passive systems are simple, have few moving parts, and require minimal maintenance with no mechanical systems. Operable windows, thermal mass, and thermal chimneys are common elements found in passive design. Operable windows are simply windows that can be opened. Thermal mass refers to materials such as masonry and water that can store heat energy for extended time. Thermal mass will prevent rapid temperature fluctuations. Thermal chimneys create or reinforce the effect hot air rising to induce air movement for cooling purposes.

Windows accounts for around 10% to 25% of heating and cooling loads in buildings. Therefore, it is recommended to install high performance windows. Double glazed windows are made from two panes of glass that are separated by a layer of air or gas and then sealed. They are designed to provide a better barrier against outside temperatures than single paned windows because the two layers of glass and the buffer layer act as insulators. Double-glazing is standard in most new houses. It is a worthwhile investment to install double glazing in an existing home anytime windows need substantial repair or replacing.

The building envelope, the interface between the interior of the building and the outdoor environment, including the walls, roof, and foundation, serves as a thermal barrier and plays an important role in determining the amount of energy necessary to maintain a comfortable indoor environment relative to the outside environment.

Usually a layer of mineral wool, plastic foam or other type of insulation is placed inside the wall structure during construction phase of new buildings. The primary feature of a thermal insulation material is its ability to reduce heat exchange between a surface and the environment, or between one surface and another surface. This is known as having a low value for thermal conductivity. Generally, the lower a material's thermal conductivity, the greater is its ability to insulate for a given material thickness and set of conditions.

For the insulation of existing buildings, additional insulation layer is fixed to the walls. This layer could be placed both outside and inside the building.

Installation of external movable sun-shading devices is highly recommended in buildings that are exposed to the summer sun. Well-designed sun shading devices will help keep the building cool and comfortable and limit the space-conditioning needs of the facility. A sun shading device acts as a barrier to solar radiation. This "barrier" is most efficient when placed outside the window, because in this case some of the solar radiation is reflected back to the outside before reaching the window. When the protection is placed inside, only a small part of the incoming solar radiation is reflected back to the outside.

Exterior shading devices have a number of advantages that contribute to a more sustainable building. It results in energy savings by reducing direct solar gain through windows. Peak electricity demand is reduced by exterior shading devices resulting in lower peak demand charges from utilities and reduced mechanical equipment costs. Moreover, shading devices have the ability to reduce glare in an interior space without the need to lower shades or close blinds. This means that daylight and view are not diminished by dark tinted glazing or blocked by interior shades. With exterior shading devices, glare control does not depend on user.

Potential of Resources

Most equipment and material are locally manufactured

Potential of Applications

There is great potential in housed, industrial facilities and commercial buildings (hotels, shopping malls, hospitals, leisure centres, warehouses, restaurants, universities, airports, offices etc.)

Financial appraisal

The cost of passive design elements can run the same or slightly more than conventional building costs. This assumes that design services are used in both approaches – passive solar design and conventional design. Interior thermal mass materials such as stone and brick generally add to the cost of a home but can also be considered aesthetic enhancements.
Sample prices of other measures are: Double glazed windows 60 to 100 JD/m2, wall insulation 70 to 130 JD/m3, CFL 0.1-0.2 JD/W, LED 0.4 to 1.0 JD/W
Payback period of all above measures are normally below 3 years

Maturity (operation, Reliability and safety)

Passive design is Well developed in passive heating but less developed in passive cooling.
A thermal chimney is a common design element in passive solar designs. Thermal chimneys are based on basic thermodynamics commonly used in passive design
Double glazed windows, shading devices, insulation, LED and CFL are all mature technology with long lifetime

Challenges/Barriers

Main barriers of the technology include higher initial investment cost compared to conventional building. Although there is a valid in-place building codes in Jordan, many contractors and/or building owners do not apply it

Energy Savings Opportunities/ Environmental/climate change mitigation Benefits

Compared to the widely used single glazed windows, the multiple glazed (double and triple) windows typically reduce energy loss through windows by as much as 30-50% both in summer and winter seasons.
In insulation, the energy saving strongly depends on the type of existing insulation and the type of new insulation. Approximate energy saving range is 10-50%
In shading, energy savings are calculated on the base of kWh/m2. However, the exact saving depends on the dimension of the space and the type of the structural element that is used.
In general utilizing energy efficient equipment and measures in building can reduce energy consumption from 20 to 50%. In case renewable energy systems are installed, buildings can 100% energy savings
According to the ministry of Energy and Mineral Resources, Household sector in Jordan consumed 43% of the country electricity bill in year 2013. This shows the great energy saving opportunities in green buildings fields

Economic benefits

Green building systems are in general economically feasible and technically reliable. This reduces burden of electricity bills on the country economy.

Social benefit

Reducing electricity bills will have a great social benefits for householders. Implementing projects will create jobs in local communities

Technology: Concentrated Solar Power (CSP)

Sector: Energy

Subsector GHG emission (20.938 Million tonnes (Mt) CO2eq.)

General Description

Concentrating Solar Power (CSP) technologies use mirrors or lenses to concentrate (focus) the sun's light energy and convert it into heat to create steam to drive a turbine that generates electrical power. The plants consist of two parts: one that collects solar energy and converts it to heat, and another that converts the heat energy to electricity.

CSP technology utilizes three alternative technological approaches: trough systems, power tower systems, and dish/engine systems.

Trough systems use large, U-shaped (parabolic) reflectors (focusing mirrors) that have oil-filled pipes running along their center, or focal point. The mirrored reflectors are tilted toward the sun, and focus sunlight on the pipes to heat the oil inside to as much as 400 °C. The hot oil is then used to boil water, which makes steam to run conventional steam turbines and generators.

Power tower systems also called central receivers, use large sun-tracking mirrors, called heliostats, to focus the sun's energy on a receiver. The receiver sits on top of a tall tower in which concentrated sunlight heats a fluid, such as molten salt, as hot as 560 °C. The hot fluid can be used immediately to make steam for electricity generation or stored for later use. Molten salt retains heat efficiently, so it can be stored for days before being converted into electricity. That means electricity can be produced during periods of peak need on cloudy days or even several hours after sunset. Molten nitrate salts absorb the heat, which is then used to boil water to steam, which is sent to a conventional steam turbine-generator to produce electricity

Dish/engine systems use mirrored dishes (about 10 times larger than a backyard satellite dish) to focus and concentrate sunlight onto a receiver. The receiver is mounted at the focal point of the dish. To capture the maximum amount of solar energy, the dish assembly tracks the sun across the sky. The receiver is integrated into a high-efficiency "external" combustion engine. The engine has thin tubes containing hydrogen or helium gas that run along the outside of the engine's four piston cylinders and open into the cylinders. As concentrated sunlight falls on the receiver, it heats the gas in the tubes to very high temperatures, which causes hot gas to expand inside the cylinders. The expanding gas drives the pistons. The pistons turn a crankshaft, which drives an electric generator. The receiver, engine, and generator comprise a single, integrated assembly mounted at the focus of the mirrored dish.

Potential of Resources

In terms of solar radiation potential and as can be seen in Figure ( ), Jordan enjoys high insolation ranges especially in the south which make solar energy project economically viable

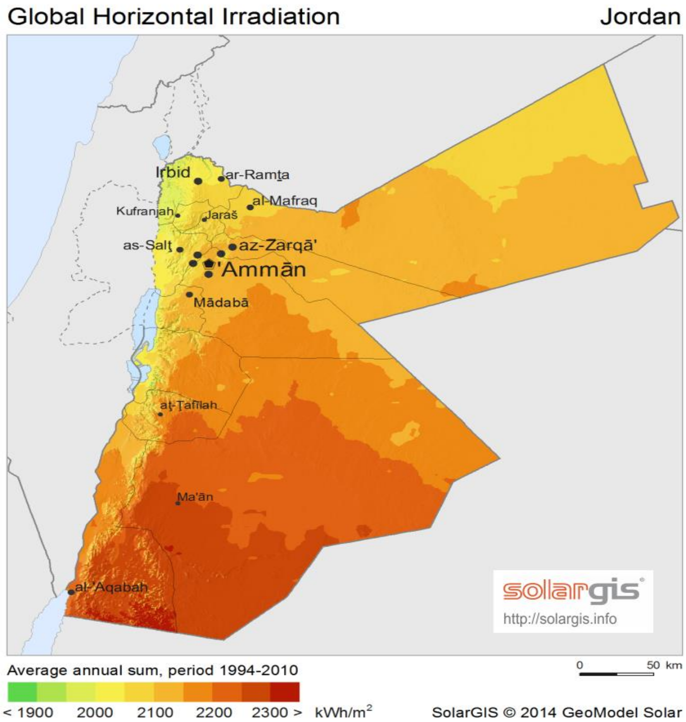
Potential of Applications

The recent increase in electricity tariff is significantly improving the economic viability of grid connected CSP applications. Sample applications are as follows

- Electricity production to support the grid
- Electricity supply in remote areas where there is no access to grid connection

CSP plants use approximately 4000 m2 of land per MW of installed capacity which is less than that of PV system.

As CSP can generate power all over the time, it provides better solutions for electricity network than PV.



Annual Global Horizontal Insulation in Jordan [38]

Financial appraisal

The average system cost is around 2 to 4 JD/kWp. Compared to other solar systems alternatives, CSP cost is relatively high and payback time is higher. However, the advantage of generating power all times may offset the drawback of the high system cost.

Maturity (operation, Reliability and safety)

CSP plants have been operating reliably for more than 15 years. Technologies are considered as mature and reliable. The health and safety risks associated with CSP power plants are the same for any power plant.

Challenges/Barriers

- High initial cost
- High payback time in comparison to other solar alternatives like PV
- Requires high DNI at the location of installation
- Water source is required at the location
- Flat land is required
- Connection to the grid and lack of transmission capacity is a challenge

Energy Savings Opportunities/ Environmental/climate change mitigation Benefits

Compared to fossil-fueled power plants, CSP power plants generate significantly lower levels of greenhouse gases and other emissions. CSP is clean, non-polluting, and has no carbon emissions that contribute to climate change.

Economic benefits

Although CSP cost is higher than the other solar system alternatives like the PV, CSP can be an option for replacing conventional power stations. .

Social benefit

Communities living at areas of installations can benefit from creating local jobs. A 50MW plant requires around 500 jobs during installation and 50 jobs d

[38]http://www.solargis.info

Annex 8 Prioritized Transport Sector Mitigation Technologies Fact Sheets

Technology: Rapid Transit System

Technology: Rapid Transit System	
Sector: Transport	
Subsector: Public Transportation	
Technology characteristics	
Introduction	Bus Rapid Transit (BRT) has increasingly been used to provide a faster, higher capacity bus service. BRTs require dedicated lanes, off-road stops, rapid boarding and alighting, level boarding, pre-board fair collection or checking, frequent service, large capacity, clear signage and real-time information displays, clean engine technologies, signal priority, intelligent control systems and excellent customer service. In one dedicated BRT lane 10-20,000 passengers can be carried – with some carrying over 40,000 – but at higher levels there is a risk of buses 'bunching' at stops. This problem can be reduced with multiple doors on the bus and well-designed stations, as occurs in Curitiba. Cities like Curitiba, Bogotá and Ottawa have examined moving to rail to solve this problem. There can also be problems with noise and emissions. BRTs can be cheaper if they take over a road lane, although this can be a difficult political issue in cities. Other cities with BRTs include Bogotá, Mexico City, Jakarta, Beijing, Kunming, Chengdu, Guangzhou, Istanbul, Ahmedabad (India), Paris, Los Angeles, Pittsburgh, Miami, Boston and Brisbane.
Technology characteristics/highlight	• Reduce the distance traveled using private vehicles by 85 million kilometers per year and the distance traveled using taxi by 12 million kilometers per year. • Each BRT bus can accommodate up to 150 passengers or equivalent to about 110 private vehicles • Waiting time between BRT buses (headway) will not exceed 90 seconds during peak periods • Reduce trip time from 1 hour 5 minutes to 30 minutes • clean engine technologies • clear signage and real-time information displays. • intelligent control systems and excellent customer service
Institutional and Organizational requirements	The development and implementation of the BRT was conceived as part of a comprehensive development plans to address the growing mobility problems in the cities with high population. The action plan for enhancing public transport development plan includes the following elements: 1-Create an effective institutional environment 2- Improve existing public transport services (i.e., for current users). This includes increasing the number of buses, implementing new specifications for buses (air conditioning, easy entry, electronic payment system), and installing new bus shelters and street furniture. 3- Develop and implement the core network, which consists of Bus Rapid Transit and Rail Transit along key corridors to provide alternative to cars.
Operation and maintenance	The operation of the system will be handled by a private operator to be selected through competitive bidding. The operator will be responsible for providing the buses, developing the depot, hiring and training drivers, as well as handling customer service functions. An effective ticketing system is essential for supporting the operations of the BRT. This is

	especially true for expediting passenger loading/unloading and reducing the bus dwell time at each station. It should be noted that the operation of the system can only take place after the completion of the infrastructure work. Construction work for the bus lanes also includes road work to alleviate current traffic congestion problems at some of the key intersections along the BRT routes.
Endorsement by experts	Worldwide BRT become common, over one hundred BRTs are being constructed in Latin America, Africa and Asia. BRTs are generally seen as an option with considerable potential in cities in the developing world, This guided the experts to endorse this technology to be implemented as it faces a great succeed in all the countries.
Adequacy for current climate	Transport sector is responsible of 41% of CO2 emissions in Jordan (National Electricity power company report 2011) 14 % goes for Public Transport (DEVELOPMENT OF LONG TERM NATIONAL TRANSPORT STRATEGY FOR JORDAN)
Scale/Size of beneficiary group	This technology is under the Public transportation sub sector, So we can consider it as public service that is affordable for the public in the targeted areas by this technology.
Disadvantages	• The absence of coordination between different sides and the difficulty of implementing such a system with possibilities of errors and reformulation processes. • The compatibility with the already existed built fabric is not guaranteed. • The need for well-designed infrastructure could be a constraint for the project success. • The lack of financial resources is one of the main barriers because of high initial cost with low interest of international sponsors to cover it.
Capital Cost	
Cost to implement adaptation technology	• The estimated cost for this technology to be implemented in Jordan is around 68 million JD, • In case of minor changes in the roads system, the investments range from $1.35 up to $ 3.5 million / km, and can increase to $4.8 - 8.2 million / km. Taking into account the needs of Chisinau, construction of about 50 km of road is needed which will require an investment of $ 2 million / km, or a total of $ 100 million. Taking into account that by 2030 the BRT system will take over 3.8 billion passenger-km, the investment per passenger-km will be $ 0.65 / one thousand passenger-km. Considering the technology lifetime of 40 years, and the required investment, the annual cost of investment is $ 2.5 million.
Development impacts, direct and indirect benefits	
Direct benefits	• Travel time saving • Increase public buses passengers capacities • Reduce traffic congestion on main roads.
Reduction of vulnerability to climate change/reduced emissions, indirect	• The change in carbon emissions is determined by the following equation: change in vehicle kms * liters of fuel burnt per km * carbon emissions per liter of fuel burnt • This equation considers the difference in kilometres between the 'with BRT' and 'without BRT' scenarios for all public transport modes (including BRT), as well as private vehicle and yellow taxi. • introduction of the BRT scheme removes a total of 114 million vehicle kilometers from the Amman transport network per annum

Economic benefits, Indirect Employment	Estimates for investment cost for BRT systems vary widely. Depending on the required capacity, urban context and complexity of the project, BRT systems can be delivered for $ 1 - 15 million per km (IPCC, 2007), with most existing BRTs in developing countries in the lower part of this range (ITDP, 2007). These figures are substantially lower than those for rail-based systems, which cost approximately $ 50 million per km (IPCC, 2007). Taking into account that by 2030 the BRT system will take over 3.8 billion passenger-km, the investment per passenger-km will be $ 0.65 / one thousand passenger-km. Considering the technology lifetime of 40 years, and the required investment, the annual cost of investment is $ 2.5 million.
Growth and Investment	GHG reduction costs - Taking into account the annual cost of $ 2.5 million investment + annual maintenance costs of 0.5 million in 2030 annual cost will be $ 3.0 million, reduction of 320 tons by 2030 with the cost of GHG reduction of $ 9.37 USD / ton CO2.
Social benefits (indirect benefits in Income, Education, and health)	• Mass transit's greater affordability, and its accessibility for people too young or unable to drive, makes it a form of transport that more people can use to meet their needs: to get to health and other services, to make vital social connections and, as just noted, to work, shop and learn. Thus it is a factor leading to greater equality and social inclusion. • Insure social equality and improve level of services provided for the middle and low-income families. • Poverty reduction by providing affordable high-quality transport • Reducing the number of accidents – the modal split towards more use of public transport for 25% of passengers would reduce the number of accidents by 20%.
Environmental benefits, indirect	The implementation of bus rapid transit can have at least six potential impacts on greenhouse gas emissions on a certain corridor: • Induced modal shift to BRT from more emission-intensive modes. • Increased fuel efficiency due to increase in mixed traffic speeds: significant increases in overall traffic speed can be achieved by removing many frequent stop buses. • Reduced vehicle kilometers travelled due to rationalized routes. • Increased fuel efficiency of buses due to improved transit vehicle speed. • Improved bus fuel efficiency of new buses and the scrappage of old buses. • Decreased auto trips due to the development of transit-supportive land.
Local context	
Opportunities and Barriers	Opportunities: • The BRT system plans and extensions could be the guideline for the upcoming urban spread. • The existence of such system helps to increase the integration and connect the city to wider ranges. • The opportunity to decrease the negative impact on the environment when going to sustainable transportation systems. Barriers: • Coordination to many stakeholders • How to influence national policy • Subsidy for operation • Bias against public transport from years of neglet
Market potential	It is assumed that by 2017, BRT systems will be one of the main factors of sustainable urban transport, capturing a share of 25% of all transport needs. This shift to BRT is expected to come from the buses (20%) and cars (80%). It is assumed that the new BRT buses will be fuelled using Compressed Natural Gas (CNG). CNG is measured in therms and BTUs (British Thermal Units),

	where: 1 Billion BTU = 10,000 therms. (Ref. AFD Study)
Status (National status of technology in Jordan)	The BRT corridors in Amman are not being designed in isolation. Rather, they are being incorporated into an integrated public transport network. For a user to get from their doorstep to their workplace, they may require more than just a BRT ride. This is why an extensive network of feeder services is being designed along with the BRT. Feeders will mostly be buses but may also include smaller vehicles. They are meant to carry users to the nearest BRT stop and will also provide a high-quality and frequent service that will minimize the time people have to sit and wait for the bus and offer a seamless travel experience.
Timeframe	
Acceptability to local stakeholders	It was already agreed by most of the local stakeholders in Jordan, This technology have got the highest rank as a most priority technology for the transportation mitigation sector.

Technology: Promote Cycling

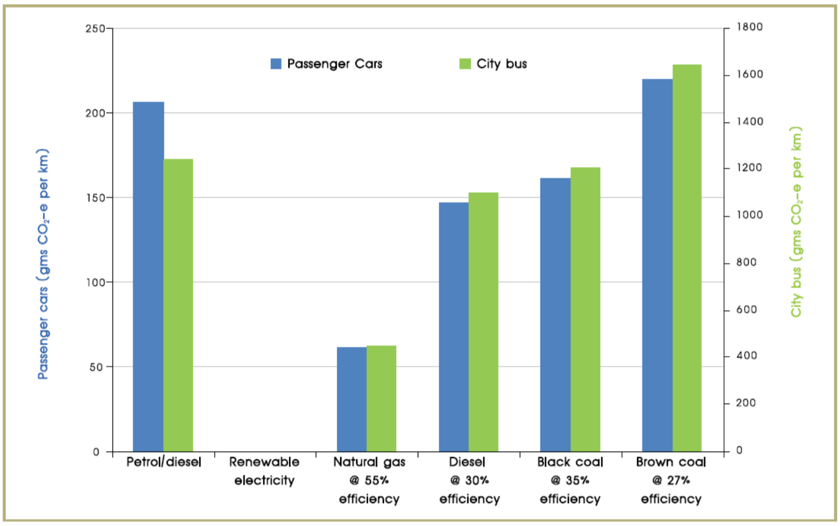
Technology: Promote Cycling	
Sector: Transport	
Subsector: Sustainable Transportation	
Technology characteristics	
Introduction	Cycling offers numerous advantages to its users and to society in general. These include affordability in terms of ownership and maintenance; health benefits; the need for very little space for movement and parking in comparison to motor vehicles; and minimal impact on the environment. Main Advantages of the technology that it can make an important contribution, not only to the transport system, but also to the environment, the economy and the social fabric of communities.
Technology characteristics/highlight	• Affordable for most community levels • Low maintenance needs • High accessibility to narrow roads and small areas. • Easy parking • Very low impact on the environment
Institutional and Organizational requirements	The infrastructure in Jordan is not ready yet to implement this technology, on the other hand this technology will solve a big problem by decreasing the traffic and reducing the cost of transportation, so it will be implemented as below phases: The Main Network: this network connects key city centers as well as its main educational and work areas with the most populated residential areas. It also connects with the secondary network. The Secondary Network: this network connects housing areas, parks, as well as facilities and centers of attraction with the main network. Complementary Network: this network links recreational areas and external routes to the system. These paths are located along the river banks, which in turn are part of a system of linear parks in the city
Operation and maintenance	Operation and maintenance for this technology is too simple, Even in urban areas there may not be anyone to fix the bicycle, or to do so at an affordable price. If cycling is to be a viable mode of transport for both rural and urban communities it is vital that they have access to affordable bicycle parts and maintenance.
Endorsement by experts	A number of developed countries have realized that cycling is a very efficient and feasible form of transport for short to medium distances. Where supported by governments and non-government organizations, cycling's popularity and its contribution to the overall transport system has greatly increased. This Technology is new to the Jordanian Market, So there is only few experts who really endorsing, at the same time most of stakeholders agreed that this technology is so important to be implemented in Jordan and it will solve some of the main transportation issues.
Adequacy for current climate	Most of the Jordanian streets are full of hells and slopes because of the mountains topography so this technology is not able to be implemented in most of the streets in Jordan, but it is necessary to be implemented in the flat parts of the main cities.
Scale/Size of beneficiary group	A bicycle provides high levels of personal mobility at very low cost, so this technology will be open for the public and anyone could be a beneficiary, but it needs a good health conditions to be used and only for short distance, this could limit the people who can use it.

Disadvantages	• Jordanian topography • Limited to the healthy people • Could be used for only short distances • Consumes time for transporting • Unsafe in the unprepared streets
Capital Cost	
Cost to implement Mitigation technology	Bicycling is an inexpensive and efficient form of transport compared with most other modes, particularly car use. As already noted, the cost of constructing cycle paths or lanes is about one-tenth of the cost of constructing roads. If included as part of the design for a new or upgraded roadway the cost will be a small fraction of the total cost of the roadway. Providing cycling lanes on existing roads can be cheaply done when resealing or restriping roads as part of regular maintenance.
Development impacts, direct and indirect benefits	
Direct benefits	• Access to markets: Bicycles can transport small freight loads over short distances at little or no cost, allowing small subsistence farmers and traders to access markets and customers affordably. • Reduced reliance on fossil fuel: Increased use of bicycles reduces reliance on crude oil, which most countries must import. • Higher worker productivity: It has been demonstrated that cycling to work leads to better attention levels, higher productivity and reduced absenteeism. • Greater economic inclusion: Because of its affordability, cycling gives more people access to jobs, education and services.
Reduction of vulnerability to climate change/reduced emissions, indirect	A bicycle emits no greenhouse gases or local air pollution when operated and far less than a car when manufactured. A two kilometer bicycle trip saves 419 grams of CO_2 (e) if it replaces a car trip, although there are some emissions generated in the production and distribution of bicycles.(TNA Guide book)
Economic benefits, Indirect Employment	• Transport efficiency: cycling and walking are the most space efficient transport modes for short trips. Bicycles need less than a third of the space cars need to transport the same number of people. • High benefit to cost ratio from investment in facilities: the cost of building facilities for cyclists is small, compared to those for cars, but the economic benefit can be significant. Benefits include reduced road infrastructure, congestion and pollution; improved road safety for pedestrians and cyclists; and savings in private and public transport running costs. • Reduced reliance on fossil fuel: Increased use of bicycles reduces reliance on crude oil, which most countries must import. • Higher worker productivity: It has been demonstrated that cycling to work leads to better attention levels, higher productivity and reduced absenteeism. • Greater economic inclusion: Because of its affordability, cycling gives more people access to jobs, education and services.
Growth and Investment	Cycling industry can grow in many investment areas including bicycle production, tourism, retail, infrastructure and services, this will employ more people than many other industries.
Social benefits (indirect benefits in Income, Education, and health)	• Good life: The more we flock to high-status cities for (money, opportunity, novelty), the more crowded, expensive, polluted, and congested those places become, surveys show that Londoners are among the least happy people • Affordability: A bicycle provides high levels of personal mobility at very low cost. • Equity across localities: Cycling can provide high levels of personal mobility for negligible cost in dispersed settlements, including rural or peri-urban areas, where population densities make public transport economically less viable.

	• Health: Physical inactivity results in increased health problems such as obesity, heart disease, diabetes, stress and high blood pressure. Cycling increases physical activity levels and reduces the economic cost of health problems
Environmental benefits, indirect	• Emissions: a bicycle emits no greenhouse gases or local air pollution when operated and far less than a car when manufactured. • Noise and congestion: bicycles are far quieter than motor vehicles and take up less space. Electric bikes have similar advantages. • Sprawl: By requiring less road space and by reducing the average length of trips, cycling contributes to urban consolidation.
Local context	
Opportunities and Barriers	Safety: Busy arterial roads are often the main impediment to cycling. Removing safety risks to cyclists within the road corridor, or providing high standard alternative routes can greatly increase levels of cycling. Cyclists need to be protected from other vehicles travelling on the same road, and from other vehicles at intersections. Jordan topography: Jordan (especially Amman) is full of steep hills needs extra efforts to ride throw; this will limit the bike users and roads to ride on. Gender Biases: The majority of Jordanians refuses female cycling on roads because of their culture.
Market potential	There is some available bike suppliers and renters, they also provide cycling training, but those suppliers still limited due to the limited use of cycling , on the other hand there will be a good market transformation toward cycling promotion if an efficient transport lows are implemented talking into account providing efficient infrastructure for cycling.
Status (National status of technology in Jordan)	There is no available infrastructure or laws that help the use of this technology in Jordan.
Timeframe	
Acceptability to local stakeholders	This technology is accepted by most of the stakeholders but at the same time strongly refused by others as their opinion was that the infrastructure in Jordan could not be adapted to host new lanes for the bikes.

Technology: electric vehicle (EV)

Technology: Electric Vehicles	
Sector: Transport	
Subsector: Making Current Modes Low Carbon	
Technology characteristics	
Introduction	An electric vehicle (EV) uses one or more electric motors for propulsion, powered by electricity generated off-board the vehicle. Electric vehicles can include electric bicycles, electric motorcycles and scooters, electric cars, electric trucks, electric buses, electric trams and trains, and even electric boats and aeroplanes. However, this section focuses predominantly on private electric road vehicles (two, three and four-wheelers). the other hand we have a plug in hybrid electric vehicle (PHEV) which is a hybrid electric vehicle with the ability to recharge its energy storage with electricity from an off-board power source such as a grid. (Pesaran et.al, 2009) The PHEV can run either on its Internal Combustion Engine (ICE) or on its battery. Increased concern over the environmental impact of petroleum-based transportation, along with the looming economic impacts of peak oil, has led to a significant boom in the development of electric vehicles.
Technology characteristics/highlight	• they can be recharged with electricity produced from local sources • they potentially offer very low running costs in terms of energy use and maintenance • they produce no direct tailpipe emissions during operation, offering significant air quality benefits • they are more easily manufactured locally • they offer a truly carbon-neutral transport solution when recharged from renewable sources.
Institutional and Organizational requirements	Governments will recognize the need to regulate the EVs. Regulations and standards can be required for a number of reasons, such as vehicle safety and fleet monitoring. However, experience shows that unregulated electric vehicle deployments can often hamper market development. For example, the Bangladeshi experience has shown how regulatory authorities can become annoyed by electric vehicles as a “nuisance” unregulated vehicle category, and in other markets (such as some Chinese cities) demand has been stifled as a result of perceived hazards from unsafe vehicles. It is generally considered best practice to create a regulatory and standards framework for the initial deployment of the new technology, and then work with all stakeholders to implement and evolve this framework as more experience is obtained.
Operation and maintenance	The mechanical simplicity of electric vehicles also brings greater reliability, which translates into reduced maintenance requirements and costs. This means less expense for the user, better operation in the absence of routine maintenance, and less chance of the vehicle breaking down due to lack of maintenance. Compare this with petroleum vehicles that typically require frequent maintenance – which can be expensive and require skilled mechanics – and if this is not carried out they can become unreliable or break down.
Endorsement by experts	Electric vehicles have a bright future in a low-carbon world. They are efficient, quiet, non-polluting at their point of use, economical to run and the power to operate them can be obtained from many sources, including 100% renewable energy. EVs are currently experiencing a massive surge in their popularity, but the technology still requires a number of issues to be addressed for true mass-market uptake, such as vehicle affordability, range and recharging infrastructure
Scale/Size of beneficiary group	Anyone can be benefited from this technology, but it is not affordable for all as it have high cost.
Disadvantages	some significant remaining barriers to the widespread use of electric vehicles for private transportation, which include: • The availability of recharging infrastructure to provide adequate utility

	• The cost of electric vehicles – in particular the cost of their batteries.
Capital Cost	
Cost to implement Mitigation technology	As a general rule, electric vehicles cost approximately 2-3 times as much as an equivalent combustion vehicle. For example, the electric Nissan Leaf currently sells in America for US$32,780 compared to the equivalent Nissan Sentra SL that costs only US$18,850. Private electric vehicles will normally be financed by individual motorists and the upfront cost can pose a significant barrier to their uptake. However, where they can be afforded, electric vehicles provide a number of compelling financial and environmental benefits to justify the investment of both private and public funds
Development impacts, direct and indirect benefits	
Direct benefits	
Reduction of vulnerability to climate change/reduced emissions, indirect	The greenhouse gas reduction potential of electric vehicles depends on the source of electricity for charging, below chart shows the CO2 (e) Produced per Km for both Cars and buses depending on source of energy used to generate the electricity for charging the EV. **Figure 3.43 Relative greenhouse gas emissions for petroleum vs. electric vehicles**[17] 
Economic benefits, Indirect Employment	**Energy Resilience**: Electric vehicles differ from petroleum-powered vehicles in that the electricity they consume can be generated from a wide range of sources, including fossil fuels, nuclear power, and renewable sources such as solar, wind or biomass, or any combination of these, and most countries have such a combination. **Use of existing infrastructure**: Electricity for transport can be distributed via established electrical infrastructure and transferred to the vehicle through overhead lines, wireless inductive charging, or a direct electrical cable connection. **Energy efficiency**: The electricity for an electric vehicle is typically stored onboard the vehicle using a battery, flywheel, or super capacitor with very high energy efficiency. **Local industry development**: Compared to petroleum propulsion, electric-vehicle systems can be highly modular and mechanically very simple (in many cases they include only a single moving part – the motor).
Growth and Investment	In developed-world markets, automakers are now launching a new generation of high-performance electric passenger cars to capitalise upon the latest technology.2 However, electric vehicles have been in use for over a century and the technology is available in many different forms that cover the full spectrum of size, performance and cost.
Social benefits (indirect benefits in Income,	**Low operating costs**: While the purchase cost of electric vehicles must be addressed if they are to be broadly available across income groups, they are very economical to run.

Education, and health)	**Employment opportunities:** The possibility of local production of electric vehicles, as well as local retrofitting, creates opportunities for local employment, and this can have a multiplier effect and create further employment in the communities concerned. **Reduced effects of pollution**: Electric vehicles generate no local pollution and are very quiet, both of which lead to major benefits for the health and wellbeing of urban populations.
Environmental benefits, indirect	**Less pollution**: Electric vehicles emit no direct tailpipe CO2 or other toxic air pollutants (such as carbon monoxide or particulates) during their operation. Pollution may be produced from the electric power generation used to recharge the vehicles, but it is typically easier to build pollution control systems into centralized power stations rather than retrofit enormous numbers of cars. **Carbon neutral transport:** Electric vehicles can be recharged with renewable electricity, thus enabling their operations to be truly carbon-neutral
Local context	
Opportunities and Barriers	**Barriers** • The availability of recharging infrastructure to provide adequate utility • The cost of electric vehicles – in particular the cost of their batteries. Opportunities • Big support from the government • Free tax and customs
Market potential	Electric vehicles can be found around the world; In developed-world markets, automakers are now launching a new generation of high-performance electric passenger cars to capitalize upon the latest technology
Status (National status of technology in Jordan)	The Government of Jordan is supporting in motivating the citizens to owning the EV by Taxing and costume freeing, and the market of it is too promising and getting bigger day by day.
Timeframe	
Acceptability to local stakeholders	This Technology is highly supported by stakeholders but the only concern is the high costs of it.

Technology: Public Transportation Maximization

Technology: Public Transportation Maximization	
Sector: Transport	
Subsector: Public Transportation	
Technology characteristics	
Introduction	Public Transportation Maximization could by occur by developing the whole Public transportation system with providing an integrated transport management systems include GPS based optimization of public transport, computerized traffic signalling, information systems such as e-ticketing, e-information etc. Such systems increase the reliability, safety, efficiency and quality of public transport systems. An increase in the efficiency of the transport system also leads to a reduction in associated GHG emissions.
Technology characteristics/highlight	• Improving road network management, including public transport pricing. • Improving road safety, by reducing collisions, casualties and deaths. • Better travel and traveller information, helping to match supply and demand by providing better information so that travellers can make informed choices on when and how to travel. • Better public transport on the roads, supporting more reliable, more accessible, safer and more efficient services. • Supporting the efficiency of the road freight industry. • Reducing negative environmental impacts
Institutional and Organizational requirements	To Maximize the usage of public transportation we need to apply Town planning and transit oriented developments (TODs), Transit oriented developments are areas of new development around BRT and train stations that feature higher density residential complexes and a mix of other land uses, for example, shops, workplaces, educational institutions, health facilities and other services, as well as good walking and cycling paths. TODs can reduce car use by around fifty percent, save money on infrastructure, and encourage community interaction. TODs can occur where there are 'greenfield' (new) sites 'brownfield' (old industrial) sites or 'greyfield' sites (redeveloped old housing areas). TODs should include a range of housing types, including affordable housing for those on low-incomes. The increased value of TOD properties can be used to help fund the mass transit system, a process known as 'value capture' that is discussed below (and TODs are described in more detail in another section of this chapter).
Endorsement by experts	The idea of maximizing the public Transportation needs an integrated efforts between infrastructure and the Public Transportation Management System, the potential of applying this needs a huge amount of efforts and funding
Adequacy for current climate	The streets infrastructure in Jordan can not incur the rapid growing in the number of private cars, and the main solution for this is to maximize the using of public transportation
Scale/Size of beneficiary group	Public Transportation is the most affordable Transportation method for the public, so my improving this services all of the public will be benefited.
Disadvantages	• High Coast • Variety of activities and actions

Capital Cost	
Cost to implement Mitigation technology	Cost of setting up an effective public transportation management system varies greatly. It depends on what is infrastructural developments need to be made, over what area or length of road or pathway as well as the degree and type of changes necessary. Some of the major costs incurred are for alterations to roads for traffic calming, creation of dedicated, lanes for buses and bikes, better controls and safety at intersections, driver education, and stronger enforcement.
Development impacts, direct and indirect benefits	
Reduction of vulnerability to climate change/reduced emissions, indirect	Using Public Transportation increases the efficiency of the transport systems leading to a reduction in associated GHG emissions. It also has a supporting role for the successful implementation of transport emission reduction strategies such as low-carbon fuels, energy efficient vehicles, public and non-motorised transport, mostly by supporting a more efficient organization of the public transport system.
Economic benefits, Indirect Employment	- A better public transport system directly results in fuel savings thereby reducing dependence on import of fuel - The cost of additional transport infrastructure (e.g. new roads, flyovers) could be avoided
Social benefits (indirect benefits in Income, Education, and health)	- Social equality and poverty reduction by providing affordable high-quality transport - Reducing the number of accidents – the modal split towards more use of public transport for 25% of passengers would reduce the number of accidents by 20%.
Environmental benefits, indirect	As well as using less energy and emitting less greenhouse gas than private vehicles do, public transportation has many other environmental benefits. As just noted, much larger numbers of people can be transported within a given space and period of time than private vehicles can transport, and this contributes to higher densities.
Local context	
Opportunities and Barriers	Opportunities • New big scale projects that emphasize the public transportation. • Huge investments on the public transportation sector Barriers • Poor infrastructure • High public transportation recent costs
Status (National status of technology in Jordan)	
Acceptability to local stakeholders	Stakeholders in general are emphasizing the usage of the Public transportation as an alternative of using private cars to reduce the carbon foot print and to provide affordable transportation methods for the public.

Technology: Ticketing System Public Transportation

Technology: Ticketing System Public Transportation	
Sector: Transport	
Subsector: Public transportation	
Technology characteristics	
Introduction	Ticketing is a tool for the implementation of a pricing policy with the consideration of operational, commercial and social objectives. The ticketing system is the translation of fares into concrete means of payment (for the passenger) and fare collection (for the operator). In public transport, e-ticketing systems are not only means of payment but process huge amount of information which offer a large range of possibilities to make public transport easier to use, to manage and to control. They offer as well opportunities to introduce integrated pricing structure that are not easy to implement with traditional payment tools.
Technology characteristics/highlight	• Convenience & speed, no cash • Seamless journeys in multimodal, multi PT schemes • Easier ways to reload value or renew passes • New card when it has been lost or stolen • Additional appreciated services when available
Institutional and Organizational requirements	• The fare levels and structure • The ticketing spectrum • The possibilities for integration • The ticketing technology • The interoperability issue • The business case • The business model • The clearing mechanisms • The exploitation of data
Operation and maintenance	It is commonly assumed that the implementation of ticketing system will reduce operation and maintenance costs related to ticketing compared to a traditional system.
Endorsement by experts	Transportation Experts in Jordan have studied the need for efficient ticketing system for public transportation in Amman, and they have applied this system on the "Citybus" that is controlled by Greater Amman Municipality, and this system found acceptance from local experts.
Adequacy for current climate	The infrastructure for this technology is not fully mature to be implemented in Jordan because the infrastructure of the public transportation is not very well developed and there is a huge gaps and missing in integrating the diverse of the public transportation modes.
Scale/Size of beneficiary group	The ticketing system will be limited to passengers with daily use of public transportation; other users would prefer the traditional fares system due to their limited use of public transportation.

Disadvantages	Possible over-costs related to standardization of new equipment
Capital Cost	
Cost to implement adaptation technology	It is not easy to estimate the overall cost of the implementation of ticketing system in a public transport network because such assessment must be carried out on the whole life cycle cost of the system in order to cover investment, operation and maintenance related costs. On the other hand, if it is commonly admitted that e-ticketing schemes have a positive impact on the image and the use of public transport, quantifying the impact is not obvious in particular when the introduction of ticketing is accompanied by a change in the fare structure or is integrated in a wider project aiming at modernizing the network. Nevertheless, it is possible at least to know the amounts invested directly linked to the e-ticketing system. For example, the Ez-Link ticketing system of Singapore had a total investment of €150 million which comprises the on-board equipment of 4,000 buses, 1,100 gates at metro stations and the installation of 400 ticket vending machines as well as the central clearing house.
Development impacts, direct and indirect benefits	
Direct benefits	• Prevention of fraud • Fare flexibility • Improved multi-modal and multi-operator integration especially where method of operation requires accurate allocation of fares to private operators. • Speed of passenger throughput – though this varies by mode • Improved passenger convenience and ease of use • Efficiency savings • Ability to pay for other services with the same card • Improved information for transport planning • Improved image for public transport
Reduction of vulnerability to climate change/reduced emissions, indirect	The use of ticketing system will encourage citizen to use public transportation as the main transportation alternative for their daily use, and this will minimize the number of private cars used, which the considered as the main contributor for CO_2 emissions, by moving toward using an efficient ticketing system CO_2 emissions will be reduced accordingly.
Economic benefits, Indirect Employment	The cost and benefits in the table below shows the importance of this technology

Costs	Benefits
Capital costs: e.g., for buying or upgrading equipment and infrastructure	Reduced administrative costs through automation of manual processes: fewer cashiers needed, reduced fare-processing time, better passenger throughput in high-demand areas
Operating costs: maintenance and replacement	Reduction of fraud resulting from cash handling and fare evasion
Additional costs: e.g., for training staff to use and handle new technology or campaigns to inform users about new technology, costs for resolving passengers disputes (especially in the first year of operation)	Better price differentiation, e.g. flexible fare structure depending on the mode and time of the day
Costs for outsourcing clearinghouse functions for the fare and data collection system, for marketing and distribution	Better transport statistics for planning purposes and thus for a better exploitation of the network capacities
	Multi-application potential for a better integration with other services
	Reputation as a modern enterprise

Growth and Investment

There are different business models which could be adopted for the development and implementation of e-ticketing systems in public transport networks. They depend on the organization of public transport in the concerned area (single mode or multimodal network, one operator or more and the weight of each operator) and the degree of risk that the organizing authority and the operators are willing to take in this field.

In one of the case studies from the Norwegian City of Trondheim, a profitability study shows the results in below table that bring a big evidence of its profitability.

Parameter	Value*
Investment costs	$2,400,000
Operating costs per year	$900,000
Annual service and maintenance costs	$200,000
Reinvestment costs (every three years)	$1,400,000
Project costs (before implementation)	$1,400,000
Total number of bus trips per year	17,300,000
Share of trips performed with the t:card	70% in 2008, 80% in 2009, 90% thereafter
Annual increase in the number of bus trips	2.5%
Average time saving per t:card transaction	6.8 seconds
Average load factor	20
Time value for bus passengers	12.5/hour
Time value for bus company	65.9/hour
Discount rate	4.5%
Appraisal period	10 years
Marginal cost of public funds	20%

**U.S dollars—values based on exchange rate of August 15, 2011*

Social benefits (indirect benefits in Income,

- Low operating costs
- Reduced health effects of pollution

Education, and health)	• Increase time efficiency • Reduction or elimination of survey costs • Reduction or elimination of survey costs In most cases, ticketing System for Public Transport is made possible by electronic ticketing technologies such as magnetic stripe cards or smart cards. Some smart card systems are also used for paying for goods and other services. Some public transport systems also use paper cash tickets that allow transfers within a specified area, and in some cases allow unlimited travel during specified times.
Environmental benefits, indirect	The Ticketing System will develop the public transport and increases its efficiency, that will motivate the people to use it instead of their own vehicles, the daily using of Public transportation is reducing energy consumption and harmful carbon dioxide (CO2) greenhouse gas emissions that damage the environment. To make progress in reducing our dependence on foreign oil and impacting climate change, public transportation must be part of the solution. Transport related air pollutants that most affect health include small particulate matter (PM10 and PM2.5). Road transport is also an important source of carbon monoxide (CO), oxides of nitrogen (NOx), ground-level ozone and benzene.
Local context	
Opportunities and Barriers	Challenges/Barriers • Lake of management for the public transportation in Jordan. • Vulnerable infrastructure for the public transportation. • Limited modes of public transportation to (Buses, Wight Taxies, Taxies). • Mental maturity and lake of awareness of the importance of the Public transportation. Opportunities • Excised experience
Market potential	The infrastructure for this technology is not fully mature to be implemented in Jordan because the infrastructure of the public transportation is not very well developed and there is a huge gaps and missing in integrating the diverse of the public transportation modes.
Status (National status of technology in Jordan)	In Jordan ticketing system is already used in one of the main companies (Citybus) but still not well activated and limited to some lines, this technology is mainly focusing on integration between all public transportation service and lines so it is easy to be applied, efforts by the Ministry of Transport are focused on have a planes to develop this service.
Timeframe	
Acceptability to local stakeholders	The ticketing system is locally recommended and used widely, as it will solves many issues related to the traditional fares systems.

Technology: Walkable locality	
Sector: Transport	
Subsector: Increasing Use of Low Carbon Modes	
Technology characteristics	
Introduction	The Walkable locality is a package of practices and technologies that enable cities and towns the world over – in developing and developed countries – to become urban communities of the future: communities that are better functioning, safer, more sustainable, better connected, more inclusive, healthier and more attractive. Walkable localities have networks of well-designed, well-connected walkways that enable people to get to their destinations or to public transit safely, pleasantly and without delay. This section outlines the concept of a walkable locality, and explains how it can be achieved.
Technology characteristics/highlight	Better functioning, Safer, More sustainable, Better connected, More inclusive, Healthier More attractive. Depends on human energy.
Institutional and Organizational requirements	In transport planning the needs of pedestrians are often ignored because there may be quite separate planning processes for different transport modes, and in most cases no one government agency has particular responsibility for pedestrian travel. There is thus a need for transport master plans that integrate all modes of transport, including walking, in planning processes. Bogotá's master plan, for example, stipulates that priority should be given to pedestrians.28 Such planning should include an explicit commitment to the provision of walkways that allow safe and fairly direct walking between any two points in a city.
Endorsement by experts	It was clear that the walkable localities is an important mitigation technology as it is a good alternative from the motorized vehicles, and it could be implemented in all countries and cities especially that it needs a very low running cost.
Adequacy for current climate	This technology is Adequate in the crowded cities and also in small villages where most of the services are close together. High density urban areas encourage pedestrian travel, because destinations – such as shops, workplaces, homes and transit stations - are likely to be closer and therefore easier to walk to.
Scale/Size of beneficiary group	The beneficiaries of this technology are the healthy and med aged people who can walk to their destinations.
Disadvantages	• Time consuming • It becomes hard in midsummer or winter. • Can't be used for long distance • Needs a good health conditions from the beneficiaries
Capital Cost	
Cost to implement Mitigation	Improvements to pedestrian facilities can also be achieved at low cost, relative to other transport developments. Costs will vary greatly depending on the length and width of walkways, the extent of upgrading that is necessary, the kinds of road crossings put in place, the surfacing materials

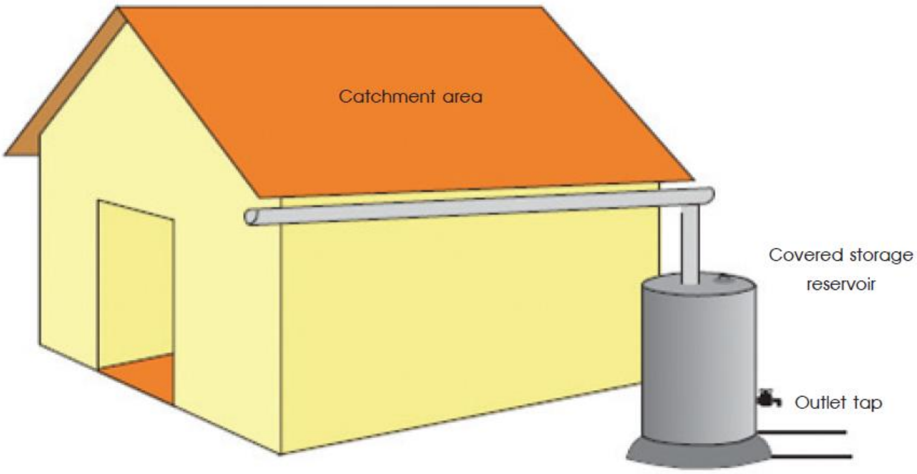
technology	used, and a range of other factors. But in general, walkways cost only a small fraction of the cost of roads, and they can even be created with paint on pavement.
Development impacts, direct and indirect benefits	
Reduction of vulnerability to climate change/reduced emissions, indirect	Once walkways are in place, walking as a mode of transport produces no greenhouse gas emissions at all. A walking trip of 2 kilometres (a very feasible distance) reduces greenhouse gas emissions by 419 grams of CO_2 (equivalent) if it replaces a car trip.
Economic benefits, Indirect Employment	Good walking facilities can save time and money. Most trips – even those in private vehicles – involve some walking. Given that walking is a slower mode of travel, indirect routes resulting from a lack of walkways and crossings, and very slow walking speeds caused by congested walkways, represent a major loss of time and therefore a significant economic cost to individuals and cities of developing countries. This can lead people to choose motorized vehicles instead, but for middle and lower income families, the cost of such vehicle travel can eat up a large proportion of family income or important trips may not be taken because they are too expensive.
Social benefits (indirect benefits in Income, Education, and health)	Walking promotes physical and mental health. It reduces or prevents obesity, cardio-vascular disease, diabetes, depression and sleep disorders. As people switch from cars or motorbikes to walking, cycling and mass transit, asthma and other respiratory diseases aggravated by motor vehicle pollution are also reduced.
Environmental benefits, indirect	As stated earlier, walking produces no greenhouse gases and is completely non-polluting. Good walking facilities encourage and enable people to use mass transit, and every person who walks or uses transit instead of using a conventional car or other motorized vehicle reduces the production of pollutants, greenhouse gases and noise, and helps to conserve the world's non-renewable resources.
Local context	
Opportunities and Barriers	Walkways need to be free of obstacles, which can force walkers onto dangerous roads, slow them down, or deter them from walking altogether. Such obstacles include parked vehicles, street traders, animals, piles of rubbish, shanty dwellings, poles, signs, and building or road-repair materials
Market potential	The core of a walkable city is a well-functioning network of walkways. This should allow everyone in urban areas to walk wherever they want to go safely, pleasantly and fairly directly. The following considers in broad terms what this entails and how it can be achieved, but governments and city leaders wanting to improve walkways in particular localities may want to use a walkability auditing tool.
Status (National status of technology in Jordan)	
Acceptability to local stakeholders	The stakeholders accepted the general idea of this technology with the concern of the topography of the main cities while is full of hells and slopes that will be an obstacle by itself. On the other hand they confirmed about the positive environmental impacts of it.

Annex 9 Prioritized Water Sector Adaptation Technologies Fact Sheets-Jordan

Technology: Rooftop Rainwater Harvesting	
Sector: Water	
Subsector: Water management for efficient use of water resources	
Technology characteristics	
Introduction	It is well known, especially in arid and semi-arid ecosystems, that the overwhelming majority of precipitation that falls on earth ground and on human settlements is lost to the atmosphere through evapotranspiration, or runs into rivers away from settlements before it can be used. However, if the rain is collected using appropriate infrastructure, it can contribute greatly to the volume of freshwater available for human use. This is particularly relevant in arid and semi-arid regions (like Jordan), where the little rainfall received is usually very intense and often seasonal (Elliot et al 2011). Rainwater harvesting (RWH) is the accumulating and storing of rainwater for reuse before it reaches the aquifer. Rooftop catchments is the most basic form of this technology and include collection of rainwater in gutters which drain to the collection vessel through down-pipes constructed for this purpose, and/or the diversion of rainwater from the gutters to containers for settling particulates before being conveyed to the storage container for the domestic use (Pacey & Cullis, 1986). As the rooftop is the main catchment area, the amount and quality of rainwater collected depends on the area and type of roofing material. RWH is popular as a household option as the water source is close to people, so it is convenient and requires a minimum of energy to collect it. An added advantage is that users own, maintain, and control their system without the need to rely on other members of 'the community' or other stakeholders. This fact sheet focuses primarily on RWH from residential rooftops for potable and other household uses. RWH for schools and other institutions follows the same general principles and generally benefits from economies of scale when serving large populations. Excess institutional roofwater can also be used to meet residential supply in some settings. RWH for solely non-potable use is also covered briefly. This includes a brief introduction to household dual piped systems that utilize harvested rainwater[39].
Technology characteristics/ highlight	• RWH is widely practiced in many countries worldwide. Over 60 million people were using RWH as their main source of drinking water in 2006 and that number is projected to increase to more than 75 million by 2020[40]. • The increased proportion of hard (e.g. metal or tile) roofs and the availability of metal and plastic for conveyance have decreased the cost of implementing household rainwater harvesting (RWH). • In most developing country settings, RWH is used to collect water for potable and other household uses. In wealthier regions with safe and reliable piped supply, it is typically collected for non-potable uses, including irrigation of landscapes (lawns and gardens), toilet flushing, and washing clothes. • The range of RWH options that are relevant in a given setting depends on the quality, cost, and sustainability of other residential water supplies, precipitation patterns, household income, and other factors. • A simple model indicates that the technology is favorable where the average design-rainfall is about 400 millimeters per year and the losses are about 20%. • A basic household RWH system is illustrated in the figure below: • The salient features of rooftop RWH systems include: (1) a catchment surface where precipitation lands; (2) a conveyance system of gutters and pipes to transport and direct the water; and (3) containers to store the water for later use Incorporating water quality protection adds one or more additional elements to system. Water quality can be protected by adding one or more of the following: filtration/screening, chemical disinfection, or a “first flush” system. First flush systems discard the

39 Elliot, M., Armstrong, A., Lobuglio, J. and Bartram, J. (2011). Technologies for Climate Change Adaptation—The Water Sector. T. De Lopez (Ed.). Roskilde: UNEP Risoe Centre.

40 WHO and DFID (2010) “Vision 2030: The Resilience of Water Supply and Sanitation in the Face of Climate Change.” http://www.who.int/water_sanitation_health/publications/9789241598422_cdrom/en/index.html

	initial volume of a precipitation event in order to protect water quality. It has been suggested that, as a rule of thumb, contamination is halved for each mm of rainfall discarded.[41] • Incorporating collected rainwater into the piped system of a residence or other building greatly increases both the expense and the expertise required.  *Source: Modified from UN-HABITAT* 
Institutional and organizational requirements/ knowledge/capa city building requirements	• Basic RWH involves collection, management and use by individual households and there are few if any institutional requirements needed. However, storage containers usually show strong economies of scale. Therefore, groups of households can often benefit by directing rainfall to one or more large, shared storage containers. • In developed regions, RWH for landscape irrigation is likewise driven by individual households. Guidance for establishing and designing these systems is available online at (Waterfall, P.H. (2006) "Harvesting Rainwater for Landscape Use" Second Edition. University of Arizona http://cals.arizona.edu/pubs/water/az1344.pdf).

[41] Martinson, D.B. and Thomas, T. (2005) Quantifying the first flush phenomenon. In: 12th International Rainwater Catchment Systems Conference, Nov 2005, New Delhi, India.

	• If RWH for piped dual systems is to be promoted, plumbing standards and building codes must often be modified. Many national and provincial governments have established codes and standards. Some of these are publically available[42,43] • RWH from rooftops into storage containers has been continuously practiced in parts of Africa and Asia for thousands of years[44]. In societies where RWH is a common part of water practices, simple household RWH can be practiced effectively with little training or capacity building; local supply chains for storage containers and other system components should be in place. • However, some training for households, especially related to protecting water quality (e.g. first flush methods, filtration) and budgeting rainwater are likely to lead to improved outcomes. • When establishing RWH in an area where it is not commonly practiced, significant capacity building is likely to be necessary. The most challenging aspects are likely to be generating sufficient demand for a self-sustaining industry and establishing supply-chains. However, most RWH hardware is not very specialized. Acceptable materials for storage and conveyance systems can be found in practically any city worldwide. • Some guidance on implementing new RWH programs is available in the references[45]. In contrast to simple systems, RWH for household dual piped systems requires professional plumbers who are trained to install such systems.
Operation and maintenance	• Operation and maintenance consists primarily of simple cleaning and basic repairs.
Endorsement by experts	• Endorsed under certain conditions: • Before implementing a basic household RWH program for potable use, three questions must be answered in the affirmative. These have been modified slightly from Thomas and Martinson (2007)[46] 1. Is current water provision thought by some householders to be seriously inadequate in quantity, cleanliness, reliability or convenience? 2. Is there an existing capacity to specify and install RWH systems in the area, or could one be created in a suitable time? 3. Is there adequate hard roofing area per inhabitant? This decision should be based on the planned use of rainwater (e.g. sole source of water all year, potable water only during the wet season), tank size, and average precipitation. • Specific parameters are available from Thomas and Martinson (2007)[47]. If these three questions cannot be answered "Yes," RWH may not be suitable.
Adequacy for current climate	The technology is adequate for current as well as future climate specially in light of projection results of climate models which predicted reduction in precipitation rates up to 15-20% until 2100, which makes every drop of water counts.

42 International Association of Plumbing and Mechanical Officials (2010) "California Plumbing Code" http://www.iapmo.org/Pages/californiaplumbingcode.aspx

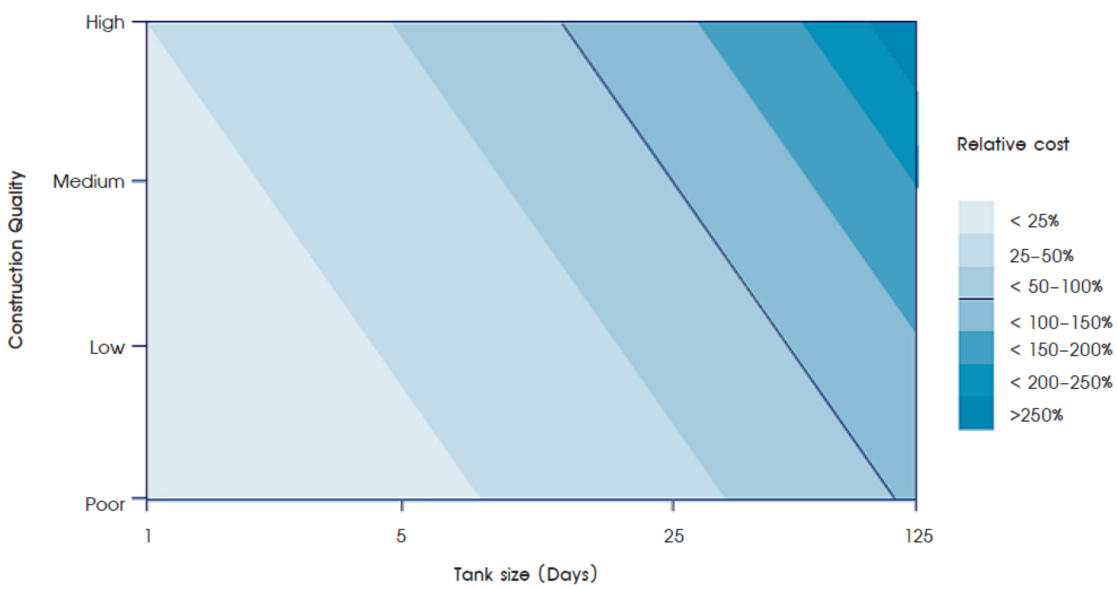
43 Nolde, E. (no date) Regulatory framework and standards for rainwater harvesting and greywater recycling. Germany. Accessed on Oct. 15, 2010. http://www.medawater-rmsu.org/archive/projects/ZER0-M%20project/reports/15%20Water%20regulations/Standards%20and%20Regulatory%20Framework.pd

44 United Nations Environmental Programme-DTIE-EITC/ Sumida City Government/People for Promoting Rainwater Utilisation. (2002) "Rainwater Harvesting and Utilisation An Environmentally Sound Approach for Sustainable Urban Water Management: An Introductory Guide for Decision-Makers" http://www.unep.or.jp/ietc/publications/urban/urbanenv-2/index.asp

45 UNESCO, Institute for Water Education (2010) IWRM as a Tool for Adaptation to Climate Change. http://www.cap-net.org/sites/cap-net.org/files/CC&%20IWRM%20_English%20manual_.pdf Accessed 25 January 2011

46 Thomas, T.H. and Martinson, D.B. (2007) "Roofwater Harvesting: A Handbook for Practitioners" IRC International Water and Sanitation Centre. Technical Paper Series; no. 49. Delft, The Netherlands Available from http://www.bvsde.paho.org/bvsacd/cd67/Roofwater/content.pdf

47 Thomas, T.H. and Martinson, D.B. (2007) "Roofwater Harvesting: A Handbook for Practitioners" IRC International Water and Sanitation Centre. Technical Paper Series; no. 49. Delft, The Netherlands Available from http://www.bvsde.paho.org/bvsacd/cd67/Roofwater/content.pdf

Scale/size of beneficiary group	It could be applied for one dwelling or multi dwelling system. One household may use one small tank but several households may share one medium to large tank. Some research[48] results in Jordan showed that a maximum of 15.5 Mm^3/y of rainwater can be collected from roofs of residential buildings provided that all surfaces are used and all rain falling on the surfaces is collected. This is equivalent to 5.6% of the total domestic water supply of the year 2005 according to the said references. The potential for water harvesting varies among the governorates, ranging from 0.023×10^6 m^3 for the Aqaba Governorate to 6.45×10^6 m^3 for the Amman governorate. The potential for potable water savings was estimated for the 12 governorates, and it ranged from 0.27% to 19.7%[49].
Disadvantages	• One can never be sure how much rain will fall, hence limited supply by the amount of rainfall • Relatively high investment costs (per household) • Importance of maintenance • Water quality is vulnerable to air pollution, animal or bird dropping, insects and organic matter (points 2-4 can be largely overcome by design, ownership and by using as much as possible local material to ensure cost recovery) • Endorsed under certain conditions (see Section "**Endorsement by experts"** above)
Capital Cost	
Cost to implement adaptation technology	• In low-density rural areas, RWH can often provide household water at lower expense than other available options. If a household already has a suitable hard roof for use as a catchment surface, storage containers are the major expense. The cost of storage containers typically depends on construction quality, tank size, and other factors. A large, high quality storage container can be a major investment for poor households. In the context of climate change, increased precipitation extremes could necessitate greater storage volume, thus enabling the capture of maximum volume during intense periods and providing for household water needs during extended dry periods. • In developed countries, RWH for landscape irrigation is generally a minor investment. In contrast, dual piped systems incorporating rainwater can add significantly to the expense of a new home and retro-fitting an old home can be even more expensive. • The relationship between cost, construction quality, and tank storage capacity is illustrated in the figure below. Extensive discussion of tank design, construction, and cost can be found in Thomas and Martinson (2007)[50].  *Source: Thomas and Martinson (2007).*[v]

[48] Abdulla, F.A. and Al-Shareef A.W. (2009). Roof rainwater harvesting systems for household water supply in Jordan. *Desalination* (243): 195–207

[49] Abdulla, F.A. and Al-Shareef A.W. (2009). Roof rainwater harvesting systems for household water supply in Jordan. *Desalination* (243): 195–207

[50] Thomas, T.H. and Martinson, D.B. (2007) "Roofwater Harvesting: A Handbook for Practitioners" IRC International Water and Sanitation Centre. Technical Paper Series; no. 49. Delft, The Netherlands Available from http://www.bvsde.paho.org/bvsacd/cd67/Roofwater/content.pdf Accessed 8 February 2011.

	• If a household already has a suitable hard roof for use as a catchment surface, storage containers are the major expense. The cost of storage containers typically depends on construction quality, tank size, and other factors. A large, high quality storage container can be a major investment for poor households. The storage capacity of the container needs to meet the demand for water during extended dry periods. • Cost per unit established = USD 50 (for a pilot project (10 000 units) total costs = USD 500 000)
Development impacts, direct and indirect benefits	
Direct benefits	• Water scarcity can hinder economic development, human health and well-being[51]. Therefore, in arid and semi-arid countries, even in places with a safe and reliable piped drinking water supply, RWH can contribute to development. By reducing demand for high quality water supplies and capturing water that would otherwise evaporate, RWH effectively increases per capita water availability. This can increase the sustainability of water resources and reduce public and private expenditures associated with water infrastructure. Incorporation of RWH into household water practices in developing countries can contribute significantly to development by saving money and time. Stored rainwater is a convenient, inexpensive water supply close to the home. This can greatly decrease the time spent fetching water or queuing at water points[52]. • It can also provide significant savings for households that are sometimes forced to purchase vended or bottled water.
Reduction of vulnerability to climate change/reduced emissions, indirect	• RWH contributes to climate change adaptation at the household level primarily through two mechanisms: (1) diversification of household water supply; and (2) increased resilience to water quality degradation. • It can also reduce the pressure on surface and groundwater resources (e.g. the reservoir or aquifer used for piped water supply) by decreasing household demand and has been used as a means to recharge groundwater aquifers. • Another possible benefit of rooftop RWH is mitigation of flooding by capturing rooftop runoff during rainstorms • RWH can aid climate change adaptation even in the most developed countries. Economic growth in low-income countries leads to increases in piped water coverage and per capita water use.238 If safe, reliable piped supplies are available, RWH for non-potable uses can partially offset the increase in household use. • In some parts of the United States, half of all residential and institutional water use goes to landscape irrigation[53]. One-third of residential water in Europe is used for toilet flushing and 15% in washing machines and dishwashers[54]. In Germany and elsewhere, the use of rainwater for these non-potable uses is becoming increasingly common[55].
Economic benefits, indirect employment	• Will have economic value as it provides another source of water and will save money • Will save expenditures on alternative water sources • Will provide job opportunity to water resources/architecture engineers • Creation of jobs to support construction of RWH systems and to provide training to users/households
Growth and investment	• Can create investments in production of storage containers, pipes, filters, etc and thus contribute , even slightly, to national economic growth
Social benefits (indirect benefits in income,	• In many settings, RWH can reduce exposure to waterborne pathogens by providing improved potable water quality and high quality water for other household purposes including hygiene, bathing and washing. • It can provide significant savings for households that are sometimes forced to purchase vended or bottled water • The water can also contribute to productive and economic livelihood purposes.

51 Gleick, P.H. (2002) "The world's water, 2002-2003: the biennial report on freshwater resources." Island Press. Washington.

52 Elliot, M., Armstrong, A., Lobuglio, J. and Bartram, J. (2011). Technologies for Climate Change Adaptation—The Water Sector. T. De Lopez (Ed.). Roskilde: UNEP Risoe Centre.

53 Gleick, P. (2000) "A Look at Twenty-first Century Water Resources Development" Water International. Vol. 25(1):127-138

54 UNEP (2004) "Freshwater in Europe - Facts, Figures and Maps" Rome. http://www.grid.unep.ch/product/publication/freshwater_europe.php

55

education, and health)	
Environmental benefits, indirect	• Will enhance availability of drinking water for domestic and agricultural water for arid and semi-arid areas. • Use of of rainwater harvesting could enhance groundwater recharge and improve water quantity. • It will also reduce overexploitation of ground and service water with consequent environmental benefits • Alleviating water shortage problem • Providing a resilience community • Storage of rainwater can provide short-term security against periods of low rainfall and the failure or degradation of other water supplies.
Local context	
Opportunities and Barriers	**Opportunities** • Opportunities for investment in RWH are greatest when it can lead to time and cost savings, in addition to improved water quality and health gains. • Conditions are most favorable for household RWH when other water sources are: far from the home, of degraded quality, unreliable, or expensive. When "hard" (e.g. metal or tile, in contrast to vegetative) roofing is already in use, capital costs are lower, and efficiency and water quality are superior. • In developed countries, social awareness of water conservation is probably the most important factor creating opportunities for RWH. Cost savings and local ordinances against landscape irrigation with piped water can also increase rainwater collection. On the other hand, subsidization of piped water supply removes some of the economic incentives for RWH. **Barriers** • inadequate or unsuitable (e.g. vegetative) roofing • lack of space for appropriate storage containers • extreme air pollution • Local supply chains for storage containers and other system components should be in place. • Difficult to predict eventual capacity limitations and bad management practices of RWH over a long period.
Market potential	• The technology is small-scale, proven and less capital-intensive. It has market potential nationwide.
Status (national status of technology in Jordan)	• Some researchers[56] conducted a designated research project to investigate the potential for this technology in Jordan. Results show that a maximum of 15.5 Mm^3/y of rainwater can be collected from roofs of residential buildings provided that all surfaces are used and all rain falling on the surfaces is collected. This is equivalent to 5.6% of the total domestic water supply of the year 2005. The potential for water harvesting varies among the governorates, ranging from 0.023×10^6 m^3 for the Aqaba governorate to 6.45×10^6 m^3 for the Amman governorate. The potential for potable water savings was estimated for the 12 governorates, and it ranged from 0.27% to 19.7%.
Timeframe	Short-term, ready for implementation
Acceptability to local stakeholders	• Acceptable for all reasons above and for relatively cheap requirements (simple cleaning and basic repairs) • Training for households, especially related to protecting water quality (e.g. first flush methods, filtration) and budgeting rainwater are likely to lead to improved outcomes.
Examples and case studies from different regions	The University of Warwick (UK) Development Technology Unit has an extensive online RWH resource featuring technical releases, papers, and case studies from projects worldwide[57]. Among these documents is a 150-page handbook that provides detailed guidance for practitioners of RWH[58]. It is freely available online and should be considered the primary resource for those attempting to implement household RWH in developing countries.

[56] Abdulla, F.A. and Al-Shareef A.W. (2009). Roof rainwater harvesting systems for household water supply in Jordan. *Desalination* (243): 195–207

[57] University of Warwick Development Technology Unit (2010) Rainwater Harvesting. Warwick, UK. http://www2. warwick.ac.uk/fac/sci/eng/research/dtu/pubs/rwh/ (or: http://www2.warwick.ac.uk/fac/sci/eng/research/civil/dtu/rwh/)

[58] http://www.samsamwater.com/library/Roofwater_Harvesting_-_a_Handbook_for_Practitioner_-_TH_THomas_and_DB_Martinson.pdf

	Seventeen case studies can be accessed from the University of Warwick RWH case study portal[59]. They give detailed accounts of the design, manufacture, and construction of diverse RWH systems in Asia and Africa. Additionally, a broader case study of RWH implementation in the barrios of Tegucigalpa, Honduras is included (case study 9). A UN-HABITAT report that is freely available online includes 23 pages of case studies on RWH projects worldwide[60]

59 University of Warwick Development Technology Unit (2010) Rainwater Harvesting Case Studies. Warwick, UK http://www2.warwick.ac.uk/fac/sci/eng/research/dtu/pubs/rn/rwh/cs01/

60 UN-HABITAT (2005) "Rainwater Harvesting and Utilisation. Blue Drop Series Book 3: Project Managers & Implementing Agencies" Nairobi.

Technology Name: Maintenance and rehabilitation of the irrigation water network to reduce losses and increase efficiency

Technology characteristics	
Introduction	The gravest challenge facing Jordan today is the scarcity of water. Limited water resources have had a profound impact on the country's social and economic development. The production of food in semi arid countries like Jordan is hardly possible without irrigation. Irrigated agriculture, however, provides most of the agricultural production in the Kingdome and offers the higher percentage of agricultural jobs and other support services. Because of the huge imbalance in the population-water resources equation, the treated wastewater effluent is added to the water stock for use in irrigated agriculture. Efficiency of irrigation systems in the world varies greatly. Among the highest reported is 85%. If the Jordanian target was set some years ago to reach 75% in the next 10 years for example, a total of about 35 MCM/year may be saved for either irrigation or other usage, of which about 25 MCM will be available in the Jordan Valley. The overall irrigation water use efficiency is the product of conveyance, on farm and application efficiency. The conveyance efficiency is enhanced by improvements on the conveyance systems and the on-farm efficiency is enhanced by improvements brought to on-farm irrigation systems, all aiming at the reduction of the quantities of water lost during distribution. In many parts of the Jordan Valley Area, the condition of the irrigation water distribution system is extremely deteriorated. The majority of its components have, after 25 years, reached the end of their lifespan. Thus maintenance, rehabilitation and leakage detection technologies are highly needed to be deployed in the area to minimize high volumes of water loss.
Size of beneficiaries group	• Country-size, governorate, water basin/watershed, or a farm size. • Water Users Associations (WUAs) involvement
Disadvantages	• High cost • Administrative arrangements
Economic Impact	
Economic Importance	• Water supplying authorities can recover and bill for water that was literally "going down the drain." • A lot of savings due to reducing amounts of pumped water, treatment at WTPs, maintenance and pipe replacement costs. Thus, reducing costs of irrigation water supply and operating costs. • Improved reliability of the irrigation water supply and thus its economic value. • Reduced damage and liability costs from fewer disruptive piping failures, • Water Users Associations (WUAs) involvement
Capital, Operational and Maintenance costs	• Savings may also be realized through reduced equipment maintenance and replacement. Along with fewer breaks and leaks to be repaired, the service life of distribution piping may be extended through pressure management and surge suppression schemes. Review of metering accuracy and other metering programs can recover lost revenues. This entail lowered capital, operational, and maintenance costs.
Development impacts, indirect benefits	
Employment and Opportunity for SMEs	• WUAs benefits (as the Jordanian government continues to pursue utilizing involvement of WUAs in managing the irrigation water distribution system). • Will provide good new job opportunities to irrigation network engineers and some admin staff.
Investment	• Good investment opportunity by allowing irrigation water supply authorities/companies to enhance their pipeline management, client database metadata system and reducing leakage ratio. • Investment plans to improving quality and reliability of the irrigation water supply • Reducing treatment, maintenance and pipe replacement costs. Thus, providing investments opportunities for reducing costs of water supply and operating costs.

Public and private expenditures	• Will be reduced significantly due to reducing amounts of pumped irrigation water, treatment, maintenance and pipe and conduits replacement costs.
Social Suitability	
Human and Informational Requirements /Institutional and Organizational Requirements	• Need information collection: The effectiveness of an irrigation water loss control program increases with the type, amount, and detail of information that is collected. • Does not need considerable amount of institutional and organizational requirements Will depend mostly on existing institutional and organizational arrangements
Income	• More income for farmers • Provide indirect raise of income of staff working on irrigation water supply authorities/companies due to saving money.
Environmental Impacts	
Environmental Impacts/Resilience to Climate	• An irrigation water loss control program equipped with suitable water loss detection technologies can help lessen the severity of the effects of drought and climate change through retention of more water in the distribution system. This not only has the effect of retaining more water for the farmers, but can lessen the amount withdrawn from the sources.The technology will reduce irrigation water loss in agricultural areas' networks and enhance availability of water for agriculture. • It will also reduce overexploitation of ground and service water with consequent environmental benefits • Reducing load on WTPs. • Reducing energy consumption.
Local context	
Opportunities and Barriers	**Opportunities** • Will provide good investment opportunity by allowing irrigation water supply authorities/companies to enhance their pipeline management and reducing leakage ratio. • An opportunity for investment plans to improving quality and reliability of the irrigation water supply and preparing a long-term plan to replace the pipes and conduits; • WUAs benefits • Reducing treatment, maintenance and pipe replacement costs. Thus, reducing costs of water supply. • Improving management capacity of water supply systems. • Improving farmers services. • Developing the asset management system of the irrigation water supply system. **Barriers** • Economic efficiency is not high compared to the cost of implementation; • The capacity of the irrigation water supply entity is limited; • Lack of data on underground work in areas that need of repair or replacement. • Lack of effective policies and regulations.
Technology Capability & Suitability/ Technology Maturity	• Good capability available. • Water loss control and water level meters are installed at the sub- regional level. • Leakage detection: technologies such as acoustic detectors, infrared, chemical marking or hydraulic principles are being used. • Fixing leaks: research and study on applications and use of new materials (for pipes, solder mount) and handling leaks.
Market potential	Promising
National status of	Currently, there is no dedicated irrigation water leakage and loss detection technologies deployed in the Jordan Valley Area. Thus new state-of-the-art technologies are highly needed to be

technology in Jordan	transferred and deployed. In many parts of the Jordan Valley Area, the condition of the irrigation water distribution system is extremely deteriorated.

Technology: Water Users Association (WUAs): Empowerment and Expansion of WUAs	
Sector: Water	
Subsector: Irrigation water management for efficient use of water resources	
Technology characteristics	
Introduction	A large number of countries around the world have adopted programs to transfer management of irrigation systems from government agencies to water users associations (WUAs) or other private sector entities. Participatory Irrigation Management (PIM) is a key term in the toolbox of current approaches to improve the efficiency and performance of water resources management in the countries that are to cope with the issue of water scarcity, or problems associated with global and climate change in the foreseeable future. The Jordanian experience with WUAs is distinguished but still faces some difficulties, where the national strategy on IMT and PPP is clear in the texts, encouraging pilot experiences to consolidate the transfer and the performance of the associations, but the lack of a legal framework (the associations are registered under a cooperative profile) and a re-orientation of the Jordan Valley Authority (JVA) mandate, coupled with the government's reservations to rapidly hand out significant responsibilities to the WUAs are slowing down the process and confining the WUAs roles to routine small scale actions. There still is a widespread need for a clearer legal status and water rights given to WUAs and farmers. Without a clear legal status, WUAs cannot operate properly because they do not know the extent of their responsibilities.
Technology characteristics/highlight	• A WUA is a unit of individuals that have formally and voluntarily associated for the purposes of cooperatively sharing, managing and conserving a common water resource[61]. • The core activity of a WUA is to operate the waterworks under its responsibility and to monitor the allocation of water among its members. • Key functions of a WUA include: — Operate and maintain a water service or structure; — Management of a water distribution system, including setting tariffs and collecting fees; — Monitor water availability and use under climate uncertainty; — Provide technical assistance in areas related to water use/irrigation — Resolve conflicts related to water use;
Institutional and organizational requirements/ knowledge/capacity building requirements	• Limited need for new institutional arrangements. Changing prevailing regulations might be a hurdle • WUA is generally run out through institutions that have experience with collective water management, such as irrigation boards. Where an appropriate national framework is in place (usually a water act/law or irrigation act/law or by-law), a WUA can become an independent legal entity upon approval of an application to a higher authority such as the Ministry of Water and Irrigation/Jordan Valley Authority in Jordan. The WUA is then able to establish a governing document or constitution, a membership and a bank account. • The WUA should interact with other actors involved in water management. • It is likely that the activities of a WUA will be relevant to more than one government department, such as the Ministries of Water, Agriculture, Energy and other development bodies. The success of the WUA will therefore depend on support from a range of different government actors and will include financial, technical and operational assistance and collaboration.
Operation and maintenance	• Operation and maintenance is expected to be at relatively lows cost; to the contrary, this practice may provide a better and timely O&M of irrigation infrastructure thus lowering O&M cost compared to a BAU settings. • O&M can include the collective infrastructure maintenance, such as canal maintenance, pump operation and the monitoring and collection of water use charges

[61] Technology Needs Assessment Reports For Climate Change Adaptation – Lebanon (the complete report could be accessed from the TNA project website http://tech-action.org/).

Endorsement by experts	• The technology is successfully applied in different countries such as Jordan. In Lebanon, for instance, implementation of WUAs should start to take place, but, first of all, a national policy (such as a Water Act/Law or Irrigation Act/Law) must be developed to support organizational and institutional requirements for WUAs. • The practice has good level of maturity world-wide, progressing well in Jordan but still need empowerment and expansion
Adequacy for current climate	• The WUA practice fits well, both for present and expected climate
Scale/Size of beneficiary group	• A country level WUA structure to a basin/watershed level is possible. • The technology could be well addressed to different beneficiaries including: farmers, local communities and municipalities profiting from a collective water source, NGOs that support the establishment of WUAs, the Ministry of Water and Irrigation, the Ministry of Agriculture, etc.
Disadvantages	• The need for development of a legal framework that incorporates the concepts of managerial and financial independence for WUAs and their long-term sustainability. • Lack of or disaggregated political support. This has resulted in an inadequate support to the process. • Lack of managerial skills within the WUAs, which has resulted in poor provision of water services. • Little has been done in the region to increase the financial capacity of WUAs to mobilize and manage resources, or to address transparency; a major asset of a successful process. • The cooperative model of organization on which the WUA approach is based can have disadvantages if the area of operation does not match a hydraulic boundary and may actually stimulate conflict over resource use. Conflicts related to irrigation farming occur between upstream and downstream farmers when the upstream farmers are (perceived as) using too much water. A WUA could heighten conflict between users where its membership is based on an existing community boundary, rather than a representative selection of all water users within a particular system[62].
Capital Cost	
Cost to implement adaptation technology	• The cost of establishing and maintaining a WUA will depend on its size, management structure, area of operations and functions[63]. WUAs usually levy a joining fee, and then an annual membership fee. During initial formation phase, additional financial support may be required to ensure the establishment of the WUA. Where the establishment of WUAs is supported by national policy (such as a Water Act/Law or Irrigation Act/Law) there may be a mechanism in place for provision of this funding support. Furthermore, this funding support may be on-going, especially in countries where WUAs are considered part of a government-led decentralization programme, such Jordan. • Independently, WUAs can generate income by charging for water supply and distribution services and provision of agricultural outreach services.
Development impacts, direct and indirect benefits	
Direct benefits	• Provide better decentralized management of water resources and increase efficiency of water resources • Prioritization of investment needs for water management/adaptation strategies, such as irrigation, and monitor their effectiveness. • Coping with water shortage • Improved agricultural productivity[64]
Reduction of vulnerability to climate change/reduced	• PIM/WUAs is a key term in the toolbox of current approaches to improve the efficiency and performance of water resources management in the countries that are to cope with the issue of water scarcity, or problems associated with global and climate change in the foreseeable future. • WUAs can play a critical role in changing from centralized control of natural resources to local management. This is particularly important for climate change adaptation efforts whereby local monitoring of water resources, improvements in infrastructure (such as canals and irrigation) and

[62] Technology Needs Assessment Reports For Climate Change Adaptation – Lebanon (the complete report could be accessed from the TNA project website http://tech-action.org/).

[63] Technology Needs Assessment Reports For Climate Change Adaptation – Lebanon (the complete report could be accessed from the TNA project website http://tech-action.org/).

[64] Technology Needs Assessment Reports For Climate Change Adaptation – Lebanon (the complete report could be accessed from the TNA project website http://tech-action.org/).

emissions, indirect	public participation in decision-making leads to more reliable, timly, and equitable distribution of supplies.
Economic benefits, Indirect Employment	• Reducing financial and budgetary difficulties of government and facilitating collection of water fees. • Improving irrigation management efficiency as well as O&M of irrigation infrastructure; • Changing farmer's attitude of over dependence on external assistance;
Growth and Investment	• Investment opportunities in improving irrigation management efficiency will create some more jobs to local communities and slightly contribute to economic growth
Social benefits (indirect benefits in income, education, and health)	• Indirect income to farmers by applying more efficient management systems and from savings from reducing water losses • The technology can lead to improved agricultural productivity, which in turn helps to raise incomes[65]
Environmental benefits, indirect	• Provision of sustainable water sources for adaptive agriculture • Improvements to canal and irrigation schemes can reduce water logging and salinity problems. By providing technical assistance to local farmers, WUA members can also have a direct impact on improving soil, water and crop management practices. • The technology is considered among the most sustainable alternatives to cope with water shortage. It would have a number of advantages that include good management between water supply and demand, better allocation of water resources, and providing sound solution to water scarcity and climate change. Moreover, improvements to canal and irrigation schemes can reduce water logging and salinity problems.
Local context	
Opportunities and Barriers	**Opportunities** • Reducing conflicts between farmers. WUAs can offer an opportunity to contribute to the reconstruction of communities through conflict resolution • Decreasing risks of water supply and maintenance costs; • Ensuring a higher security of water supply through improved reliability of the system and increasing the cultivated areas due to a lower share of buffer zones within irrigation plots which are a part of farmers reaction against the risk in water supply. • An approach for irrigation sector reform. The institutional change in irrigation management and the adoption of PIM policy necessitate an institutional change in the irrigation agencies. • WUAs also provide a suitable organizational structure through which to support a range of participatory initiatives (such as water resource monitoring) that can help strengthening local capacity to make decisions about natural resource management and agricultural production options in the face of possible climate change scenarios. • Introduction of new functions and methods for irrigation management. **Barriers** • PIM still needs systematic public awareness campaigns, capacity building programs, consultations and involvement of all stakeholders. • A big need for a clearer legal status and water rights given to WUAs and farmers. • Among the major barriers are the absence of legislative framework, and the individualist mentality of the local communities and water users[66]. • Globally, a major challenge which would make pathways for IMT most favorable, is a productive agriculture. If agriculture is more profitable, then farmers will be more interested in irrigation management and PIM projects, which often assume that they will improve farmer incomes, but have not included elements directly focusing on income generation. Moreover, little has been done to increase the financial capacity of WUA to mobilize and manage resources.
Market potential	• WUA settings will help farmers exchange idea about opportunities for new markets

[65] Technology Needs Assessment Reports For Climate Change Adaptation – Lebanon (the complete report could be accessed from the TNA project website http://tech-action.org/).

[66] Technology Needs Assessment Reports For Climate Change Adaptation – Lebanon (the complete report could be accessed from the TNA project website http://tech-action.org/).

Status (National status of technology in Jordan)	The Jordanian experience with WUAs is distinguished. Governmental strategies, supported by international programs and donors, promoting a demand management approach and a Public Private Partnership are driving the participatory process in Jordan. *The Irrigation Policy 1998* of MWI in Article 34 stipulates that "Pilot irrigation areas shall be designated to test the workability of PIM, where farmers will assume the responsibility of water delivery to their farms. When found successful, PIM will be extended to the Jordan Valley irrigation systems". Jordan's policy documents indicate a strong intent to shift toward greater participation, establishment and enhancement of WUAs, including legitimizing legislation which is advocated in several documents. But evidence is hindered among others by the government's reservation to move rapidly beyond transferring irrigation water distribution to the WUAs in addition to pending legal issues related to the lack of financial autonomy of JVA. Attempts to consider end users' demands in irrigation management in the Jordan Valley allowed for a distinction into two programs. The first started in 1998 with the so-called TO2 (Turn Out at Km 2 of King Abdallah Canal) Pilot project in the area of Adassyeh (a Cooperation program between JVA and the French Technical Cooperation – Water and Agriculture Regional Mission - based in Amman) and focused on the improvement of technical premises in on-farm water distribution. The direct incorporation of farmers' views was restricted to a consultation via a rapid rural appraisal in 2000. The second program in Jordan's attempts to involve farmers in irrigation management focuses on a participation that exceeds the role of information delivery and reception of extension messages on improved irrigation methods. *The GTZ-funded Water Resource Management in Irrigated Agriculture* (WMIA) project, which started in 2001, supported the creation of farmer-owned WUAs in the Jordan Valley by building on knowledge about traditional and informal cooperation structures in rural societies in Jordan. Responsibilities transferred to the associations comprised in the first step the self-administration of water distribution within the respective irrigation area and the hand-over of the keys of the concrete boxes (farm turnouts), which contain meters and valves of each farm outlet to the farmers' fields. The WMIA project started negotiations with the farmers in 14 pilot plots in 2002 and supported them in establishing their formal WUAs until the end of 2003. Based on the service contracts between JVA and the WUAs responsible for retail distribution, JVA covers the operation costs and provide WUAs with spare parts. With the support of the GTZ (currently GIZ) project, JVA regularly provides technical training for WUAs on irrigation water distribution, maintenance of farm turnouts and monitoring, and assists in building administrative skills as well. When the concept gained the support of the farmers, forming the suitable shape of water associations in the pilot study area in the north, middle and south of the Jordan Valley started and took the following forms: Water councils: They are based on the traditional mechanism of problem solving. Water councils are recognized by JVA. Each council has 15 – 20 elected farmers. Water users committees: they are also based on or similar to the traditional form of farmers' management that existed before the formation of JVA. A water users committee is a group of representatives of farmers elected by the farmers in a general assembly after several informal meetings. Although the committees have no legal status as such, they are recognized by JVA; normally a letter is issued by the JVA Secretary General to this respect. Water users cooperatives: they are the type of associations that have a legal status. Cooperatives follow the JCC (Law No. 18 / 1997). Cooperatives must have their internal statutes that specify the objectives, capital, membership procedures and financial and administrative issues. It should be noted that JCC was the only available facility to register the water associations. In January 2010, however, a dedicated bylaw to allow establishing WUAs under the water related authority was drafted. A bylaw for a WUAs federation was also being drafted (German-Jordanian Programme – Management of Water Resources, 2010[67]). To date, a total of 23 WUAs exist in the Jordan Valley, representing 80% of the total irrigated areas. After the confidence building and WUA establishment phases, the Task Transfer Phase started (2006-2009). The continuous monitoring allowed the identification of 12 WUAs which were high on selected targets including participation on voluntary basis, willingness to undertake the responsibility of retail distribution, reduction of the number of complaints submitted by the farmers and the increase of distribution efficiency in the area managed by the WUA. These WUAs (representing 45% of the area) were transferred few tasks through agreements stipulated between the WUAs and JVA. Tasks transfer was effected following two months of intensive training on the technical and management functions

[67] German – Jordanian programme, 2010: "Water User Associations; The story of participative irrigation management in the Jordan Valley".

	that will be assumed by the WUAs, such as water budgeting, meter readings, reading of the irrigation order released by JVA, controlling of pressure valves and calculating distribution efficiency, minutes and report writing, filing, computer skills, and internal financial auditing[68]. The period 2009 to present corresponds to the *Sustaining Phase*. It marks establishing new WUAs and extends the task transfer areas. It is foreseen that the partial transfer of tasks will affect 5 additional WUAs, which will raise the whole IMT area to 62%, expanding the experience with a view to full devolvement of responsibilities over retail distribution and partial maintenance, so far confined to farm turnouts. Moreover, a WUA unit was established at JVA during this phase to monitor and evaluate WUAs performance, supervise the implementation of management contracts, follow up financial claims and assist WUAs staff. In the near future this unit will also be responsible for WUAs registration (substituting thereby the role of the JCC). However, even with the success stories in the establishment of WUAs in Jordan the tasks transferred to the WUAs' remain limited to distribution of irrigation water to farmers, and there is still a strong need for further empowerment through, among others: Official re-orientation of JVA mandate. A draft amendment to the Jordan Valley development Law is presently under review, involving changes to transfer JVA mandates for retail distribution to the WUAs. The said law will allow JVA to provide the legal umbrella for the establishment of WUAs and the legal requirements for the WUAs to collect fees from farmers. Acquisition of the right to enforce sanctions related to the transferred functions such as illegal water use. Currently, WUAs simply report illegal actions to JVA and are represented in its sanction committee taking part to the related decision making. In Jordan, the national strategy on IMT and PPP is clear, encouraging pilot experiences to consolidate the transfer of retail distribution to performing associations. However, the lack of a re-orientation of the JVA mandate, and reluctance to transfer tasks beyond irrigation water distribution, are slowing down the process, confining the WUAs roles to routine small scale actions, and the legal evidence legitimizing WUAs is still awaiting among other things, the resolution of the financial autonomy of JVA. Moreover, a low performing irrigation system in some targeted areas mainly preoccupies the farmers. Despite the success stories, these problems coupled with the technical and managerial skills of farmers, remain the problems at the basis of a process, further slowed down by resistance to change by some JVA officers and influential farmers who feel threatened by the establishment of a democratic process. What si need in Jordan in this regard is to ***address the bottlenecks Jordan*** impeding the transfer to higher levels through: clear legal framework; re-orientation of the agencies mandates; training of agencies and WUAs; building on success stories like **Pump 55** *WUA* **in the Jordan Valley** mainly related to a productive agriculture, a transparent management and a continuous support by the agency. Also is needed to ***work with government teams for the introduction of PIM,*** possibly supported by consultants, is more effective in the long term. These teams are usually subjected to a powerful capacity building process and become advocates of PIM within government organisations. This is clearly obvious in Jordan's experience, where the international programs evolved somehow into the organizational set up of the ministries. However, the reform should include both "hard" and "soft" interventions. It involves inter alia strong political commitment, negotiations among stakeholders and continuous capacity building. This initially long process can evolve into diverse progresses: re-organization of the institutional set up of the agriculture sector; irrigation modernization; economic changes in support to irrigation.[69]
Timeframe	In Jordan, short-termas practice is already deployed (but **empowerment and expansion is medium-term goal)**. In other countries like Lebanon, it is a medium term technology, as creating the enabling environment requires time.
Acceptability to local stakeholders	In Jordan, it is well accepted by stakeholders. But according to other countries like Lebanon[70], the technology is more or less accepted by local communities, due to the inherited water committees and water shares in collective water source. Moreover, it is compromised by the conflicts that can rise between upstream and downstream beneficiaries.

68 REGIONAL ASSESSMENT - WATER USERS' ASSOCIATIONS IN THE SWIM-SM PARTNER COUNTRIES. Final document produced after discussion and validation during the WUAs Expert Regional Workshop (23-24 April, 2012, Athens, Greece). Sustainable Water Integrated Management (SWIM) - Support Mechanism Project

69 REGIONAL ASSESSMENT - WATER USERS' ASSOCIATIONS IN THE SWIM-SM PARTNER COUNTRIES. Final document produced after discussion and validation during the WUAs Expert Regional Workshop (23-24 April, 2012, Athens, Greece). Sustainable Water Integrated Management (SWIM) - Support Mechanism Project

70 Technology Needs Assessment Reports For Climate Change Adaptation – Lebanon (the complete report could be accessed from the TNA project website http://tech-action.org/).

Technology Name: **Greywater treatment and re-use**

Technology characteristics	
Introduction	Jordan is considered one of the 10 most water stressed countries in the world. Per capita available water is projected to decline from the current low of 145 cubic meters per year to only 90 cubic meters per year by 2025. The deficit between total water supply and demand is around 500 MCM, with increasing water demand projected to exceed water supply by 33 % in 2025. Installation of decentralized grey water treatment systems in small rural communities is believed to contribute to a more sustainable water supply. However, this practice is still not widely deployed in Jordan and in many cases is demonstrated in a pilot scale projects.
Size of beneficiaries group	From a country to watershed-scale size to a governorate/city, small water basin-scale size to a household size units.
Disadvantages	• potential risks, as there is some concern that the high levels of organic load produced in kitchens might pose an unacceptable risk of pathogenic contamination in grey water. • Cost: the cost of treatment encompasses the system cost, operations and maintenance (O&M) costs and building retrofitting cost.
Economic Impact	
Economic Importance	• Limited as some references question the value added and economic benefits of of greywater recycling. it is reasonable to expect that greywater recycling is predominantly dependent on available water supply for domestic landscapes with only minimal reuse being based on conservation principles. • The cost of a secondary treatment system for greywater would be more than twice the amount required to retrofit dual flush toilets, low- flow shower heads, repair all taps, purchase a five-star rated washing machine and install a water efficient landscape Plan. • However, other references side with the economic and environmental benefits of recycling greywater. A cost-benefit analysis of onsite graywater recycling in single-family and multifamily homes was conducted[71] to evaluate the merits of graywater recycling in arid urban regions using the City of Los Angeles as a case study. Onsite graywater recycling reduces potable water demand by 27% and 38% in single family and multifamily homes, respectively. At participation of 10%, the City will be able to reduce water supply and treatment related energy by 43,000 MWh/year, potable water demand by 2% and wastewater treatment load by 3%.
Capital, operational and Maintenance costs	• Still relatively an expensive system to install, operate, and maintain (system cost, operations and maintenance (O&M) costs and building retrofitting cost). • Graywater treatment systems (provide organic, total suspended solids and turbidity removal) marketed for single-family homes can vary between \$6,000 and ~\$13,000 for treatment capacity of 1.2 – 1.6 m3 /day (EMRC, 2011)[72]. Additionally, maintenance is usually required and can ranges between \$200 to \$900 per year (GHD Australia Pty Ltd., 2012)[73].
Development impacts, indirect benefits	
Employment and Opportunity for SMEs	• Limited to fairly good employment opportunities.
Investment	• Limited to good investment opportunities. A third-party ownership model could be a viable model for residential graywater recycling program that reduces the upfront system and installation cost barrier as well as relieves residential property owners the responsibility for system operation and maintenance.
Public and private expenditures	• A cost-benefit analysis of onsite graywater recycling in single-family and multifamily homes was conducted[74] to evaluate the merits of graywater recycling in arid urban regions (City of Los Angeles) as a case study. Onsite graywater recycling reduces potable water demand by 27% and 38% in single

[71] Cost-Benefit Analysis of Onsite Residential Graywater Recycling – A Case Study: the City of Los Angeles Zita L.T. Yu, J.R. DeShazo, PhD, Michael K. Stenstrom and Yoram Cohen, PhD,
[72] EMRC (2011) Reuse of Greywater in Western Australia, Eastern Metropolitan Regional Council Belmont, , Western Australia.
[73] GHD Australia Pty Ltd. (2012) Yarra Valley Water Report for North Warrandyte Sewerage Backlog: Alternative Options Assessment.
[74] Cost-Benefit Analysis of Onsite Residential Graywater Recycling – A Case Study: the City of Los Angeles Zita L.T. Yu, J.R. DeShazo, PhD, Michael K. Stenstrom and Yoram Cohen, PhD,

	family and multifamily homes, respectively, which means reducing public and private expenditures. At participation of 10%, the City will be able to reduce water supply and treatment related energy by 43,000 MWh/year, potable water demand by 2% and wastewater treatment load by 3%[75].
Social Suitability	
Human and Informational Requirements /Institutional and Organizational requirements	• Minimal as it will utilize existing institutional set-ups
Income	• Minimal from savings due to a new marginal water resource.
Environmental Impacts	
Environmental Impacts/Resilience to Climate	• Might be good solution/technology for countries (like Jordan) and cities in arid regions that are facing water scarcity and have limited capability for reusing centralized recycled water due to the lack of distribution system.
Local context	
Opportunities and Barriers	**Opportunities** • Some see treatment and reuse of grey water systems as an opportunity to conserve potable quality water, generate locally sustainable water sources, and match the water supply quality with that required for the intended use. • implementation of grey water systems with simple installation, operation, maintenance, cost and energy requirements will assist in rural community adoption of these systems for reuse of a portion of their effluents for irrigation. **Barriers** • some potential risks, as there is some concern that the high levels of organic load produced in kitchens might pose an unacceptable risk of pathogenic contamination in grey water
Technology Capability & Suitability/ Technology Maturity	• Fairly mature technology/practice. Onsite graywater reuse has emerged as an important sector in water reuse, especially in arid regions and where water reuse capability is limited
Market potential	• Need more evaluation studies.
National status of technology in Jordan	• Low water consumption in rural areas in Jordan had resulted in the production of concentrated grey water. Average COD, BOD and TSS values were 2568 mg/l, 1056 mg/l and 845 mg/l, respectively76. The average grey water generation was measured to be 14 L/c.d. Three different treatment options were selected based on certain criterions, and discussed in a local study77. The examined treatment systems are septic tank followed by intermittent sand filter; septic tank followed by wetlands; and UASB-hybrid reactor. Advantages and disadvantages of each system are presented. It was concluded that UASB-hybrid reactor would be the most suitable treatment option in terms of compactness and simplicity in operation. The volume of UASB-hybrid reactor was calculated to be 0.268 m3 with a surface area of 0.138 m2 for each house having 10 inhabitants on average. Produced effluent is expected to meet Jordanian standards set for reclaimed water reuse in irrigating fruit trees.

[75] Cost-Benefit Analysis of Onsite Residential Graywater Recycling – A Case Study: the City of Los Angeles Zita L.T. Yu, J.R. DeShazo, PhD, Michael K. Stenstrom and Yoram Cohen, PhD,

[76] Halalsheh M.; Dalahmehb, S.; Sayed, M.; Suleiman, W.; Shareef, M.; Mansour, M.; Safi M., 2008. Grey water characteristics and treatment options for rural areas in Jordan. Short Communication: Bioresource Technology. Volume 99, Issue 14, September 2008, Pages 6635–6641

[77] Halalsheh M.; Dalahmehb, S.; Sayed, M.; Suleiman, W.; Shareef, M.; Mansour, M.; Safi M., 2008. Grey water characteristics and treatment options for rural areas in Jordan. Short Communication: Bioresource Technology. Volume 99, Issue 14, September 2008, Pages 6635–6641

Technology Name: Maintenance and rehabilitation of the drinking water network to reduce losses and avoid water contamination

Technology characteristics	
Introduction	Jordan is considered one of the 10 most water stressed countries in the world. Per capita available water is projected to decline from the current low of 145 cubic meters per year to only 90 cubic meters per year by 2025. The deficit between total water supply and demand is around 500 MCM, with increasing water demand projected to exceed water supply by 33 % in 2025. However in 1999, water was supplied sporadically, more than 54 percent was unaccounted for due to leaks, illegal connections and invoicing problems, and the Water Authority of Jordan (WAJ) was recovering only 78 percent of its operational cost. The water sector in Jordan is characterized by choking scarcities. Water shortages have made it unaffordable for the country to suffer from operational inefficiencies in its water utilities and systems. Water losses, due to water theft and leakages, are high, and currently amount to 33 percent in Amman[78]. Nearly 40% of Amman's water comes from the Yarmouk River, located 230 m below sea level and as far as 70 km from the city's distribution network. As a result, the 45-year-old water network is 6000 kms long. As the exploitation of new water resources is costly, Jordan invested and is still investing heavily in the development, rehabilitation and maintenance of water infrastructure. Among the projects requiring immediate attention are rehabilitation of distribution systems projects, and augmenting urban water supplies.
Size of beneficiaries group	• Country-size, governorate, city or local area size. • Private sector benefits (public-private partnerships)
Disadvantages	• High cost • Administrative arrangements
Economic Impact	
Economic Importance	• Recover and bill for water that was literally "going down the drain." • A lot of savings due to reducing amounts of pumped water, treatment, maintenance and pipe replacement costs. Thus, reducing costs of water supply and operating costs. • Improved quality and reliability of the water supply and thus its economic value. • Private sector benefits (public-private partnerships)
Capital, Operational and Maintenance costs	Reduced water losses in the distribution system can translate to[79]: • Less electricity required to treat and pump the water, • Reduced damage and liability costs from fewer disruptive piping failures, • Potential reduction in the feed rates of treatment chemicals and potential reduction in disinfectant dose. • It can also mean deferred treatment facility upgrades. Savings may also be realized through reduced equipment maintenance and replacement. Along with fewer breaks and leaks to be repaired, the service life of distribution piping may be extended through pressure management and surge suppression schemes. Review of metering accuracy and other metering programs can recover lost revenues.
Development impacts, indirect benefits	
Employment and Opportunity for SMEs	• Private sector employment benefits (public-private partnerships) • Will provide good new job opportunities to network engineers and some admin staff. • Limited to fairly good opportunities to SMEs as sub-contractors.
Investment	• Good investment opportunity by allowing water supply companies to invest in enhancing their pipeline management, client database metadata system and reducing leakage ratio. • Investment plans to improving quality and reliability of the water supply • Reducing treatment, maintenance and pipe replacement costs. Thus, reducing costs of water supply.

[78] http://www.venture-mag.com/index.php?option=com_k2&view=item&id=427%3Aplugging-the-leak&Itemid=34&limitstart=270
[79] EPA, CONTROL AND MITIGATION OF DRINKING WATER LOSSES IN DISTRIBUTION SYSTEMS, http://water.epa.gov/type/drink/pws/smallsystems/upload/Water_Loss_Control_508_FINALDEc.pdf

	• Developing the asset management system of the water supply system.
Public and private expenditures	• Will be reduced significantly due to reducing amounts of pumped water, treatment, maintenance and pipe replacement costs. Thus, reducing costs of water supply and operating costs.
Social Suitability	
Human and Informational Requirements/ Institutional and Organizational Requirements	• The effectiveness of a water loss control program increases with the type, amount, and detail of information that is collected. • Does not need considerable amount of institutional and organizational requirements • Will depend mostly on existing institutional and organizational arrangements
Income	• Provide indirect raise of income of staff working on water supply companies due to saving money.
Environmental Impacts	
Environmental Impacts/Resilience to Climate	• A water loss control program equipped with suitable water loss detection technologies can help lessen the severity of the effects of drought and climate change through retention of more water in the distribution system. This not only has the effect of retaining more water for the customers, but can lessen the amount withdrawn from the sources.The technology will reduce drinking water loss in networks and enhance availability of drinking water for domestic and agricultural water. It will also reduce overexploitation of ground and service water with consequent environmental benefits • Reducing energy consumption.
Local context	
Opportunities and Barriers	**Opportunities** • Will provide good investment opportunity by allowing water supply companies to enhance their pipeline management, client database metadata system and reducing leakage ratio. • An opportunity for investment plans to improving quality and reliability of the water supply. • Private sector benefits • Reducing treatment, maintenance and pipe replacement costs. Thus, reducing costs of water supply. • Improving management capacity of water supply systems. • Improving customer services. • Preparing a long-term plan to replace the pipes; • Developing the asset management system of the water supply system. **Barriers** • Economic efficiency is not high compared to the cost of implementation; • The capacity of the water supply entity is limited; • Lack of data on underground work in areas that need of repair or replacement. • Lack of effective policies and regulations.
Technology Capability & Suitability/ Technology Maturity	• Good capability available. • Water loss control: decentralization; water level meters are installed at the sub- regional level. • Leakage detection: technologies such as acoustic detectors, infrared, chemical marking or hydraulic principles are being used. • Fixing leaks: research and study on applications and use of new materials (for pipes, solder mount) and handling leaks.
Market potential	• Promising
National status of	Due to business contracts with private water companies, 70 per cent supply increase happened since the last decade. Using monitoring tools, corrective maintenance, and energy and well data

technology in Jordan	management, these companies dramatically improved the water supply situation in Amman. In 1999, water was supplied to Amman residents once a week, averaging 200,000 m3 per day. By 2005, residents were receiving water 70-80 hours a week, and the actual supply of available water was increased by 70 percent. In 2006 approximately 11 percent of the population had a continuous supply of water during the winter months. Water pressure management was also introduced. One prime source of this increase in supply was due to such private companies, for example LEMA's extremely successful leak reduction programme. When LEMA's contract ended after 7 years (2006), there was a six-month transition period. The company was renamed *Miyahuna*, which operates to this day under government management. LEMA created a system that is still in operation [under Miyahuna]. According to some references, the private company met all its milestones with the exception of one relating to the reduction of water losses. The target set in the contract was to some experts unrealistic. They were expected to reduce the water loss rate from 54 percent to 25 percent. However, they managed to bring it down to about 35 percent according to the same refernces[80]. Miyahuna now continues to reduce water losses in Amman, which have reached 33 percent in 2012. However, more robust programs and advanced technologies still need to be deployed to enhance rehabilitation of the drinking water network to reduce losses and avoid water contamination.

[80] http://www.venture-mag.com/index.php?option=com_k2&view=item&id=427%3Aplugging-the-leak&Itemid=34&limitstart=270

Technology Name: Integrated Water Resource Management (IWRM)

Technology characteristics	
Introduction	Water is a key driver of economic and social development while it also has a basic function in maintaining the integrity of the natural environment. Thus, the water crisis in many countries like Jordan is not only caused due to shortage of water resources but also due to to mismanagement. Water resources managers, whether in the government or private sectors, have to make difficult decisions on water allocation. More and more they have to apportion diminishing supplies between ever-increasing demands. Drivers such as demographic and climatic changes further increase the stress on water resources. The traditional fragmented approach is no longer viable and a more holistic approach to water management is essential. This is the rationale for the Integrated Water Resources Management (IWRM) approach that has now been accepted internationally as the way forward for efficient, equitable and sustainable development and management of the world's limited water resources and for coping with conflicting demands.[81]
Size of beneficiaries group	• From a Country to watershed-scale size to a governorate/city to small water basin-scale size.
Disadvantages	• Long process that takes time to feel impact • Lack of internationally-agreed on performance indicators
Economic Impact	
Economic Importance	• IWRM has a big economic return due to effects of sound water policies on the economy • Economics applied to IWRM: — Helps to assess the economic implications of different water policies (at different levels) — Supports the selection of policy targets — Assists in the choice of the optimal water resources management strategy — Supports the achievement of policy objectives by providing implementation tools & instruments
Capital, operational and Maintenance costs	• IWRM's capital & operational cost is the same cost of managing and maintaining the water resources but at a reduced cost (savings) due to sound management. • The cost may include Opinions of Probable Construction Cost (OPCC) for major capital projects included in the Integrated Plan.
Development impacts, indirect benefits	
Employment and Opportunity for SMEs	• IWRM provide employment for additional staff to augment the human and institutional readiness. • It provide indirect opportunity for SMEs to supply auxiliary services to areas under improvements in the water sector.
Investment	• Provides an opportunity for investment programs to benefits from holistic reform polices
Public and private expenditures	• IWRM will reduce public and private expenditure on water and will increase water tariff collection.
Social Suitability	
Human and Informational Requirements/Institutional and Organizational requirements	• Jordan is in a good and relatively advanced status with regard to Human and Informational Requirements/Institutional and Organizational requirements for IWRM

[81] http://www.un.org/waterforlifedecade/iwrm.shtml

<table>
<tr><td>Income</td><td>• IWRM will increase income for water sector, for example water tariff collection.</td></tr>
<tr><td colspan="2">Environmental Impacts</td></tr>
<tr><td>Environmental Impacts/Resilience to Climate</td><td>• Will strengthen capacities of water entities to develop the needed mechanisms and strategies on adaptation of the water sector and management of potential risks in the context of IWRM. This may include training in new approaches, systems, and tools to enable appropriate planning and implementation of climate change adaptation.
• IWRM is the foundation upon which the implementation of adaptation strategies, based on a sequence of climate change projections, and impact assessments can be realized. It is important to consider appropriate adaptation measures to ensure sustainable water security for social, economic and environmental needs. There is a high need for inclusion of potential climate change impacts and associated uncertainties in the national water planning and management plans as well as strategies and polices. This is highly needed so that climate change may become part of the national policies and decision-making routine to foster a acclimate-resilient IWRM.</td></tr>
<tr><td colspan="2">Local context</td></tr>
<tr><td>Opportunities and Barriers</td><td>Opportunity
• Opportunity for inclusion of potential climate change impacts and associated uncertainties in the national water planning and management plans as well as strategies and polices. This is highly needed so that climate change may become part of the national policies and decision-making routine to foster a climate-resilient IWRM.
• The water sector-involved entities may have an opportunity to strengthen capacities of water entities to develop the needed mechanisms and strategies on adaptation of the water sector and management of potential risks. This may include training in new approaches, systems, and tools to enable appropriate planning and implementation of climate change adaptation.
• IWRM will improve the adaptive capacity of the country for climate change and skills of water personnel and planners involved significantly will be improved with regard to adapting measures and mitigating vulnerability.
• Transboundary IWRM Opportunities:
— Can facilitate regional co-operation
— Leads to better results: holistic view on water management (integrative problem perception)
— Must be perceived as a “win-win“ situation by all involved actors to ensure co-operation
— May involve the redistribution of benefits (through eg direct payments or ownership arrangements)

Barriers
• Transboundary IWRM, which is complicated by:
• Different legal frameworks
• Uneven distribution of costs and benefits of water policies (upstream - downstream)
• Differences in problem perception
• Differences in preferences & policy dynamics</td></tr>
<tr><td>Technology Capability & Suitability/ Technology Maturity</td><td>• IWRM is mature in some European countries like France and Spain
• Still in fairly middle-way status in Jordan</td></tr>
<tr><td>Market potential</td><td>• It does not have solid local market potential but has much high potential in some western countries</td></tr>
<tr><td>National status of technology in Jordan</td><td>There is a high need for inclusion of potential climate change impacts and associated uncertainties in the national water planning and management plans as well as strategies and polices. This is highly needed so that climate change may become part of the national policies and decision-making routine to foster a climate-resilient IWRM.
Based on very recent study from European Commission’s SWIM Program (2010 – 2015), Contributing to Sustainable Water Integrated Management in the Mediterranean, ACTIVITY</td></tr>
</table>

	1.3.6 titled "ASSESSMENT OF IWRM MONITORING INDICATORS IN SELECTED MEDITERRANEAN COUNTRIES (EGYPT, JORDAN & LEBANON)", the study's results shows the following results. The approach used to achieve the objectives was based on the development of a comprehensive questionnaire to collect the relevant information from each one of the three SWIM SM focus countries. After collection of the information, a comparison was conducted to match IWRM indicators listed in the literature with currently available ones monitored and reported by the three selected SWIM focus countries. The questionnaire was addressed to water officials in Jordan in charge with national water planning and monitoring and water relevant institutions. These included the following four institutions (or their equivalent) in each one of the three focus countries: — Ministry of Water and Irrigation / Water Resources Monitoring and Studies Directorate. — Ministry of Environment / Monitoring and Evaluation Directorate. — Ministry of Planning and International Cooperation / Sustainable Development Division. — Department of Statistics / Environmental Statistics Division. • The study revealed the following conclusions: • No standard monitoring mechanism for the implementation of IWRM as yet exists in the three SWIM-SM selected focus countries, whilst a monitoring system for measuring progress in managing water resources as a separate sector is well established in the three focus countries. Mechanisms for integrating socio-economic and environmental aspects in managing water resources are yet to be developed for monitoring progress towards implementation of IWRM concepts. • Currently, there is no mechanism in place whereby focus countries can report and share information on their progress in implementing IWRM. However a conventional mechanism for reporting water resources management as an independent separate sector does exist. • There is a serious inadequacy in the generation, compilation, analysis and sharing of systematic data covering fundamental aspects of IWRM such as economics, social and to a lesser extent environmental dimensions related to water resources management. • The three focus countries have exhibited some progress in establishing an enabling environment for the implementation of IWRM through development of policies, amending legislations and reforming some institutions. However, National water policies and water laws in focus countries reflect only few basic IWRM principles. • Cost recovery and economic return, in particular, are not strong elements in the management of water resources in any of the three focus countries. • All questionnaires' feedback indicated that adequate data and information are already available for traditional water resources management. The problem seems to be first, the accessibility and exchange of these information by decision and policy makers and second, the adequate selection, analysis, interpretation and utilization of the information in a valuable manner for decision-maker and stakeholder. • There are further evidences and observations from the analysis of the questionnaires that the three SWIM focus countries have not spent either much time or significant resources on the development of IWRM monitoring and evaluation protocols. Furthermore, the stakeholders have not been often involved either in the monitoring and evaluation, or in the establishment of benchmarks and indicators for monitoring implementation of IWRM principles. The high importance of an adequate monitoring and evaluation system and the limited role of stakeholders might explain the slow progress in implementing IWRM principles. • Primary data on traditional water resources management and necessary to populate IWRM indicators is available to a great extent in the three focus countries. However, this wealth of information isn't invested in developing well-structured indicators to support the decision making process for sustainable water resources management. • In SWIM-SM focus countries, IWRM concepts are already planned and some reforms are either completed or underway. What remains is the development of a set of indicators to monitor the implementation of IWRM concepts including the incorporation of socio-economic and environmental dimensions in a balanced way.

	• The gathered information gives a clear evidence that management of water resources in the three focus countries is not giving adequate considerations to the optimization of its economic value and/or the maximization of the economic return from the available water resources. This is a grave indication that a main principle and a vital IWRM pillar is overlooked in managing water resources.

Technology: <u>Desalination/brackish water treatment and re-use</u>	
Sector: Water	
Subsector: Water management for efficient use of water resources/diversification of water supply; Resilience to water quality degradation	
Technology characteristics	
Introduction	Over 97% of the water on earth is unsuitable for human consumption due to its salinity. The vast majority (about 99%) of this is seawater, with most of the remainder consisting of saline groundwater[82]. Purification of this saline water holds the promise of nearly unlimited water resources for human civilizations in coastal regions. However, purification of seawater is expensive, energy intensive and often has large adverse impacts on ecosystems[83]. Despite these drawbacks, desalination can be an appropriate technological choice in certain settings. Technological advancements continue to decrease the economic and environmental costs of desalination[84]. Desalination is the removal of sodium chloride and other dissolved constituents from seawater, brackish waters, wastewater, or contaminated freshwater. Approximately 75 million people worldwide rely on desalination and that number is expected to grow as freshwater resources are stressed by population growth and millions more move to coastal cities with inadequate freshwater resources[85]. Desalination is most widely used in arid regions; more than half of the world's desalination capacity (volume) is located in the Middle East and North Africa[86]. The prospect of desalinating seawater and thus gaining an almost inexhaustible source of fresh water has been intriguing experts for a long time[87]. Desalination is already an important source of supply in Saudi Arabia, the Gulf States, and Malta. Most of the current global desalination capacity is already installed in the Middle East: Saudi Arabia has 26.8%, Kuwait 10.5%, and the United Arab Emirates 10% (by comparison, the United States has 12%)[88]. Brackish waters made up the majority of source waters for desalination, with most of the remainder consisting of river waters and wastewaters. The use of desalination is widely expected to increase in the 21st Century, primarily for two reasons. Research and development will continue to make desalination less energy intensive, more financially competitive, and more environmentally benign. Increasing demand: population growth, economic development and urbanization are leading to rapidly increasing demand for water supply in coastal and other regions with access to saline waters.
Technology characteristics/high light	Two streams of water result from desalination: (1) a pure product water and (2) a high-concentration waste stream or brine. The principal desalination methods fall into two categories: thermal processes (Figure 1) and membrane processes (Figure 2).

82 US Geological Survey (2010) Earth's water distribution. http://ga.water.usgs.gov/edu/waterdistribution.html Accessed November 5, 2010

83 Elliot, M., Armstrong, A., Lobuglio, J. and Bartram, J. (2011). Technologies for Climate Change Adaptation—The Water Sector. T. De Lopez (Ed.). Roskilde: UNEP Risoe Centre.

84 WHO (2007) Desalination for Safe Water Supply: Guidance for the Health and Environmental Aspects Applicable to Desalination. Rolling Revision. World Health Organization. Geneva. http://www.who.int/water_sanitation_health/gdwqrevision/desalination.pdf Accessed November 5, 2010.

85 Khawaji, A.D., Kutubkhanah, I.K. and Wie, J.M. (2008) Advances in seawater desalination technologies Desalination Vol. 221:47–69.

86 Elliot, M., Armstrong, A., Lobuglio, J. and Bartram, J. (2011). Technologies for Climate Change Adaptation—The Water Sector. T. De Lopez (Ed.). Roskilde: UNEP Risoe Centre.

87 Mohsen M. S., (2007). Water strategies and potential of desalination in Jordan, Desalination 203 (2007) 27–46

88 Mohsen M. S., (2007). Water strategies and potential of desalination in Jordan, Desalination 203 (2007) 27–46

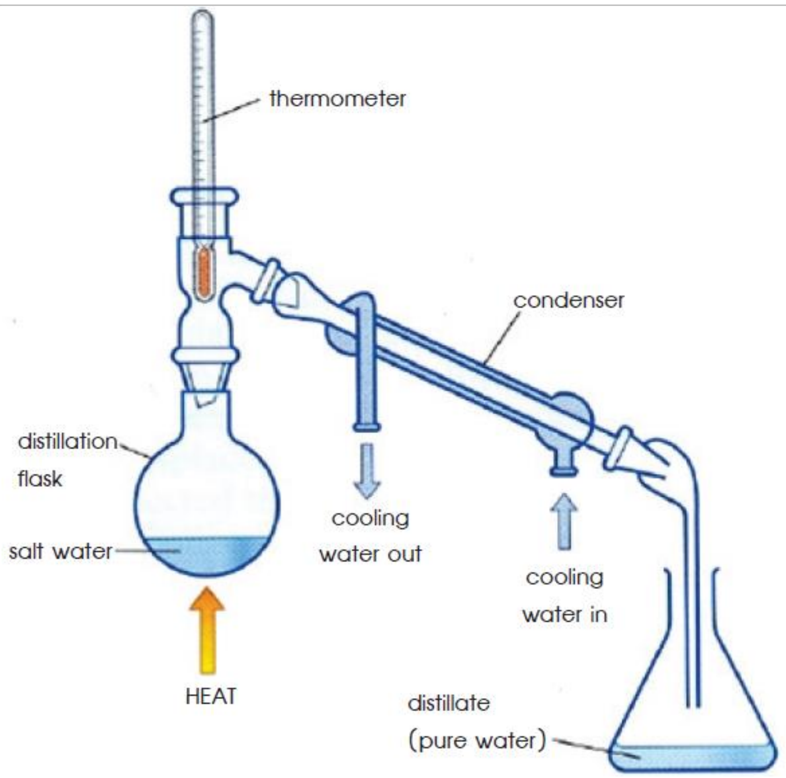


Figure 14: A diagram of water distillation, the most simple thermal desalination process. Here, a flame is applied to a beaker containing salt water; the water evaporates leaving the salts behind. The water vapor then travels up and into the adjacent tube, where it condenses and drips into the flask as pure liquid water. Modern thermal processes (MSF, MEE, VCD, etc.) yield much greater energy efficiency than simple distillation.

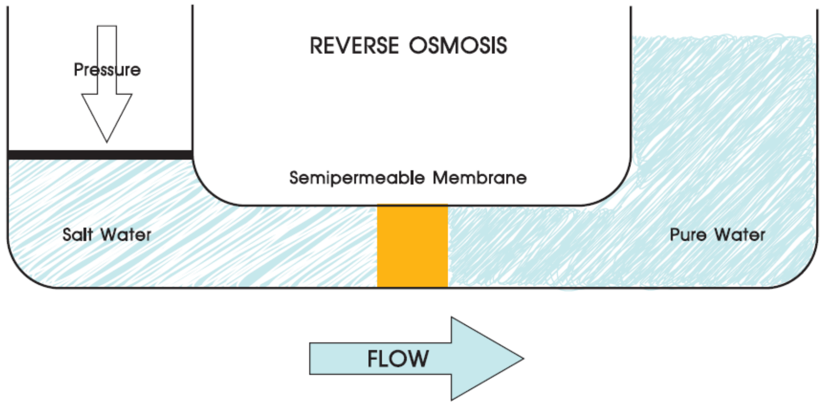


Figure 15 simple diagram of reverse osmosis, the most commonly used membrane process for desalination. In this diagram, high pressure is applied to salt water, forcing water molecules through a membrane with very small holes while leaving the salt behind.

- Thermal desalination processes generally use heat to evaporate water, leaving dissolved constituents behind. The water vapour is then condensed and collected as product water. Distillation is the simplest of these thermal processes and the energy efficiency of this simple process has been greatly improved[89].
- The most common thermal desalination process today is multi-stage flash (MSF) distillation; in 2005, MSF was reported to account for 36% of desalination worldwide.
- MSF improves on the energy efficiency of simple distillation by utilizing a series of low-pressure chambers, recycling waste heat and, in some cases, can be operated at even greater efficiency by utilising the waste heat from an adjacent power plant[90].

	• Multiple-effect Evaporation (MEE) (also known as multiple-effect distillation) is another thermal process that utilizes low-pressure chambers; it is possible to achieve much greater efficiency in MEE than in MSF. However, MEE is not as popular because early designs were plagued by mineral scaling. Newer designs have reduced mineral scaling and MEE is gaining in popularity[91, 92]. • For smaller operations with volume needs around 3000 m3/day, vapour compression distillation (VCD) can be an appropriate thermal distillation option. VCD is a technically simple, reliable and efficient process that is popular for resorts, industries and work sites where adequate freshwater is unavailable. • Membrane desalination processes utilize high pressure to force water molecules through very small pores (holes) while retaining salts and other larger molecules. Reverse osmosis (RO) is the most widely used membrane desalination technology, and represented 46% of global desalination capacity in 2005. Because osmotic pressure must be overcome, the energy needed to drive water molecules across the membrane is directly related to the salt concentration. Therefore, RO has been most often used for brackish waters that are lower in salt concentration and, in 1999, only accounted for 10% of seawater desalination worldwide[93]. However, the energy efficiency and economics of RO have improved markedly with development of more durable polymer membranes, improvement of pretreatment steps, and implementation of energy recovery devices. In many cases, RO is now more economical than thermal methods for treating seawater. About 90% of global volume capacity for desalination is represented by the four thermal and membrane processes discussed above. Other desalination processes include electrodialysis, freezing, solar distillation, hybrid (thermal/membrane/power), and other emerging technologies. • Interest in harvesting solar energy has led to significant progress on solar distillation processes. Hybrid desalination combining thermal and membrane processes and usually operated in parallel with a power generation facility is a promising emerging technology that has been implemented successfully[94,95]
Institutional and organizational requirements/ knowledge/capacit y building requirements	• Until recently, little information was available on institutional aspects of desalination. A World Bank[96] project helped to define the key institutional issues related to desalination and provide recommendations for implementation. These issues include how and when desalination should be incorporated into a larger water policy, how to integrate desalination into energy policies and energy co-production, the role of private enterprise, and how to distribute and charge for desalinated water. • Key recommendations for governments exploring development of desalination include: — Develop a clear water policy using an integrated water resources management (IWRM) approach to determine accurately renewable freshwater resource potential, demand and consumption. Only when the adequacy of conventional water resources is understood should development of nonconventional (e.g. saline) water resources be pursued.[97] — Implement conservation and water demand management in all sectors. Key methods include reduction of non-revenue water in piped systems, use of only limited targeted subsidies, and prevention of groundwater pollution.

89 Foundation for Water Research (2006) Review of Current Knowledge: Desalination for Water Supply. Marlow, United Kingdom. http://www.fwr.org/desal.pdf Accessed November 5, 2010.

90 Elliot, M., Armstrong, A., Lobuglio, J. and Bartram, J. (2011). Technologies for Climate Change Adaptation—The Water Sector. T. De Lopez (Ed.). Roskilde: UNEP Risoe Centre.

91 Khawaji, A.D., Kutubkhanah, I.K. and Wie, J.M. (2008) Advances in seawater desalination technologies Desalination Vol. 221:47–69.

92 Miller, J.E. (2003) Review of Water Resources and Desalination Technologies. Sandia National Laboratories. SAND 2003-0800. Albuquerque, USA. http://ocw.mit.edu/courses/mechanical-engineering/2-500-desalinationand-water-purification-spring-2009/readings/MIT2_500s09_read19.pdf Accessed November 5, 2010.

93 Khawaji, A.D., Kutubkhanah, I.K. and Wie, J.M. (2008) Advances in seawater desalination technologies Desalination Vol. 221:47–69.

94 Ludwig, H. (2004) Hybrid systems in seawater desalination- practical design aspects, present status and development perspectives. Desalination Vol. 164:1-18.

95 Hamed, O.A. (2005) Overview of hybrid desalination systems — current status and future prospects. Desalination Vol. 186:207-214.

96 DHV Water BV, the Netherlands, and BRL Ingénierie (2004) Seawater and Brackish Water Desalination in the Middle East, North Africa and Central Asia: A Review of Key issues and Experience in Six Countries. Report for the World Bank. http://siteresources.worldbank.org/INTWSS/Resources/Desal_mainreport-Final2.pdf Accessed November 9, 2010.

97 DHV Water BV, the Netherlands, and BRL Ingénierie (2004) Seawater and Brackish Water Desalination in the Middle East, North Africa and Central Asia: A Review of Key issues and Experience in Six Countries. Report for the World Bank. http://siteresources.worldbank.org/INTWSS/Resources/Desal_mainreport-Final2.pdf Accessed November 9, 2010.

	— Consider desalination in combination with other non-conventional water sources including reuse of treated wastewater, importation of water across boundaries, rainwater harvesting and microcatchments • "It may be preferable not to engage in desalination on a large scale unless the underlying weaknesses of the water sector are addressed...desalination should remain the last resort, and should only be applied after having carefully considered cheaper alternatives in terms of supply and demand management[98] • The said World Bank report on desalination in the Middle East and Central Asia includes a chapter on capacity building[99] Training and formal education requirements for desalination are also discussed in detail in the said report. The major needs identified include the inadequacy of: — information and data resource assessment specifically on desalination — technical capabilities — financial resources dedicated to research — national policies in long-term planning and establishment of institutional infrastructures for management and operation of desalination
Operation and maintenance	High: The cost of desalination is beyond the purchase capability of Jordan. Unlike many of its Arab neighbors, Jordan has virtually no indigenous energy sources. Jordan is not a rich country. Consequently any desalination project will be very carefully examined with regards to capital and operating costs. It is therefore almost certain that RO will be selected as the optimum process for large scale desalination. ED & EDR may have useful small scale applications.
Endorsement by experts	Progress in desalination technology has been incremental, resulting in consistent improvements in energy efficiency, durability and decreased operation and maintenance across many technologies. However, new technologies in research and development could potentially result in large improvements.
Adequacy for current climate	The technology is adequate for current as well as future climate specially in light of projection results of climate models which predicted reduction in precipitation rates up to 15-20% until 2100, which makes every drop of water counts.
Scale/Size of beneficiary group	• from a municipality to a city scale. • Many places in Jordan and thus wide population pools. • Various studies have shown that Jordan has a considerable brackish water resource. There is therefore considerable scope for both RO and EDR plants in the future. • Brackish water in the Southern Ghore between Dier Alla town and the Dead Sea with salinity of about 5000–7500 ppm and a yield of about 60 MCM/y as drinking water is one of the sources of brackish water in Jordan. Other resources are: the saline springs east and west of the Jordan Valley with capacity of about 10 MCM/y. The third source is brackish water distributed all over the country estimated at hundreds of millions m^3.
Disadvantages	• The major drawbacks of current desalination processes include costs, energy requirements and environmental impacts. The environmental impacts include disposal of the concentrated waste stream and the effects of intakes and outfalls on local ecosystems • The large energy demands of current desalination processes will contribute to greenhouse gas emissions and could set back climate-change mitigation efforts. • Desalination could raise the cost of fresh water production by as much as two- or three-fold • it is not reasonable to expect that desalination can solve the problem of water supply for agriculture in the near future. • For the time being, desalination will serve mainly domestic and some industrial water supply requirements.
Capital Cost	

98 DHV Water BV, the Netherlands, and BRL Ingénierie (2004) Seawater and Brackish Water Desalination in the Middle East, North Africa and Central Asia: A Review of Key issues and Experience in Six Countries. Report for the World Bank. http://siteresources.worldbank.org/INTWSS/Resources/Desal_mainreport-Final2.pdf Accessed November 9, 2010.

99 DHV Water BV, the Netherlands, and BRL Ingénierie (2004) Seawater and Brackish Water Desalination in the Middle East, North Africa and Central Asia: A Review of Key issues and Experience in Six Countries. Report for the World Bank. http://siteresources.worldbank.org/INTWSS/Resources/Desal_mainreport-Final2.pdf Accessed November 9, 2010.

Cost to implement adaptation technology	• In general the cost is high: For example, the cost of desalination is beyond the purchase capability of Jordan. Unlike many of its Arab neighbors, Jordan has virtually no indigenous energy sources. Jordan is not a rich country. Consequently any desalination project will be very carefully examined with regards to capital and operating costs. It is therefore almost certain that RO will be selected as the optimum process for large scale desalination. ED & EDR may have useful small scale applications. • However, a recently published review of desalination cost literature has shown that the costs are very much site-specific and the cost per volume treated can vary widely. Some of the factors reported to have the greatest influence on the cost per m^3 include: the cost of energy, the scale of the plant, and the salt/TDS content of the source water[100]. Capital costs of construction are clearly a major consideration as well, but are almost entirely site specific. • The cost of membrane desalination decreases sharply as the salt concentration decreases. Seawater, on average, contains about 35,000 mg/L TDS; brackish waters, at 1000-10,000 mg/L, can be treated much less expensively[101]. • The costs per volume to desalinate brackish water using RO have generally been reported to range from \$0.26-0.54/m^3 for large plants producing 5000-60,000 m^3/day and are much higher (\$0.78-1.33/m^3) for plants producing less than 1000 m^3/day. • Cost per volume for seawater RO are reported to be \$0.44-1.62/m^3 for plants producing more than 12,000 m^3/day[102]. • Costs for thermal desalination plants were reported to be \$2-2.60/m^3 for 1000-1200 m^3/day and \$0.52-1.95/m^3 for plants producing more than 12,000 m^3/day.
Development impacts, direct and indirect benefits	
Direct benefits	• Access to an adequate supply of freshwater for drinking, household, commercial and industrial use is essential for health, well being, and economic development[103]. In many settings, desalination processes can provide access to abundant saline waters that have been previously unusable.
Reduction of vulnerability to climate change/reduced emissions, indirect	• Reduces impact of climate change on limited water resources and preparing resilient communities • Desalination can greatly aid climate change adaptation, primarily through diversification of water supply and resilience to water quality degradation. Diversification of water supply can provide alternative or supplementary sources of water when current water resources are inadequate in quantity or quality. • Desalination technologies also provide resilience to water quality degradation because they can usually produce very pure product water, even from highly contaminated source waters. • Increasing resilience to reduced per capita freshwater availability is one of the key challenges of climate change adaptation. Both short-term drought and longer-term climatic trends of decreased precipitation can lead to decreased water availability per capita. These climatic trends are occurring in parallel with population growth, land use change, and groundwater depletion; therefore, rapid decreases in per capita freshwater availability are likely. • However, the large energy demands of current desalination processes will contribute to greenhouse gas emissions and could set back climate-change mitigation efforts.
Economic benefits, Indirect Employment	• Economic benefits in terms of feasibility of technology option is questionable because cost is high but it should be assessed case by case. • The technology will provide a good opportunity for creating well-established desalination industry is the presence of the qualified manpower. • Water companies will be urged to recruit qualified staff, thus providing good amount of job opportunities
Growth and Investment	• Good opportunity for investment in small-scale to medium-scale projects in small countries like Jordan with limited energy resources.
Social benefits (indirect benefits	• Will provide incomed to investors and will provide training opportunities as wlel as research programs

100 Karagiannis, I.C. and Soldatos, P.G. (2008) Water desalination cost literature: review and assessment. Desalination Vol. 223:448-456.

101 Greenlee, L.F., Lawler, D.F., Freeman, B.D., Marrot, B., and Moulin, P. (2009) Reverse osmosis desalination: Water sources, technology, and today's challenges. Water Research Vol. 43 (9):2317-2348.

102 Karagiannis, I.C. and Soldatos, P.G. (2008) Water desalination cost literature: review and assessment. Desalination Vol. 223:448-456.

103 WHO (2007) Desalination for Safe Water Supply: Guidance for the Health and Environmental Aspects Applicable to Desalination. Rolling Revision. World Health Organization. Geneva. http://www.who.int/water_sanitation_health/gdwqrevision/desalination.pdf Accessed November 5, 2010.

in Income, Education, and health)	• Access to an adequate supply of freshwater for drinking, household, commercial and industrial use is essential for health, well being, and economic development[104].
Environmental benefits, indirect	•
Local context	
Opportunities and Barriers	**Opportunities:** • Access a nearly unlimited water resource. • The best opportunities for implementation are in water sectors that are functioning well, with well-defined water policy, well-characterized water resource availability and demand, technical expertise, and relatively little waste and inefficiency. • Opportunities for desalination are greatest when: — Freshwater resources are inadequate to meet demand (water stress or water scarcity) — For membrane systems, an abundant source of brackish water with low salt/TDS concentration is available; or, for thermal systems, the population is located on a coastline with an adjacent facility (e.g., a power plant) that yields abundant waste heat — Consumers are opposed to the reuse of treated wastewater • According to analysis conducted by many academic researchers in Jordan, it was concluded that desalination is the most appropriate option for Jordan to alleviate water scarcity and overcome water budget deficit. Yet even this is not commercially viable for Middle Eastern agriculture at present. Perhaps a generation from now we will possess economical technology for mass desalination of water[105]. • Jordan has a considerable brackish water resource. There is therefore considerable scope for both RO and EDR plants in the future. • Studies and projects were carried out to evaluate the feasibility of water desalination in Jordan. Some of the proposed actions focused on utilizing the water in the Gulf of Aqaba for water supply and desalination for major industries. **Barriers** • environmental impacts. These include: — effects of the concentrated waste stream on ecosystems; — the impact of seawater intakes on aquatic life; and — greenhouse gas emissions. • Cost is high. Desalination could raise the cost of fresh water production by as much as two- or three-fold • It is very difficult to exploit brackish water resources in Jordan due to the topography of the country, the distance between these scattered resources, the need for special treatment to remove some sorts of chemicals such as manganese, sulfates and iron, as well as gases such as hydrogen sulfide and, finally the main problem is the disposal of the brine which can cause environmental problems. These scattered resources, however, can supply desalted water for small communities by using solar energy or/and wind power (an opportunity).
Market potential	• **Large Market potential:** Jordan has a considerable brackish water resource. There is therefore considerable scope for both RO and EDR plants in the future. But market potential still has some limitation: due to the reasons above.
Status (National status of technology in Jordan)	Some researchers investigated potential of desalination in Jordan, as the only realistic hope[106]. To date, the desalination of either seawater or brackish water in Jordan has been very limited. In the case of seawater, Jordan has a very short shoreline on the Gulf of Aqaba and this is very distant from the main centers of population. This is further aggravated by the fact that these centers of population are at high elevations (Amman 1000 m above mean sea level) and would therefore involve high pumping costs. Jordan does have reserves of brackish water and a small number of

104 WHO (2007) Desalination for Safe Water Supply: Guidance for the Health and Environmental Aspects Applicable to Desalination. Rolling Revision. World Health Organization. Geneva. http://www.who.int/water_sanitation_health/gdwqrevision/desalination.pdf Accessed November 5, 2010.

105 Mousa S. Mohsen, 2006, Water strategies and potential of desalination in Jordan, Desalination 203 (2007) 27–46

106 Mousa S. Mohsen, 2006, Water strategies and potential of desalination in Jordan, Desalination 203 (2007) 27–46

	brackish water desalination plants have been built. Wangnick's survey of 2002[107] lists 19 plants on 13 sites with a total capacity of 11000 m^3/d. There are more plants than this survey indicates as the situation is changing rapidly with new plants coming on stream. Jordan's experience in brackish water desalination has been fairly limited. All of the plants built to date have been small and built for commercial/industrial use or for agriculture. Most have been RO plants but there are at least two EDR plants. Various studies have shown that Jordan has a considerable brackish water resource. There is therefore considerable scope for both RO and EDR plants in the future. In particular there may be scope for EDR for small remote locations. This technology is more robust than RO and the feed water requires significantly less pre-treatment. It may be powered by PV. Currently in deployment is a large RO plant at Abu Zighan. The project will was design in 2006 to deliver 40,000 m^3/d (eventually 18 MCM at maximum capacity). In the Jordan Valley there is small-scale brackish water desalination. Twenty-one stations deliver water destined largely for irrigation use. These stations are located north of the Dead Sea and are privately owned. Studies indicate that there is a maximum of 80 million m^3 of water that can be used in the Jordan Valley. Salinity in the valley is maximum 7000–8000 ppm, but on average it is some 3000 ppm. The Hisban project was proposed to start by 2015. This project should deliver some 9–15 MCM/y. There is a groundwater desalination plant at Zarqa, operating at 600 m^3/h. MWI and WAJ have signed an agreement in September 2003 [108] for the construction of the Wadi Ma'in, Zara and Mujib desalination plant and conveyance project. The desalination is carried using the reverse osmosis techniques. This is a Design-Build-Operate contract. The plant will be operated for 2 years before being handed over to the Government. The plant includes desalination of 55 MCM per year of water with a salinity of 1500–2000 mg/l. It shall provide Amman with 38 MCM per year with a TDS of 250 mg/l. As part of the current expansion of the Aqaba wastewater treatment plant a conveyer pipeline is constructed to supply filtered effluent wastewater for certain uses, such as watering of municipal green. Unlike many of its Arab neighbors, Jordan has virtually no indigenous energy sources. Jordan is not a rich country. Consequently any desalination project will be very carefully examined with regards to capital and operating costs. It is therefore almost certain that RO will be selected as the optimum process for large scale desalination. ED & EDR may have useful small scale applications. Some other studies and projects were carried out to evaluate the feasibility of water desalination in Jordan. JICA carried out a study on the evaluation of brackish groundwater resources potential and brackish groundwater Hisban, Kafrain, Karameh, and Abu Zieghan areas. The study formulated a brackish groundwater resource development strategy for the northern part of Jordan including the Jordan Valley and Amman City. The study concluded that there is a potential for producing 60 MCM/y of desalinated brackish water in the study area. A pilot plant producing 5 MCM/y of desalinated water was proposed in the Kafrain/Hisban area, and recently studies were carried out to desalinate 30 MCM from Kafrain/Hisban for the urgent need in Amman, as well as 10 MCM from seawater at Aqaba, mainly for industrial purposes, in addition to some small desalination units in the desert area. It is very difficult to exploit brackish water resources in Jordan due to the topography of the country, the distance between these scattered resources, the need for special treatment to remove some sorts of chemicals such as manganese, sulfates and iron, as well as gases such as hydrogen sulfide and, finally the main problem is the disposal of the brine which can cause environmental problems. Technologies could be used and proposed in Jordan were multistage flash (MSF) or reverse osmosis (RO) and electrodialysis (ED). Currently, there are few, very small desalination plants which are used for industrial purposes. Technologies used in these plants are RO and ED, i.e., Hussein thermal station, oil refinery, Electricity Authority, and medical industries.
Timeframe	Short-term to medium term as improvements in energy efficiency of technology is still sought.
Acceptability to local stakeholders	Fairly acceptable due to limitations discussed above.

[107] IDA Worldwide Desalting Plants Inventory No. 17, Wangnick Consulting GMBH and IDA, 2002.
[108] The World Bank–Bank–Netherlands Water Partnership, Seawater and Brackish Water Desalination in the Middle East, North Africa and Central Asia, Final Report, Annex 3, Jordan, 2004.

Technology Name: Improvement of wastewater treatment and reuse systems in the agricultural sector

Technology characteristics	
Introduction	Modern technology to collect and treat wastewater was introduced in the late 1960s in Jordan when the first collection system and treatment plant was built at Ain Ghazal utilizing the conventional activated sludge process. The system consisted of a sewage network that runs by gravity to the lowest point in Amman, where the treatment plant was located and built. The treatment plant was designed to handle an average flow of (60,000 m^3/day) with a BOD5 loading of (18,000 kg/d), for a population of (300,000). The design effluent standard was BOD5 (20 mg/1). The treated effluent was discharged to Sell Zarqa.[109] However, due to the high strength of the raw sewage (i.e. the BOD5 of the incoming sewage was greater than 600 mg/1) the effectiveness of the activated sludge process was drastically reduced. Nevertheless, Ain Ghazal Treatment Plant (AGTP) continued to operate under high organic overloading conditions, which resulted in major operational and environmental problems. As a result, AGTP produced odors that were a source of public nuisance to the surrounding areas. The quality of the effluent of AGTP deteriorated the quality of surface, ground and irrigation water in the region. Since the year 1980 the Government of Jordan carried out significant and comprehensive plans with regard to the different issues of wastewater management primarily related to the improvement of sanitation. As irrigated agriculture in the Jordan Valley consumes about 42 % of the available freshwater resources, which are also urgently needed as drinking water, the use of marginal water resources, such as brackish and reclaimed water for irrigation is highly desirable[110]. The irrigation water policy addressed irrigation water including agricultural use, resource management, technology transfer, water quality and efficiency. It stated that irrigation water should be managed as an economic commodity that water price has to cover at least operation, maintenance, and, as far as possible, capital costs, and that different prices should be applied to different water quality.
Size of beneficiaries group	A GIZ Project in Jordan (2007-2015) examined potential for about 4,000 farm units with 10,000 ha irrigable area[111]. The project area is situated in the middle and southern Jordan Valley extending over a length of about 50 km between Kreimeh and the Dead Sea. The majority of the farmers are small scale farmers, with an average farm unit area of about 3 ha.
Disadvantages	• The use of reclaimed water for irrigation is generally a sensitive topic in the public due to lack of information. • The implementation of crop quality monitoring is difficult because governmental agencies do not feel responsible for sampling and analysis of crops irrigated with reclaimed water. Providing guidelines in this field helps to clarify and improve the situation. • The majority of farmers is not aware of the nutrient content of the reclaimed water and is starting to appreciate information regarding reclaimed water quality. • Potential **Health and hygiene risks** include the risk of exposure to pathogens and hazardous substances but potential improvement of livelihood achieved by the application of a certain sanitation system.
Economic Impact	
Economic Importance	• Has many economic importance as enhancement of WWTPs will reduce cost of wastewater treatment and cut down on O&M cost
Capital, Operational and Maintenance costs	• The cost required for decentralized WWTPis high. In the long run it is foreseen to transfer operation and maintenance responsibilities for parts of the irrigation infrastructure to water user associations.

[109] State of the Wastewater Management in the Arab Countries-Jordan Country Report, Arab Water Council (AWC), Expert Consultation, UAE-Dubai 22-24 May 2011

[110] GIZ Water Programme: Sustainable use of reclaimed water, Jordan Valley Authority, Jordan.

[111] GIZ Water Programme: Sustainable use of reclaimed water, Jordan Valley Authority, Jordan.

Development impacts, indirect benefits	
Employment and Opportunity for SMEs	• Opportunity for national (and international) expertise, • Experts working on guidelines for irrigation water quality and crop quality and • Experts for monitoring and information systems
Investment	• Good investment opportunities for projects aiming at improvement of wastewater treatment and reuse systems in the agricultural sector
Public and private expenditures	• Lowered expenditures for farmer due to water and fertilizers use savings • The results from the demo sites revealed that fertilizer expenditures can be cut by 60%.[112]
Social Suitability	
Human and Informational Requirements/Institutional and Organizational requirements	• Low to moderate need for Human and Informational Requirements/Institutional and Organizational requirements
Income	• Extra income for farmer due to water and fertilizers use savings • The results from the demo sites revealed that fertilizer expenditures can be cut by 60%, which is equivalent to EUR 564 per hectare and can be translated into income improvements of 30 %[113].
Environmental Impacts	
Environmental Impacts/Resilience to Climate	• Minimum environmental impact potential on soil and groundwater quality. • The technology will contribute to the reduction of chemical fertiliser uses in the middle and southern part of the Jordan Valley, lowering the soil salinisation pace. • The impact of irrigation with reclaimed water on soils and groundwater should be monitored at selected sites in order to develop recommendations for long-term monitoring needs regarding possible adverse effects on the environment. • Will develop resilient communities. In the long run it is foreseen to transfer operation and maintenance responsibilities for parts of the irrigation infrastructure to water user associations.
Local context	
Opportunities and Barriers	**Opportunities** • Opportunity for co-ordination between the involved organisations and stakeholders with regard to irrigation water quality, health and environment. • Awareness raising among water users and agricultural producers regarding possible health and environmental risks. • Dissemination of good agricultural practices to extension workers and farmers with regard to reclaimed water use. • Will develop resilient communities. **Barriers** • The use of reclaimed water for irrigation is generally a sensitive topic in the public due to lack of information. • The implementation of crop quality monitoring is difficult because governmental agencies do not feel responsible for sampling and analysis of crops irrigated with reclaimed water. Providing guidelines in this field helps to clarify and improve the situation. • The majority of farmers in the project area is not aware of the nutrient content of the reclaimed water and is starting to appreciate information regarding reclaimed water

112 GIZ Water Programme: Sustainable use of reclaimed water, Jordan Valley Authority, Jordan.
113 GIZ Water Programme: Sustainable use of reclaimed water, Jordan Valley Authority, Jordan

	quality.
Technology Capability & Suitability/ Technology Maturity	• There are many technologies available and in an advanced stage of maturity concerning improvement of wastewater treatment and reuse systems in the agricultural sector is a well mature technology
Market potential	• It is estimated that farmers would save up to 60 % of their fertilisation cost, which is equivalent to EUR 564 per hectare and can be translated into income improvments of 30 %[114].
National status of technology in Jordan	Currently little attempt is being made in Jordan to use treated waste water or to develop other non-conventional water harvesting techniques to augment dwindling water supplies. Low investment in water infrastructure is a major cause for this, while low water recovery rates have also undermined the incentive to invest in this sector. The effectiveness of treatment plants depends on the quality of incoming wastewater and reflects the quality of wastewater discharged into the sewer system. The current performance of many wastewater treatment plants is inadequate for handling the quantity of water that needs treatment and end up discharging low quality effluent (Ministry of Water and Irrigation, Jordan 2009). This effluent can adversely impact public health due to pathogen contamination of crops or the accumulation of toxins in irrigated soils. Further, septic water is not regulated and untreated water discharged into the watershed may be a health and environmental issue. The salinity of municipal water is around 580 ppm of TD and the average domestic water consumption is low, which is why wastewater in Jordan, in comparison to other countries, tends to be highly saline and have high organic loads. Wastewater treated in waste stabilization ponds aggravates this problem as water is also lost through evaporation, increasing salinity levels in effluents. Nonetheless, water supplied through waste water treatment will likely become increasingly important for agricultural and industrial production in Jordan in the near future. Treated wastewater, generated at sixteen existing wastewater treatment plants is an important component of Jordan’s water resources. Due to the topography and the concentration of urban population above the Jordan Valley escarpment, the majority of treated wastewater is discharged into various watercourses, and flows downstream to the Jordan Valley, where it is used for irrigation. Currently around 55 MCM of treated wastewater is used for restricted irrigation purposes in the country. MWI forecasts state that the amount of wastewater used for irrigation should reach 232 MCM by 2020, especially in the Jordan Valley. However, the existing wastewater treatment plants are over-used beyond their design capacity due to increased inflow of wastewater. This has reduced the quality of treated wastewater, and this “resource” has not been effectively used to gradually replace freshwater resources in agricultural uses. At present Jordanian wastewater treatment plants produce about 85 Mio m^3 of effluent per year. Approximately 66 % of that amount is used for irrigation in the Jordan Valley. In Jotrdan, the main source of reclaimed water for irrigation is the treatment plant at Khirbet As Samra, the country’s largest treatment plant with a yearly effluent of about 50 Mio. m^3. This effluent is discharged into two consecutive wadies and then temporarily stored in the King Talal Reservoir, the country’s largest reservoir. From there it is led via further wadis and canals to the middle and southern Jordan Valley where it is finally used for irrigation on about 4,000 farm units with an area of approx. 10,000 ha.

[114] GIZ Water Programme: Sustainable use of reclaimed water, Jordan Valley Authority, Jordan

Technology Name: Water saving devices: Zero Reject Household RO System

<table>
<tr><th colspan="2">Technology characteristics</th></tr>
<tr><td>Introduction</td><td>The water treatment systems that operate by Reverse Osmosis is the highest efficiency. It is the most widespread in the desalination of drinking water in various countries around the world, the most effective system in home and also the safest. However, such systems waste up to ten times the fresh water resulting from the treatment process. The salt water is featured with a high degree of purity but unpalatable for drinking. But, this source of water, if adequately treated can be used in cooking, cleaning, drinking, and washing dishes and utensils, fruits, and vegetables.</td></tr>
<tr><td>Size of beneficiaries group</td><td>• There is about 500,000 existing RO System in the Jordanian houses and the average of the people lives in the same house is 5 so 2,500,000 people will directly benefit from an enhanced RO system that saves water loss (reject water).</td></tr>
<tr><td>Disadvantages</td><td>• Occupies extra space in houses (under kitchen's sink) due to deployment of two tank-system</td></tr>
<tr><th colspan="2">Economic Impact</th></tr>
<tr><td>Economic Importance</td><td>• High economic importance due to potential saving of 20,000,000 cubic meters annually by preventing loss of reject water. Water cost saving is displayed below:
<table>
<tr><th>Amount of wasted water</th><th>20.000.000 (m3)</th></tr>
<tr><td>Cost per cubic meter to the government</td><td>136 (Jordanian piastres)</td></tr>
<tr><td>Total cost of wasted water</td><td>27.200.000 JD</td></tr>
<tr><td>Total cost of wasted water – what government pays</td><td>16.400.000 JD</td></tr>
<tr><td>Total cost of wasted water – what citizen pays</td><td>10.800.000 JD</td></tr>
</table></td></tr>
<tr><td>Capital, Operational and Maintenance Costs</td><td>• Minimal at the household level. At a country-lever, each rationalization unit cost about 65 JDs to be installed in 500,000 existed system: 500,000 * 65 = 32,500,000 JOD</td></tr>
<tr><th colspan="2">Development impacts, indirect benefits</th></tr>
<tr><th colspan="2">Economic benefits</th></tr>
<tr><td>Employment and Opportunity for SMEs</td><td>• As this technology will be manufactured in Jordan, all the staff will be Jordanian in all of the presses as a rough count: 60 employees in the factory, 30 as a company staff, 20 technicians.
• So the total number of employees who will benefit directly from this technology is around 110.</td></tr>
<tr><td>Investment</td><td>• The technology application is an investment as it is registered as a Jordanian patent and fully manufactured in Jordan with a high return of investment.</td></tr>
<tr><td>Public and private expenditures</td><td>• It will cut down on public (government water entities) and private (households, small businesses, etc) expenditures.
• This technology will be provided by the Jordanian private sector. In addition, it has a very promising investment for private companies that work in the field of trading water treatment systems for households, and for the government. This technology will saves water that costs about 1.8 JD for each m^3 so if this technology applied it will</td></tr>
<tr><th colspan="2">Social Suitability</th></tr>
</table>

Human and Informational Requirements/Institutional and Organizational requirements	• Very minimal
Income	• Will indirectly increase income for the household by saving more cost of water in Jordan. • More sources of income for maintenance companies.
Environmental Impacts	
Environmental Impacts/Resilience to Climate	• If we apply this technology for every single RO System we will save 20 M m^3 of drinking water, a very important adaptation action in the water sector Jordan.
Local context	
Opportunities and Barriers	**Opportunities** • Big water saving • environmental, social, economic and investment opportunities • Continuous research • Developing and enforcing environmentally-friendly specifications and water-saving RO in the country **Barriers** • Confrontation from traditional water-loss RO systems • Relatively higher cost of system
Market potential	• Will have a great potential as a new more efficient water saving device will be introduced to the market. The RO market for regular, water wastage RO systems is declining recently because of several issues especially the huge quantity of wasted water they cause so this technology will refresh the market by solving this issue.
National status of technology in Jordan	The technology is ready to be implemented and the factory is under construction.

Annex 10 Prioritized Agriculture Sector Technologies Fact Sheets

Technology: Support of water saving technologies, such as drip or subsurface irrigation	
Sector: Agriculture	
Subsector: Water management	
Technology characteristics	
Introduction	Drip irrigation technology will support farmers to adapt to climate change by providing efficient use of water supply. Particularly in areas subject to climate change impacts such as seasonal droughts, drip irrigation reduces demand for water and reduces water evaporation losses (as evaporation increases at higher temperatures). Scheduled water application will provide the necessary water resources direct to the plant when required. Furthermore, fertilizer application is more efficient since it can be applied directly through the pipes.
Technology characteristics/highlight	Drip and subsurface irrigation is based on the constant application of a specific and focused quantity of water to soil crops. The system uses pipes, valves and small drippers or emitters transporting water from the sources (i.e. wells, tanks and/or reservoirs) to the root area and applying it under particular quantity and pressure specifications. The system should maintain adequate levels of soil moisture in the rooting areas, fostering the best use of available nutrients and a suitable environment for healthy plant roots systems. Managing the exact (or almost) moisture requirement for each plant, the system significantly reduces water wastage and promotes efficient use. Compared to surface irrigation, which can provide 60% water-use efficiency and sprinkler systems which can provide 75% efficiency, drip irrigation can provide as much as 90% water-use efficiency.
Institutional and Organizational requirements	• Low to moderate need for institutional and organizational requirements.
Operation and maintenance	• Operation and management requires more consistent oversight than some alternative irrigation systems. • Requires regular timely and consistent maintenance and repairs to ensure high performance and long life potential
Endorsement by experts	• The technology is highly endorsed by experts and practationers
Adequacy for current climate	• Highly adequate.
Scale/Size of beneficiary group	• All farmers in the Jordan Valley and irrigated upland farms
Disadvantages	• It is difficult to evaluate system operation and application uniformity. • System mismanagement can lead to under irrigation and crop yield and quality reductions or over irrigation, resulting in poor soil aeration and deep percolation problems.
Capital Cost	
Cost to implement adaptation technology	• The initial cost of drip irrigation systems can be higher than other systems. Higher costs are generally associated with the costs of pumps, pipes, tubes, emitters and installation.
Development impacts, direct and indirect benefits	
Direct benefits	• Soil evaporation, surface runoff, and deep percolation are greatly reduced or eliminated.
Reduction of vulnerability to	• Improve water use efficiency • Resilience to water scarcity, as well as areas with potential risks of droughts and high

climate change/reduced emissions, indirect	temperature.
Economic benefits, Indirect Employment	• leads to increase in income of rural population • increase water productivity • Creation of jobs in systems installations and maintenance
Growth and Investment	• Contributes to food security priority by increasing productivity
Social benefits (indirect benefits in Income, Education, and health)	• leads to increase in income of rural population • Improved livelihood of farmers and rural population.
Environmental benefits, indirect	• Fertilizer costs and nitrate losses can be reduced. • Nutrient applications can be better timed to meet the needs of plants. • Runoff into streams is reduced or eliminated, and there is less nutrient and chemical leaching due to deep percolation.
Local context	
Opportunities and Barriers	*Opportunities:* • Existence of good institutional and technical arrangements to implement the technology. • Promoting drip irrigation contributes to efficient water use, reduces requirements for fertilizers and increases soil productivity. *Barriers:* • Lack of access to finance for the purchase of equipment, • High initial investment
Market potential	• Very High market potential nationwide.
Status (National status of technology in Jordan)	• Widely spread in the Jordan Valley farming areas.
Timeframe	• The implementation can start immediately
Acceptability to local stakeholders	• There is good knowledge of the technology by local stakeholders which can make the acceptance easy.

Technology option # 2: Conservative agriculture

Background

Conservation tillage refers to a number of strategies and techniques for establishing crops in a previous crop's residues, which are purposely left on the soil surface. Conservation tillage practices typically leave about one-third of crop residue on the soil surface. This slows water movement, which reduces the amount of soil erosion. Conservation tillage is suitable for a range of crops including grains, vegetables, root crops, fruits and wines.

Unpredictability of rainfall and an increase in the mean temperature may affect soil moisture levels leading to damages to, and failures in, crop yields. Conservation tillage practices reduce risk from drought by reducing soil erosion, enhancing moisture retention and minimizing soil impaction. In combination, these factors improve resilience to climatic effects of drought and floods. Improved soil nutrient recycling may also help combat crop pests and diseases. Such technology will be applied at agricultural cultivated lands with low fertility.

Advantages of the technology:

Conservation tillage benefits farming by minimizing erosion, increasing soil fertility and improving yield. Plowing loosens and aerates the soil, which can facilitate some deeper penetration of roots. Tillage is believed to help in the growth of microorganisms present in the soil and help mix in the residue from the harvest, organic matter and nutrients evenly in the soil. Conservation tillage systems also benefit farmers by reducing fuel consumption and soil compaction. By reducing the number of times the farmer travels over the field, farmers make significant savings in fuel and labor. Labor inputs for land preparation and weeding are also reduced once the system becomes established. In turn, this can increase time available for additional farm work or off-farm activities for livelihood diversification. Additionally, once the system is established, requirement for herbicides and fertilizers can be reduced.

Disadvantages of the technology:

Conservation tillage may require the application of herbicides in the case of heavy weed infestation, particularly in the transition phase. The practice of conservation may also lead to soil compaction over time; however this can be prevented with chisel plows or sub soilers. Initial investment of time and money, along with purchases of equipment and herbicides, will be necessary for establishing the system. Higher levels of surface residue may result in increased plant diseases and pest infestations, if not managed properly. There is a strong relationship between this technology and appropriate soil characteristics. This is detrimental in high clay content and compact soils.

- How the options impact development priorities.

Social Impact	- Contributes to food security priority by increasing productivity
Economic Impact	- Contributes to diversification of economic activities - Leads to improvement of economic condition of rural population - Leads to increase in agricultural productivity
Environmental Impact	- Reduces greenhouse gases (GHGs) emission - Increases land fertility - Reduce soil erosion

Technology: : Introduction of plant varieties resistant to Climate change	
Sector: Agriculture	
Subsector: Plant Breeding	
Technology characteristics	
Introduction	Agriculture sector is highly climate sensitive and there exist potential adverse changes in temperature, precipitation, and frequency of extreme events (e.g. droughts, heat waves, floods) with climate change. New plant varieties more resistant to high temperatures and droughts will enable farmers to sustain or increase productivity. The introduction of new cultivated species and improved crop varieties is a technology aimed at enhancing plant productivity, quality, health and nutritional value and/or building crop resilience to diseases, pest organisms and environmental stresses.
Technology characteristics/highlight	Breeding new and improved crop varieties enhances the resistance of plants to a variety of stresses that could result from climate change. These potential stresses include water and heat stress, water salinity, water stress and the emergence of new pests. Varieties that are developed to resist these conditions will help to ensure that agricultural production can continue and even improve despite uncertainties about future impacts of climate change. Varieties with improved nutritional content can provide benefits for animals and humans alike, reducing vulnerability to illness and improving overall health.
Institutional and Organizational requirements	• Agricultural research institutions must be involved in the process in order to provide analyses and experiments with new species. • Capacity building is required both at the institutional level, i.e. for increasing research capability, and the organizational level, i.e. for extension of research findings and to carryout field demonstrations.
Operation and maintenance	• This technology requires substantial investments in skills, labor, equipment, money and time. Research institutions have the capacity to ensure operation and maintenance in such as NCARE and National Universities. • Varieties testing in experimental stations and at farmers' fields. • Farmers need to be provided with necessary capacity building and awareness raising activities in order to adapt new technology.
Endorsement by experts	• The technology is highly endorsed by experts and practitioners.
Adequacy for current climate	• Highly adequate.
Scale/Size of beneficiary group	• All farmers are concerned, namely those growing vulnerable crops. The technology is appropriate for use by small or large farmers.
Disadvantages	• The costs of new species, as well as costs for cultivation can be higher than others. • Farmers may also face risk from poor economic returns if crops are not selected based on a market assessment. • Replacement of local cultivars would result in a loss of agro-biodiversity for few crops, an increase in agriculture importation bills and an increase in investments for farmers.
Capital Cost	
Cost to implement adaptation technology	• This is a relatively new technology requiring full development of facilities.
Development impacts, direct and indirect benefits	
Direct benefits	

Reduction of vulnerability to climate change/reduced emissions, indirect	• Reduces negative impact of forecasted climate change , • improving drought resilience • cover production losses made by climate change impact with increased yield and quality • Breeding new and improved crop varieties enhances the resistance of plants to a variety of stresses that could result from climate change. These potential stresses include water and heat stress, water salinity, water stress and the emergence of new pests. • Disposal of larger range of varieties and rootstocks would increase the farmer's choice and consequently the resilience to climate change.
Economic benefits, Indirect Employment	• Leads to improvement of economic condition of rural population • Contributes to the diversification strategy of countries economy by increasing weight of agricultural sector within economic system • strengthen the farmers cropping systems by increasing yields, , as well as by capturing new market opportunities. • enables farmers to grow surplus products for sale at market and thus obtain increased income to meet other needs related to household well-being. • Reduce risk and increase yields (by 2-3 fold) and profitability • promote economic development • Job opportunities would increase especially at the technical level within the service providers' enterprises, nurseries, labor force, as well as within the research institutes.
Growth and Investment	• Capital requirements are essential at research institutes, nurseries, and farmer's level. An increased production of selected plant material is reflected in an increased economic growth.
Social benefits (indirect benefits in Income, Education, and health)	• leads to improved livelihood of rural population • Contributes to food security and better health.
Environmental benefits, indirect	
Local context	
Opportunities and Barriers	*Opportunities:* • Introducing new cultivars is an opportunity to replace old varieties is suffering from pest and diseases and a lower quality and quantity of production. • Introduce new varieties demanded both on local and international markets to diversify and widen the period of production for a better resilience to climate change. *Barriers:* • The higher initial cost to develop these technologies • The absence of skills and expertise and the enabling environment for the protection of property right. • Another problem is the lack of expertise and research staff within the research institutes not only to conduct plant breeding, but also to test varieties and reproduce them locally. • The dissemination of new varieties should be carried out along with extension service to obtain the required results.
Market potential	• Very High market potential nationally and regionally
Status (National status of technology in Jordan)	Research institutes and National Center for Agricultural research and extension (NCARE) have some programs in plant breeding and introducing new varieties.
Timeframe	Medium to Long Term.
Acceptability to local	Most farmers are unable to adopt new selected rootstocks and varieties if left alone due to socio-economical constrains and to their lack of knowledge.

stakeholders	new plant varieties are not easily welcomed due to the farmer's fear from market constraints.

Technology option # 4: Information and Knowledge Management

Background

Strategic monitoring on specific indicators and reporting activities provide baseline information that may indicate the inception of impacts. Early warning systems help decision makers and private individuals at all levels to reduce the impacts on extreme climate events. The information should be reliable and timely available with a strong focus on the people exposed to risk, in order to increase resource use efficiency. Information can be obtained from improved flood predictions, weather forecasts by weather radar and satellites observations and collected and shared through related networks. Global climate change will increase the probability of extreme weather events, which may be associated either with high precipitation (i.e., storms, floods, and landslides) or with low precipitation (i.e., heat, drought). These events often overwhelm the capacity of communities and local governments to respond, requiring outside assistance. At present the analysis and preparation of information are particularly critical points of an early warning chain. The responsible decision makers are usually confronted with huge amounts of structured and unstructured data. To enable reliable early warning, the available data must be pre-selected, analysed and prepared.

Advantages of the technology

The measure reduces the impact of extreme climate events on people and assets affected by decreasing the sensitivity state (preparedness) through monitoring, networking and the improved prediction of extreme events. Timely warning could result in a change in resource use efficiency. This measure encompasses actions that promote awareness for the altered conditions under Climate Change. It strengthens the capacity of stakeholders affected by weather extremes from civil society groups, local and national governments to better address the impacts of climate change by their involvement. Awareness and capacity building can address groups of people in a region affected by a particular CC threat, groups of stakeholders, the general public, etc. The ultimate aim is to achieve behavioural changes.

Expert and stakeholder judgement

Drought monitoring and improved flood predictions have a high urgency and high priority to Jordan.

- How the options impact development priorities.

Social Impact	- improvement of awareness and better preparedness. - Leads to increase in income of rural population - Reduces migration to urban areas from rural communities - Improved emergency response by governments and enhanced community preparedness
Economic Impact	- Reduction of crop production losses and economic damages.
Environmental Impact	- Reduces negative consequences of CC - Allows forecasting extreme weather events

Technology: Water Harvesting	
Sector: Agriculture	
Subsector: Water management	
Technology characteristics	
Introduction	Collection and storage of rainwater can provide a convenient and reliable water supply during seasonal dry periods and droughts. Additionally, widespread rainwater storage capacity can greatly reduce land erosion and flooding. Rainwater collection can also contribute greatly to the stabilization of declining groundwater tables.
Technology characteristics/highlight	This technology covers collection, storage and use of rainwater that falls on the ground, utilizing "micro-catchments" to divert or slow run-off so that it can be stored before it evaporates. Collection and storage infrastructure can be natural or constructed and can take many forms. These include: • Below ground tanks (i.e. cisterns) and excavations into which rainwater is directed from the ground surface • Small reservoirs with earthen bunds or embankments to contain run-off. • Groundwater aquifers can be recharged by directing water down.
Institutional and Organizational requirements	Moderate need for institutional and organizational requirements.
Operation and maintenance	• simple cleaning and basic repairs • training for users, especially related to protecting water quality
Endorsement by experts	• The technology is highly endorsed by experts and practationers
Adequacy for current climate	• Highly adequate
Scale/Size of beneficiary group	• All farmers in the uplands and rain-fed areas.
Disadvantages	• The initial cost of these systems can be higher than other systems. Higher costs are generally associated with the costs of infrastructure and installation. • Unexpected rainfall can affect the system.
• **Capital Cost:**	
Cost to implement adaptation technology	• Relatively high investment costs
• **Development impacts, direct and indirect benefits**	
Direct benefits	• Increase water availability and increase crop production.
Reduction of vulnerability to climate change/reduced emissions, indirect	• In soils low in organic matter, it plays an important role in capturing atmospheric carbon dioxide through increased biomass production both in the water conservation zones and in the surrounding land. • resilience to water scarcity, as well as areas with potential risks of droughts and high temperature.

Economic benefits, Indirect Employment	• Creation of jobs to support construction of water harvesting storage. • leads to increase in income of rural population • increase water productivity • It facilitates high value cash crop production. • increase agricultural productivity and reduce depletion of groundwater resources.
Growth and Investment	• Contributes to food security priority by increasing productivity.
Social benefits (indirect benefits in Income, Education, and health)	• Contributes to water security priority by increasing water availability • Leads to improved living standards of rural population and sanitation • Reduces use of drinking water from centralized system for other purposes • Reduces health and environmental issues related to lack of sanitation.
Environmental benefits, indirect	• Reduce soil erosion and siltation downstream. • recharge groundwater aquifers • use for irrigation of crops in the vicinity of the harvested water. • It improves soil fertility
• **Local context**	
Opportunities and Barriers	• Barriers to implementation include inadequate or unsuitable landscape (catchment area). • Difficult to predict eventual capacity limitations and bad management practices of water harvesting over a long period.
Market potential	• The technology is small-scale, proven and less capital-intensive. It has very High market potential
Status (National status of technology in Jordan)	• Present in some areas, lacking in other.
Timeframe	• The implementation can start immediately. • Prior to construction, the users are required to prepare the sites for construction.
Acceptability to local stakeholders	• Easy to accept for all involved stakeholders.